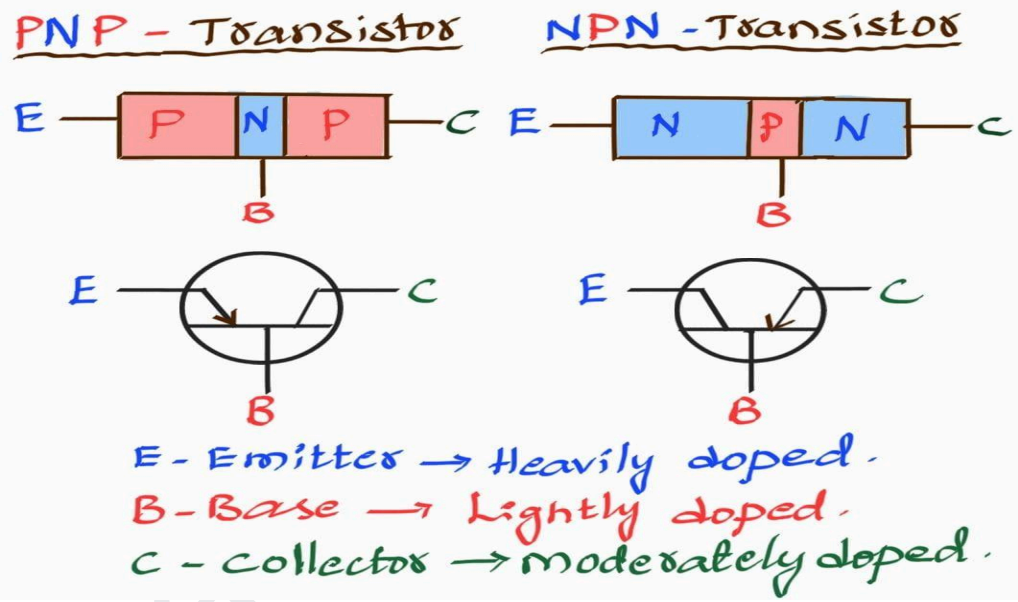
BIPOLAR JUNCTION TRANSISTOR (BJT)

- **INTRODUCTION:**
- The BJT transistor was invented by William Shockley, Bardeen & Brattain at Bell Laboratories in 1947.
- BJT Transistor transfers signals from low resistance circuit to high resistance circuit.
- **DEFINITION:**
- A bipolar junction transistor (BJT) is a three-terminal semiconductor device used to amplify or switch electronic signals and electrical power.
- **SCHEMATIC REPRESENTATION:**
- The schematic symbols of P-N-P & N-P-N transistors are shown below:

