MODULE 3

BIPOLAR JUNCTION TRANSISTOR (BJT)

Transistor is a 3 terminal device. Three terminals are Base, Emitter and collector. It can be used for voltage as well as current amplication.

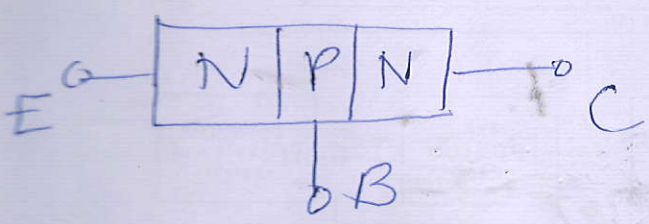
The input signal of small amplitude is applied at Base (B) to get magnified output signal at the collector (C). Thus it provides an amplification of the signal.

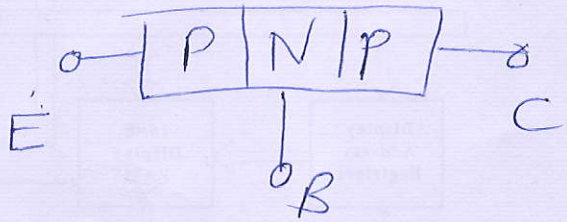
The amplification is adhieved by passing input current signal from a regim of low resistance to a region of high resistance. Hence the name TRANSfer-resISTOR (TRANSISTOR)

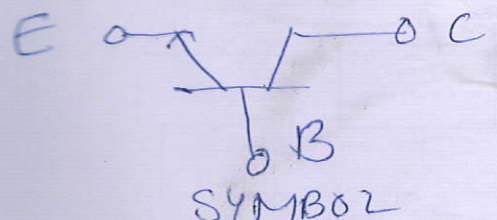
On BJT, the conduction is due to both types of carriers.

There are 2 types of BJT.

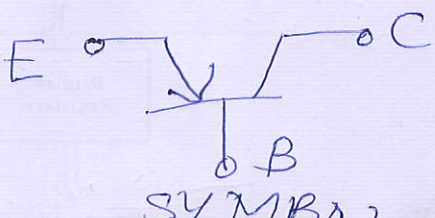
(1) N-P-N (2) P-N-P







SYMBOL



SYMBOL

(2 p-n junctions are there in BJT)

2 P-N junctions are
(1) Emitter - Base junction - J_E
(2) Collector - Base junction - J_C

Why it is not possible to construct BJT using 2 back to back diodes?

(1) Relative doping levels of B, E and C must be satisfied to work that device as a transistor. Two normal p-n junction diodes cannot satisfy this requirement.

(2) For a transistor E-B junction is forward biased while B-C junction is reverse biased But due to diffusion process almost entire I_E reaches C and I_B is negligibly small. Thus due to diffusion, the device works as a transistor.

while in back to back connected diodes, these are 2 separate diodes, one forward biased and other reverse biased and diffusion cannot take place. Thus maximum series current which can flow is reverse saturation current of reverse biased diode.

