

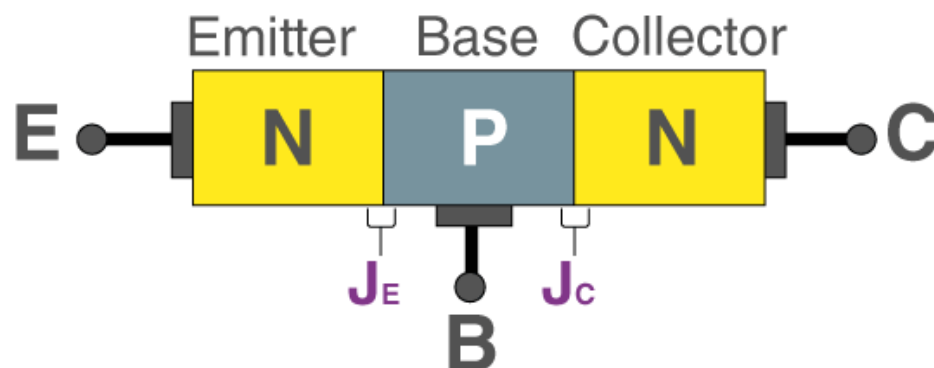
Bipolar Junction Transistor

W. Shockley, J. Barden, and W. Brattain invented the transistor in 1947. The term 'transistor' is derived from the words 'transfer' and 'resistor.' These words describe the operation of a BJT which is the transfer of an input signal from a low resistance circuit to a high resistance circuit. In this article, let us learn more about the Bipolar Junction Transistor.

What is a 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. It is a current controlled device. The three terminals of the BJT are the base, the collector, and the emitter. 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. Note that it does require an external source of DC power supply to carry out the amplification process.

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.

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 operate 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.

Types of Bipolar Junction Transistor

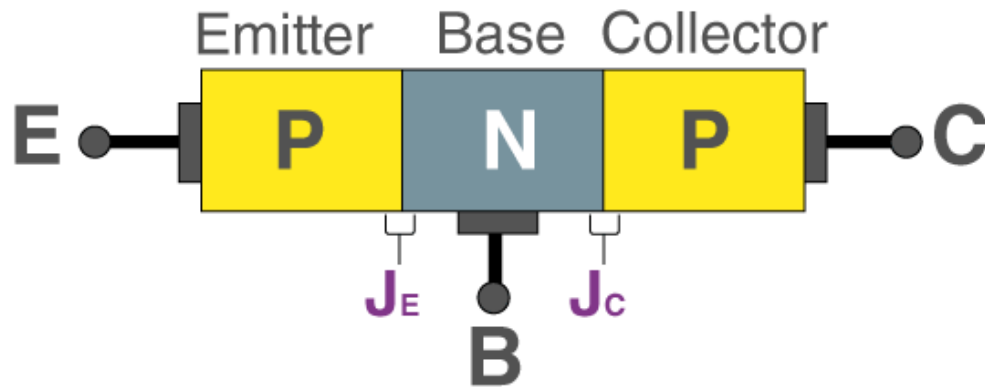
There are two types of bipolar junction transistors:

- PNP bipolar junction transistor
- NPN bipolar junction transistor

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

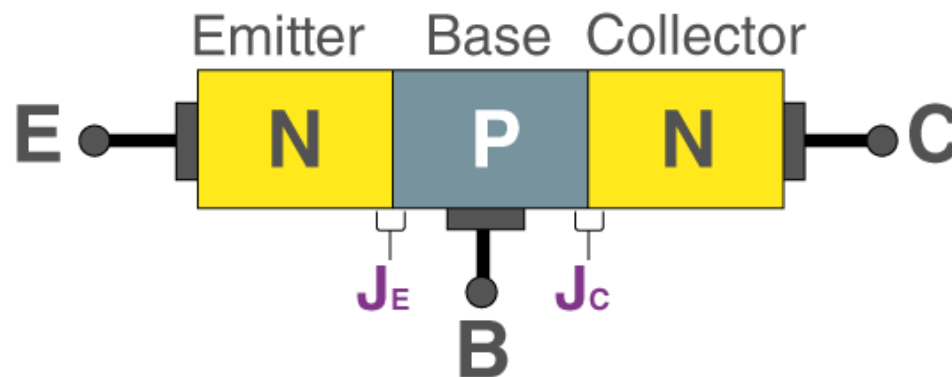
acts as a base. This is shown in the figure below.



