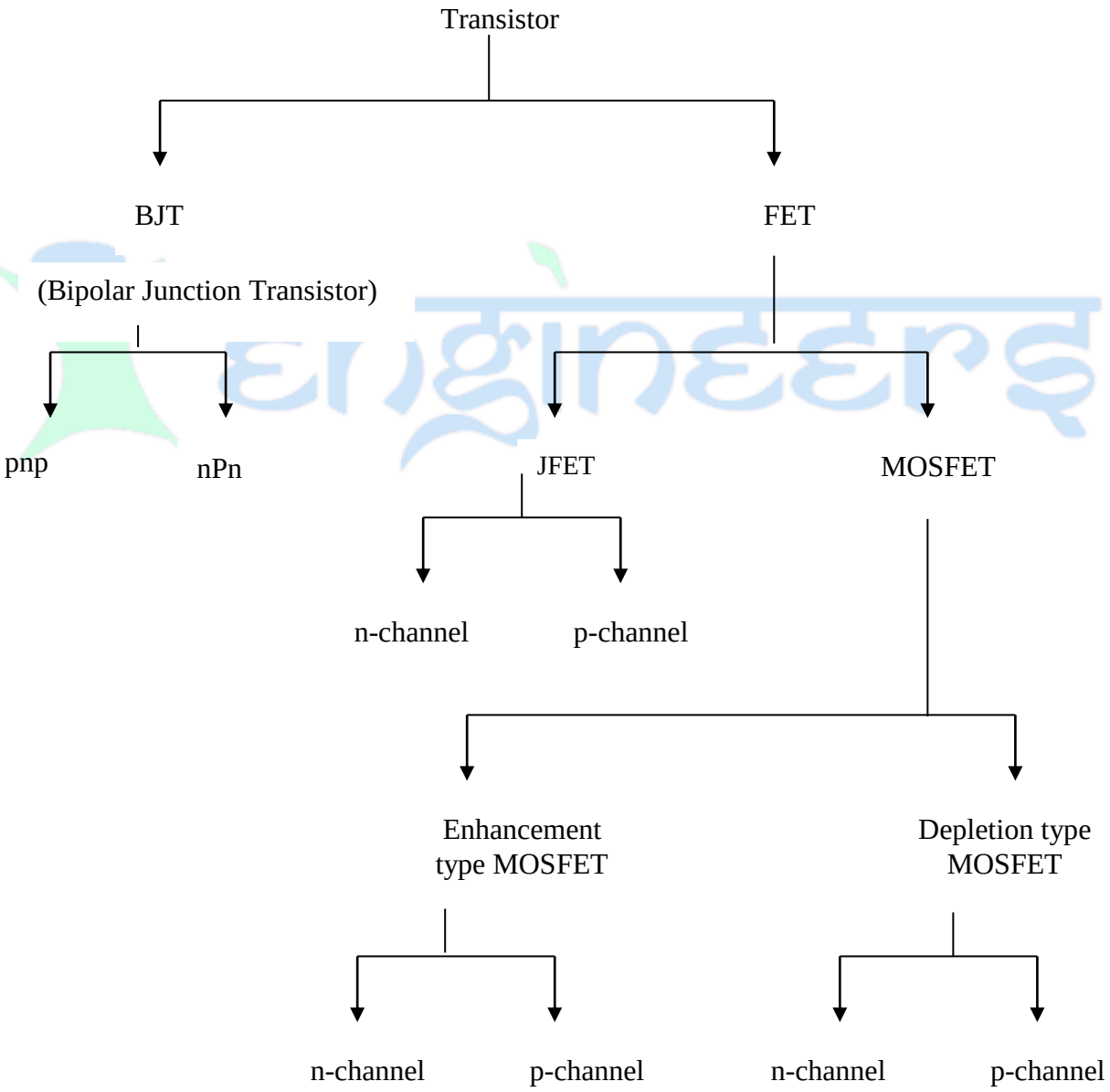
Transistor

Introduction

Transistor is a device which transfers applied signal from one type of resister to other type, for example signal can be transferred from low resistor to high or from high resistor to low resistor. By combination of two words **transfer** and **resister** it is called "**Transistor**" (**Transfer +resistor**)

Classification of Transistor:

Transistor can be classified in following manner.