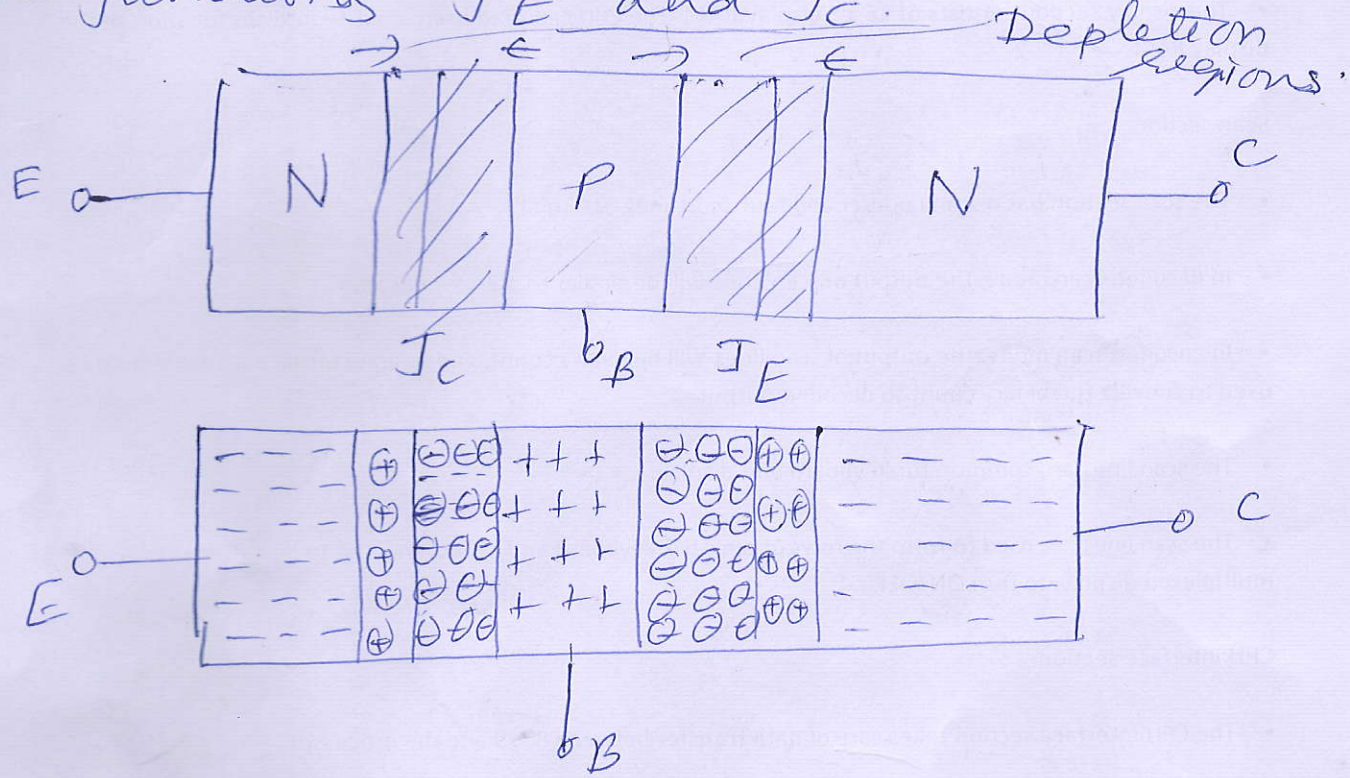
DOPING:

(i) Emitter - Highly doped
(ii) Base - Lightly doped.
(iii) Collector - Less doping than Emitter (Higher doping than Base)
but the collector region is more wide than E because it has to handle more

power than the E and more surface area is required for heat dissipation.

UNBIASED TRANSISTOR.

In this case, no external voltage or biasing is applied. There will be no current flowing from any of the transistor leads. Depletion regions are created at both the junctions J_E and J_C.



During diffusion process, depletion region penetrates more deeply into the lightly doped side in order to include an equal number of impurity atoms on each side of the junction.

Depletion region at J_E penetrates less in the heavily doped E and extends more into B region. Similarly depletion region at J_C penetrates less in the heavily doped C and extends more in the Base region. As C is slightly less doped than Emitter

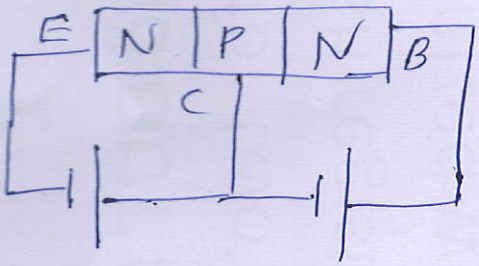
the depletion layer width at J_C is more than depletion layer width at J_E.