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.

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.

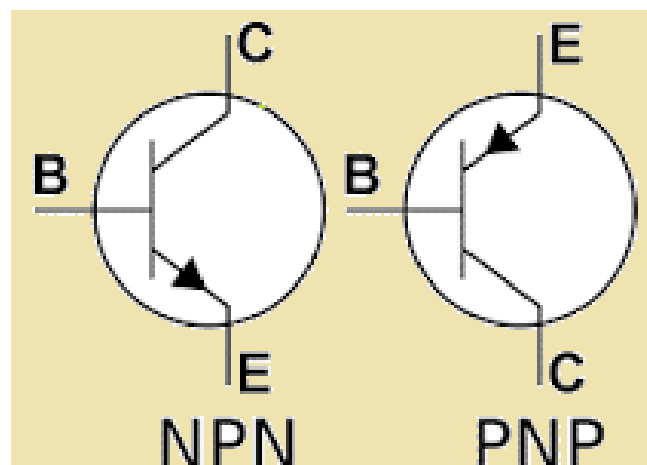


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Current entering the emitter, base, and collector has the sign convention of positive while the current that leaves the transistor has the sign convention of negative.

Function of Bipolar Junction Transistor

BJTs are of two types namely **NPN** and **PNP** based on doping types of the three main terminals. An NPN transistor consists of two semiconductor junctions that have a thin p-doped anode region and PNP transistor also consists of two semiconductor junctions that have a thin n- doped cathode region.



The flow of charge in a Bipolar transistor is due to the diffusion of charge carriers between the two regions belong to different charge concentrations. Regions of BJT are known as the base, collector, and emitter.

The emitter region is highly doped when compared to other layers. Both collector and base layers have the same charge carrier concentrations. Among these junctions, the base-emitter junction is forward biased, and the base-collector junction is reverse biased. Forward biased means p-doped has it contains more potential than the n-doped side.

Suggested Reading

- [Junction Transistor](#)
- [Types of Transistor](#)
- [Uses of Transistor](#)

Voltage, Charge Control and Current

The base-emitter current is controlled by collector-emitter current. This conclusion is drawn by the current-voltage relation of the base-emitter junction. Collector current has a base region where minority carriers are concentrated.

Transistor models such as the *Glenn poon model* are responsible for the distribution of the charge which explains the behavior of a transistor.

Configuration of Bipolar Junction Transistors

Since Bipolar Junction Transistor is a three-terminal device, there are three ways to connect it within an [electric circuit](#) while one

terminal is the same for both output and input. Every method of connection responds differently to the input signals within a circuit.

- Common Emitter Configuration – has both voltage and current gain
- The common Collector Configuration – has no voltage gain but has a current gain
- The common base configuration – has no current gain but has a voltage gain

Characteristics of different transistor configurations are given in the following table:

Characteristics	Common Base	Common Emitter	Common Collector
Power Gain	low	Very high	medium
Current gain	low	medium	high
Voltage gain	High	Medium	low
Phase angle	0	180	0
Output impedance	Very high	high	low
Input Impedance	Low	medium	high

Applications of BJT

We know that a bipolar junction transistor is used as a switch, as an amplifier, as a filter, and even as an oscillator. Below is the list of other applications of bipolar junction transistor:

- BJT is used as a detector or also known as a demodulator.
- BJT finds application in clipping circuits so that the waves can be shaped.

- Logic circuits and switching circuits use BJT.

Frequently Asked Questions

Who invented BJT?

BJT was invented by W.H Brattin, Bardeen, and William Shockley.

What are the operating regions of BJT?

The operating regions of BJT are:

- Forward active or active region
- Reverse active or inverted region
- Saturation
- Cut-off

What are the applications of BJT?

Following are the applications of Bipolar Junction Transistor:

- It is used as an amplifier
- It is used as an oscillator
- It is used as a demodulator

What happens if the transistor is not biased properly?

Following is the list of consequences if the transistor is not biased properly:

- The work efficiency of the transistor reduces
- There will be a distortion in the output signal
- The operating point may shift
- Transistor parameters will change

Why there is a maximum limit for the collector supply voltage for a transistor?

There is a maximum limit for the collector supply voltage for a transistor because when the collector current is increased rapidly there are chances of transistor getting damaged. To avoid this, the voltage in the collector should have a maximum limit.