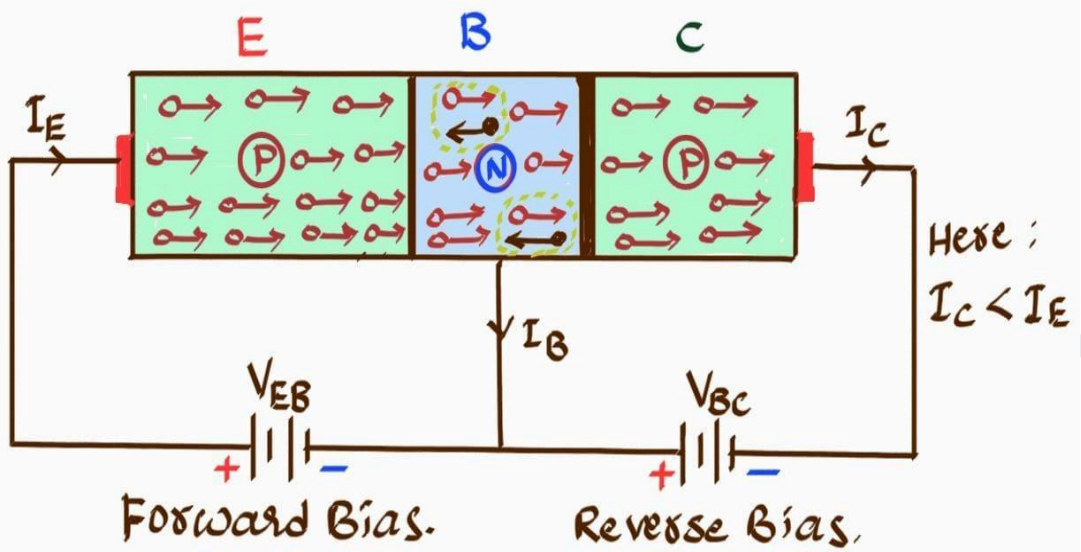


- **PRINCIPLE:**
- The principle of a Bipolar Junction Transistor (BJT) revolves around controlling a larger current flow between the collector and emitter (C-E) by a smaller current applied to the base(B).
- **CONSTRUCTION OF BJT:**
- A bipolar junction transistor (BJT) is constructed by sandwiching a thin, lightly doped layer of one semiconductor type (P-type or N-type) between two heavily doped layers of the opposite type.

- This creates three regions named as 1.Emitter, 2.Base, 3.Collector and two PN junctions: one between the emitter and base(E-B), and the other between the base and collector(B-C).
- **Emitter (E):**
- It is heavily doped than any of the other regions because its main function is to supply majority charge carriers to the base.
- **Base (B):**
- It is lightly doped and very thin ($\approx 10^{-3}$ cm). Its function is to pass most of the injected charge carriers from the emitter into the collector.
- **Collector (C):**
- It is moderately doped and its function is to collect the majority charge carriers coming from the emitter and passing through the base.
- In most transistors, the collector region is made physically larger than the emitter region because it has to dissipate much greater power.
- **Types:** Based on the doping of the three semiconductor regions BJT transistors are categorized into two types.They are 1.PNP Transistor

2.NPN Transistor

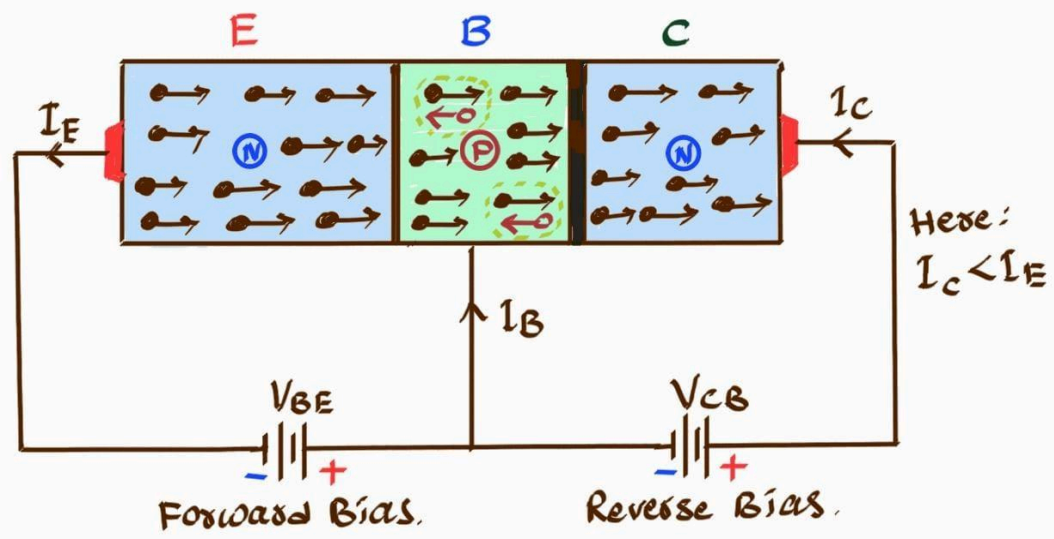
- **1.PNP Transistor:** A thin layer of N-type is sandwiched between two layers of P-type silicon, to get a P-N-P Junction transistor.
- The two end regions of the P-N-P Transistor contain an excess of holes, while the central region contains an excess of electrons.
- **2.NPN Transistor:** A thin layer of P-type material is sandwiched between two layers of N-type material, to get a N-P-N Junction transistor.
- The two end regions of the N-P-N transistor contain an excess of electrons, while the central region contains an excess of holes.
- **PRINCIPLE-OPERATION (OR) WORKING OF P-N-P TRANSISTOR):**
- The **+ve** terminal of a voltage source (V_{EB}) is connected with Emitter (P-type) and the **-ve** terminal is connected with the Base terminal (N-type). Therefore the E-B junction is connected in forward bias.
- Now, the **+ve** terminal of voltage source (V_{BC}) is connected with base terminal (N-type) and the **-ve** terminal is connected with the collector terminal (P-type).Therefore the C-B junction is connected in reverse bias as shown below.