BIASED TRANSISTOR

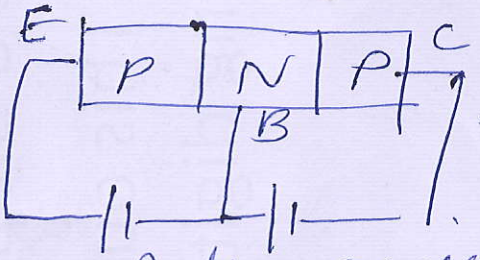
There are 3 combinations of biasing

	REGION	J_E	J_C
(1)	Active	Foward biased	Reverse biased
(2)	CUT-OFF	Reverse biased	Reverse biased
(3)	SATURATION	Foward biased	foward biased
(4)	INVERTED	Reverse biased	fowrad biased

Depending upon the external bias voltage polarities, the transistor works in one of the 3 regions.



(1) Active region



(1) Active region

Draw diagrams for cut off and saturation regions for NPN and PNP transistors.

OPERATION OF N-P-N TRANSISTOR (ACTIVE REGION) J_E Fowrad biased and J_C reverse biased.

The foreward biased E-B junction causes the electrons in N type E to flow towards the B. This constitutes I_E.

As these electrons flow through the

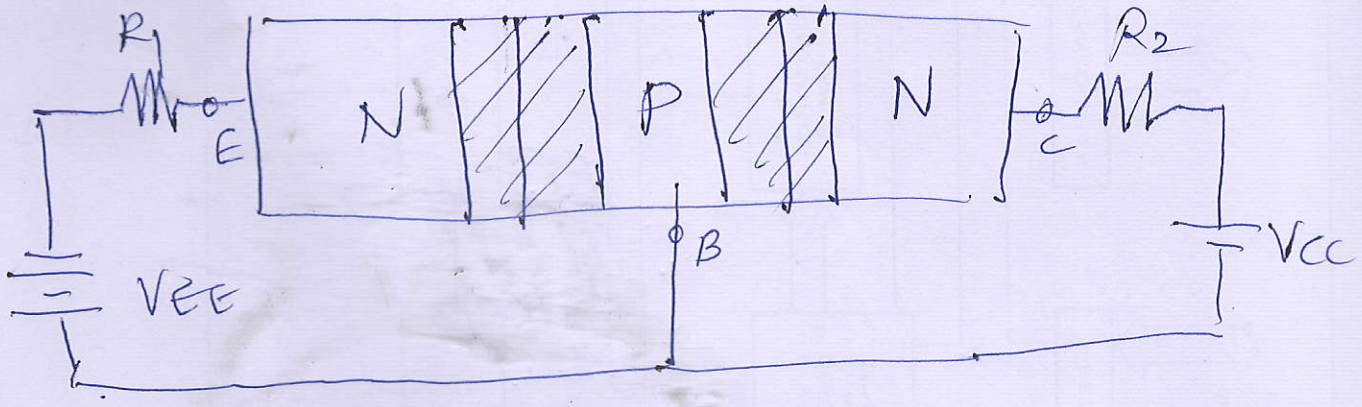
P type B, they tend to combine with holes in the P region (B).

The B region is very thin & lightly doped. Light doping means

(i) Free electrons have a long lifetime in the B region.

(ii) Very thin base region means the free electrons have only short distance to go to reach the C,

For these 2 reasons, very few of the electrons injected from E into B recombine with holes to constitute I_B. & the remaining large number of electrons cross the B region and move through the C region to the +ve terminal of external d.c. source: This constitutes I_C.



OPERATION OF P-N-P TRANSISTOR

Draw diagram and write description Replaces holes for electrons & electrons for holes in the description

