2.1 TRANSISTORS

The transistor is the main building block ―element of electronics. It is a semiconductor device and it comes in two general types: the Bipolar Junction Transistor (BJT) and the FieldEffect Transistor (FET).

It is named as transistor which is an acronym of two terms: ‒transfer-of-resistor. It means that the internal resistance of transistor transfers from one value to another values depending on the biasing voltage applied to the transistor. Thus it is called Transfer resistor: i.e. TRANSISTOR.

A bipolar transistor (BJT) is a three terminal semiconductor device in which the operation depends on the interaction of both majority and minority carriers and hence the name bipolar. The voltage between two terminals controls the current through the third terminal. So it is called current controlled device. This is the basic principle of the BJT

It can be used as amplifier and logic switches. BJT consists of three terminals:

- Collector: C
- Base: B
- Emitter: E

➢ TYPES

There are two types of bipolar transistors

- NPN transistor
- PNP transistor.

TRANSISTOR CONSTRUCTION

PNP Transistor: In PNP transistor a thin layer of N-type silicon is sandwiched between two layers of P-type silicon. NPN Transistor: In NPN transistor a thin layer of P-type silicon is sandwiched between two layers of N-type silicon. The two types of BJT are represented in figure2.1.1

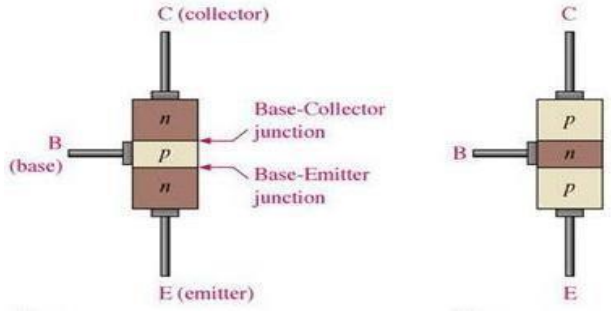

Figure 2.1.1 Transistors: NPN, PNP

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 210]

The symbolic representation of the two types of the BJT is shown in figure 2.1.2

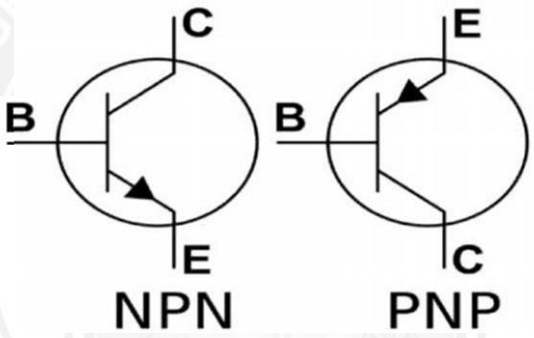

Figure 2.1.2 circuit symbol: NPN transistor, PNP transistor

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 210]

Junctions:

- There are two junctions in this transistor – junction J-1 and junction J-2
- The junction between or C-B junction. Collector layer and base layer is called as collector-base junction
- The junction between base layer and emitter layer is called as base-emitter junction or B-E junction. The two junctions have almost same potential barrier voltage of 0.6V to 0.7V, just like in a diode.

Equivalent diode representation:

The transistor formed by back to back connection of two diodes

The states of the two p n junctions can be altered by the external circuitry connected to the transistor. This is called biasing the transistor. Usually the emitter- base junction is forward biased and collector –base junction is reverse biased. Due to

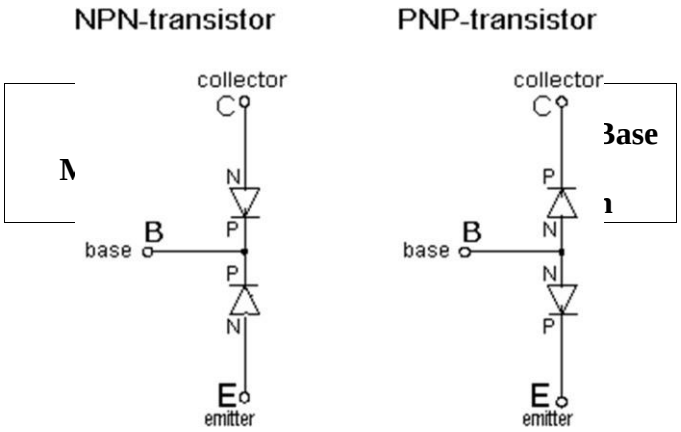

Figure: 2.1.3 NPN-PNP Transistor

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 211]

Forward bias on the emitter- base junction an emitter current flows through the base into the collector. Though, the collector –base junction is reverse biased, almost the entire emitter current flows through the collector circuit.