BJT (Bipolar Junction Transistor)

In this chapter we will study Bipolar Junction Transistor (BJT). The BJT has three portions inside it, namely the emitter, the base and the collector, denoted by E, B and C respectively.

Emitter: Emitter is a portion of transistor through which charge carriers enter into it.

Base: Base is a portion of transistor which controls the flow of charge carriers between emitter and collector.

Collector: Collector is a portion of transistor at which charge carriers are collected.

Classification:

Transistor can be constructed of either silicon or germanium as the base material. Further, transistor are of two types i.e. p-n-p and n-p-n in p-n-p type, a thin layer of n-type is sandwiched between two layers of p type semiconductor. In n-p-n type a thin layer of p-type is sandwiched between two layers of n-type semiconductor.

It means in p-n-p transistor n-type base is sandwiched between p-type emitter and collector. Similarly in n-p-n type emitter and collector is n-type and p-type base in sandwiched between them.

Working Concept of Transistor:

Let us begin our discussion of BJT by considering the reverse biased p-n junction diode (as in figure-1). As we know in reverse bias condition the current through diode is due to the minority charge carriers, minority charge particles are very small in number so diode shows very small current but independent of applied reverse bias voltage.

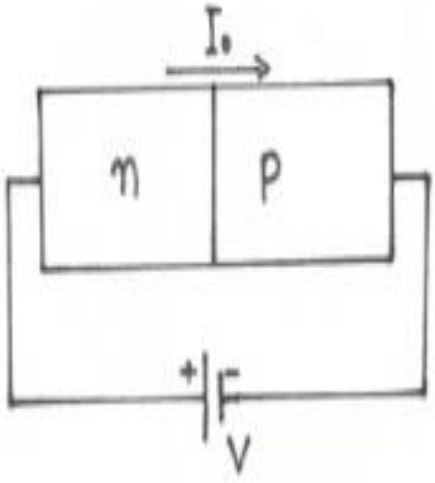


Figure-1

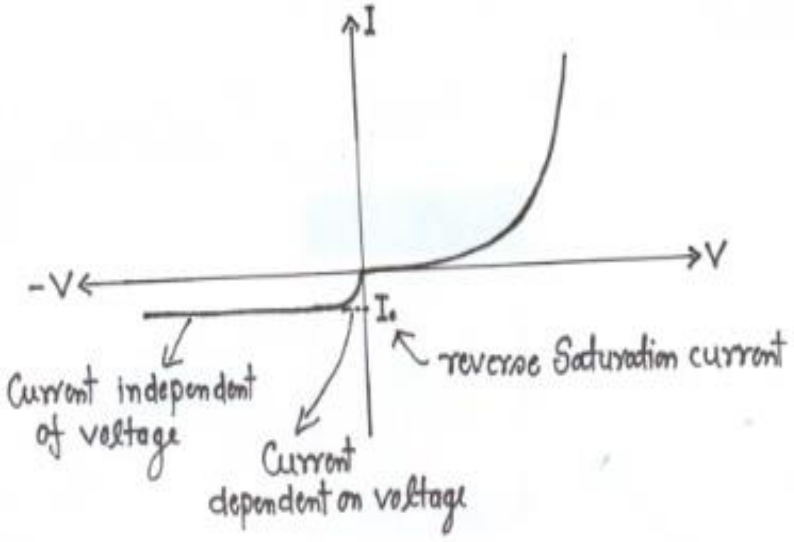


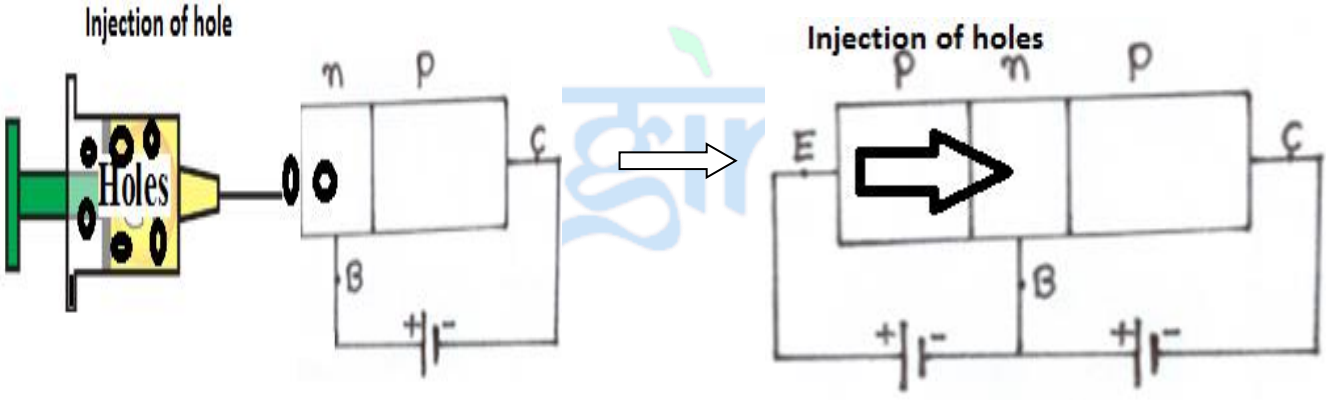
Figure-2

From diode characteristics we can see that initially current increases on increasing reverse bias voltage at p-n junction but after some particular voltage current becomes constant and independent of applied reverse

bias voltage (see figure-2).As a result it is possible to increase reverse saturation current only by increasing minority charge carriers near the reverse biased p-n junction.

Minority charge particles can be increased by increasing temperature or by applying optical energy. But practically it is not realizable all the time. To increase reverse saturation current we can imagine about a hypothetical device which can inject holes in n-side of reverse biased p-n junction (see figure-3). If it becomes possible current from n to p through reverse biased p-n junction will be increased. Essentially this current will be independent of reverse bias voltage and will be dependent on injection rate of holes in n-side of reverse biased p-n junction.

A most convenient hole junction device is a forward biased p-n junction. If we make a forward biased p-n junction on left side of n-side of reverse biased p-n junction. Then reverse current of reverse biased p-n junction will be increased and will be totally dependent on hole injected from forward biased left side p-n junction. On making this arrangement p-n junction in figure-1 will be converted into p-n-p structure (see figure-3). Now reverse saturation current through reverse biased p-n junction will increased and it will be dependent on rate of injection of hole from forward biased left-side p-n junction (see figure-4)