Transistor current components

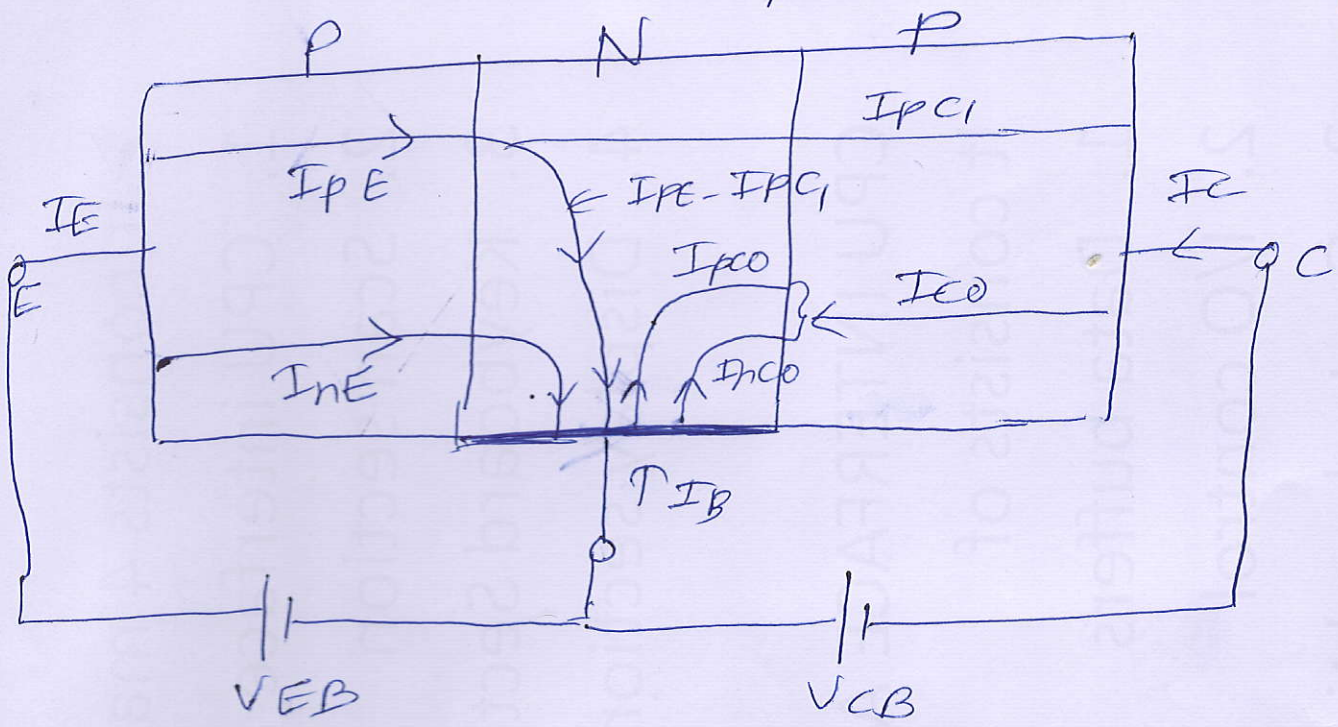


Figure shows the PNP transistor with Foewaed biased emitter junction and the reverse biased collector junction.

I_E consists of hole current I_{pE} (holes crossing from E to B) and electron current I_{nE} (electrons crossing from B into the E

The ratio of I_{pE} / I_{nE} crossing the J_E is proportional to the ratio of the conductivity of the p material to that of n material. Doping of E is made much larger than the doping of the base. Thus I_E consists almost entirely of holes.

A few of holes crossing J_E combine with electrons in N type Base and rest of them cross J_C. This reduces the number of holes ~~so lost through recombination so lost~~ which ultimately reach the collector. To reduce the number of

lost through recombination with electrons in N region, the width of the B region is kept extremely small.

$$I_B = I_{PE} - I_{PC}.$$

If the E was open circuited then $I_E = 0$ i.e. I_{PC} would be zero. Under this condition the B and C together act as a reverse biased diode and I_C equals the reverse saturation current I_{CO}

$$I_{CO} = I_{nCO} + I_{pCO}$$

I_{nCO} = caused by electrons moving across JC from P region to N region.