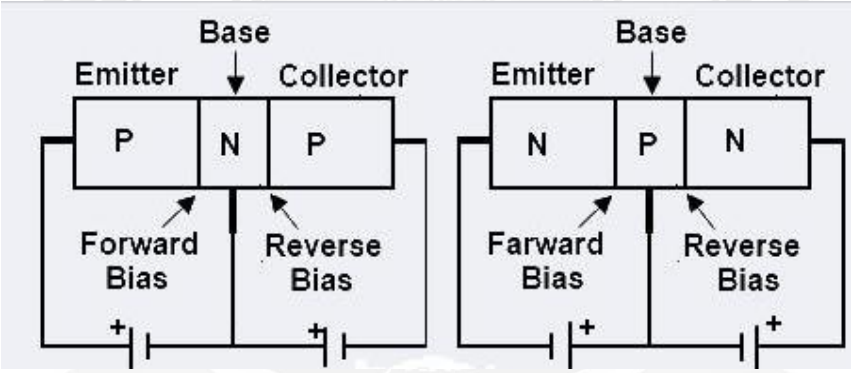

Figure 2.1.4 Transistor biasing: PNP transistor, NPN transistor

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 211]

A single p n junction has two different types of bias:

- Forward bias
- Reverse bias

There are two junctions in bipolar junction transistor. Each junction can be forward or reversebiased independently. Thus there are four modes of operations:

Cutoff	Reverse	Reverse
Active	Forward	Reverse
Saturation	Forward	Forward
Reverse active	Reverse	Forward

Table 2.1 Modes of operation of transistor

Forward Active

In this mode of operation, emitter-base junction is forward biased and collector base junction is reverse biased. Transistor behaves as a source. With controlled source characteristics the BJT can be used as an amplifier and in analog circuits.

Cut off

When both junctions are reverse biased it is called cut off mode. In this situation there is nearlyzero current and transistor behaves as an open switch.

Saturation

In saturation mode both junctions are forward biased large collector current flows with a small voltage across collector base junction. Transistor behaves as a closed switch.

Reverse Active

It is opposite to forward active mode because in this emitter base junction is reverse biased and collector base junction is forward biased. It is called inverted mode. It is no suitable for amplification. However the reverse active mode has application in digital circuits and certainanalog switching circuits.

TRANSISTOR CURRENTS

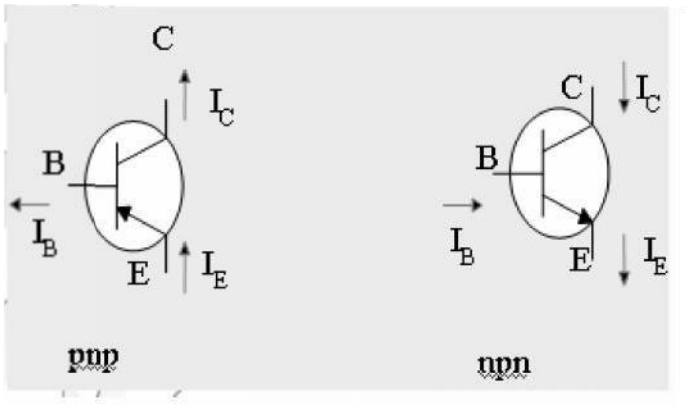

Figure 2.1.5 Transistor current flow directions

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 215]

- The arrow is always drawn on the emitter The arrow always point toward the n-type
- The arrow indicates the direction of the emitter current:
  - PNP: E-> B
  - NPN: B-> E

I_C = the collector current, I_B = the base current, I_E = the emitter current

OPERATION OF AN NPN TRANSISTOR

Emitter base junction is forward biased and collector base junction is reverse biased. Due to emitter base junction is forward biased lot of electrons from emitter entering the base region.

Base is lightly doped with P-type impurity. So the number of holes in the base region is very small.

Due to this, electron- hole recombination is less (i.e,) few electrons (<5%) combine with holesto constitute base current (I_B)

The remaining electrons (>95%) crossover into collector region, to constitute collector current(I_C).

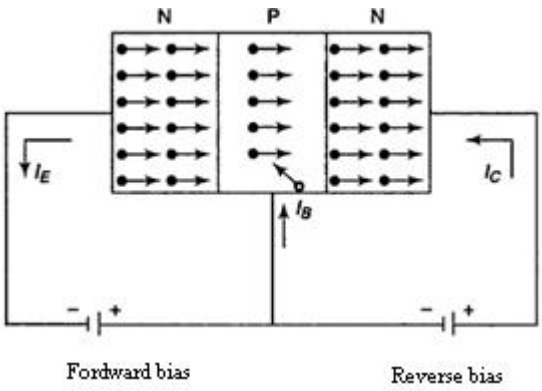

Figure: 2.1.6 Current in NPN transistor

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 216]

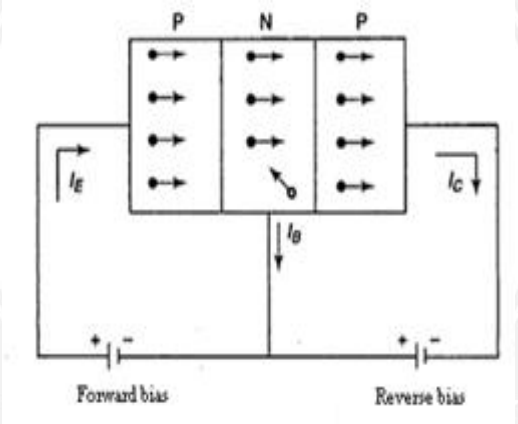

Figure: 2.1.7 Current in PNPtransistor

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 216]

Emitter base junction is forward biased and collector base junction is reverse biased. Due to emitter base junction is forward biased lot of holes from emitter entering the base region and electrons from base to emitter region.

Base is lightly doped with N-type impurity. So the number of electrons in the base regionis very small.

Due to this, electron- hole recombination is less (i.e,) few holes (<5%) combine with electronsto constitute base current (IB)