- Due to this type of bias the depletion region at E-B Junction is narrow, while C-B is wide.
- When the voltage (V_{EB}) is applied as shown in the figure, the holes are repelled from the +ve terminal and injected into the base region from the emitter region.
- As the base is lightly doped with N-type impurity and very thin, the number of electrons in the base region are very low. Hence, probably 5% of holes combined with these electrons to constitute a base current (I_B).
- The remaining holes (more than 95%) cross over into the collector region, constituting a collector current (I_C).
- Each hole flows out of the collector and enters into the -ve terminal of the battery, then enters into the emitter from +ve terminal of the battery. This process is repeated.
- It should be noted that the charge carriers are holes in P-N-P transistors and the collector current is less than the emitter current($I_C<I_E$) because of recombination of electrons & holes in the base region.
- This emitter current is given by Kirchhoff's junction law (KJL), $I_E=-(I_C+I_B)$ [$\therefore$ As per KJL $I_E+I_C+I_B=0$]
- Therefore, the magnitude of the Emitter current in the external circuit of the P-N-P BJT: $\mathbf{I_E=I_C+I_B}$
- **NOTE:** Base voltage is a minimum of 0.7V in reverse bias to conduct the transistor and if the Base voltage is zero or less than 0.7V, the current cannot flow and it acts as an open circuit.
- For Si: v= 0.7V & Ge: v= 0.3V

❖ PRINCIPLE-OPERATION WORKING OF N-P-N TRANSISTOR:

- The **-ve** terminal of a voltage source (V_{BE}) is connected to the Emitter (N-type) and the **+ve** terminal of V_{BE} is connected with the Base terminal (P-type). Therefore B-E Junction is connected in Forward Bias (FB).
- Now, the **+ve** terminal of a voltage source (V_{CB}) is connected with collector terminal (N-type) and **-ve** terminal of a V_{CB} is connected with Base terminal (P-type). Hence the CB junction is Reverse Bias (RB).
- Due to this type of Bias, the depletion region at E-B junction is narrow and CB junction is wide.
- When a voltage (V_{EB}) is applied as shown in the figure, electrons are repelled from the **-ve** terminal and ejected into the emitter junction shown in figure.



- As the base is lightly doped with P-type impurity and very thin, the number of holes in the base region is very low. Hence, probably 5% of electrons that combine with holes in the P-type base region, constitute a base current (I_B).
- The remaining electrons (more than 95%) cross over into the collector region, constituting a collector current (I_C).
- Each electron flowing out of the collector enters into the terminal of V_{CB} and then enters into the emitter from the **+ve** terminal of Battery. This process is repeated.
- It should be noted that charge carriers are predominantly electrons in N-P-N transistors and the collector current (I_C) is less than emitter current (I_E) because of electrons & holes occurring in the base region.

- This emitter current is given by Kirchhoff's junction law, $I_E=-(I_C+I_B)$ [$\therefore$ As per KJL $I_E+I_C+I_B=0$]
- Therefore, the magnitude of the emitter current in the external circuit of the N-P-N BJT $\mathbf{I_E=I_C+I_B}$
- **APPLICATIONS OF BJTs**
- The BJTs have many applications (OR) BJTs are used as
- (i) Amplifiers in electronic signals.
- (ii) Oscillators.
- (iii) Switches in low voltage environments in logic circuits.
- iv) Filters
- v) Components of modulators.
- vi) Clipping circuits to shape waves.
- vii) Temperature sensors.
- viii) BJTs are used to convert compute logarithms and antilogarithms.
- ix) BJT can be used for Avalanche pulse generation.
- x) Components in logic circuits.