I_{pCO} = caused by holes moving across JC from N region to P region.

$$\therefore \quad I_C = I_{PC} + I_{pCO}$$

(Majority, minority)

For a PNP transistor

$$I_E = I_B + I_C$$

BJT CIRCUIT CONFIGURATIONS

Following are the 3 configurations

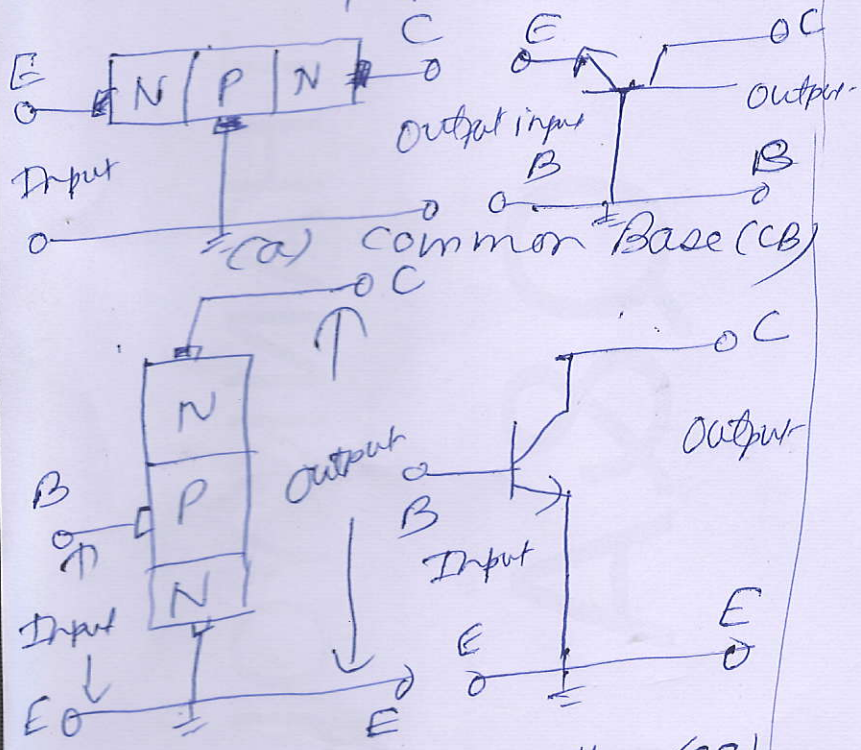
(i) common base (CB (ii) Common-emitter (CE)

(iii) Common collector (CC)

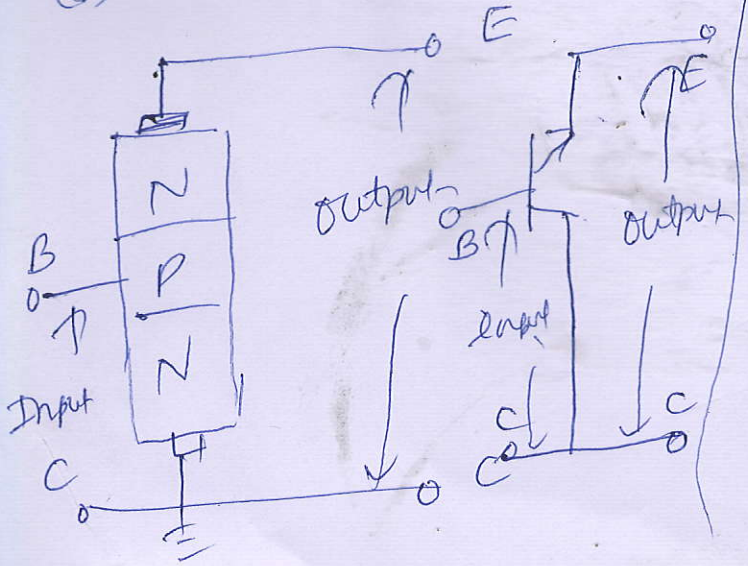
The term 'common' is used to denote the transistor lead which is common to the input and output circuits

This is because when a transistor is connected in a circuit, 4 terminals are required (two for input and two for output) while a transistor has only 3 terminals. This difficulty is removed by making one terminal of the transistor common to both input and output terminals. The common terminal is generally grounded.

NPN PNP



(b) Common Emitter (CE)



Draw diagrams for PNP transistors.