Hypothetical hole injecting device **Forward p-n junction for hole injection**

Figure-3

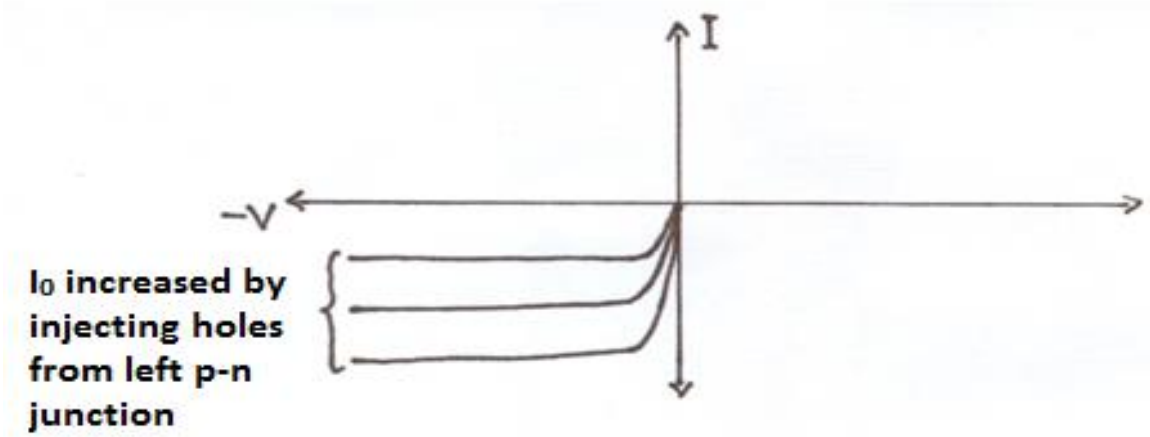


Figure-4

Injection of holes from left p-n junction to the centre n region will provide minority carrier holes to provide reverse saturation current for right n-p junction. Injected holes in centre n-region can be recombined with free electrons available there. To reduce recombination of holes in centre n-region, concentration of doping and width of centre n-region should be as small as possible.

The structure about which we have described is a p-n-p bipolar junction transistor. The forward biased left p-n junction which injects holes in centre n-region is called the **Emitter junction** and reverse biased junction (right side) which collects the injected holes is called the **Collector junction.** The left p-region which serves as the source of injected holes is called the **emitter**, and the p-region in which injected holes are collected is called the **collector**. The centre n-region is called the **base**. (See figure-5)

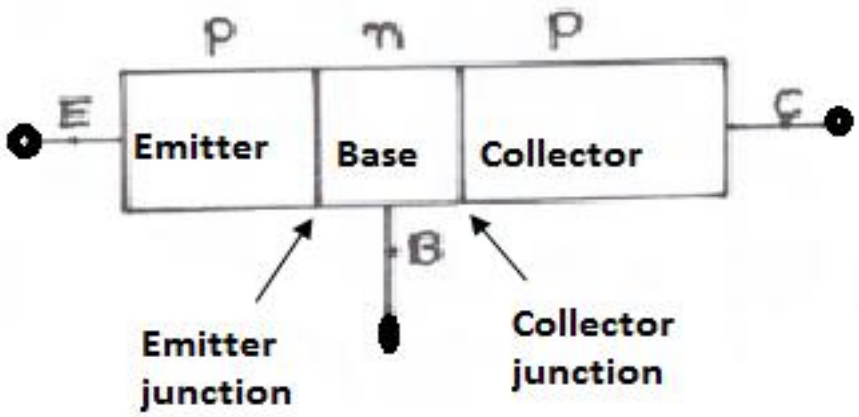


Figure-5

As a good p-n-p transistor all injected holes from emitter should reach in collector with minimum recombination in base. For minimum recombination width and concentration of doping in base should be as small as possible. Emitter serves as source of holes, so concentration of doping in Emitter should greater than collector and should be much greater than base. Collector collected all injected holes from emitter, so size of collector should be larger than emitter and should be much larger than base.

Size and concentration of doping can be sorted as follows-

Size- $S_C > S_E >>> S_B$, Concentration-$C_E > C_C >>> C_B$

Operation of Transistor

Operation of transistor is dependent on the biasing of emitter and collection junction. As we know there are two junction in the BJT and each junction can biased in two ways either forward bias or reverse bias. It means operation of BJT can be dependent on following four situations.

- Emitter junction is forward based and collector junction is reversed bias. In this situation BJT will be called in active region and BJT will be used as an amplifier.

- Emitter junction is forward base and collector junction is also forward bias. In this situation BJT will be called in saturation region and it will be used as a switch.
- Emitter junction is reverse bias and collector junction is also reversed bias in this situation BJT will be called in Cut off Region and it will be used as switch.
- Emitter junction is reversed bias and collector junction is forward bias. In this situation BJT will be called reversed active and there is no use of this type of biasing.