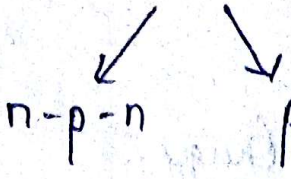
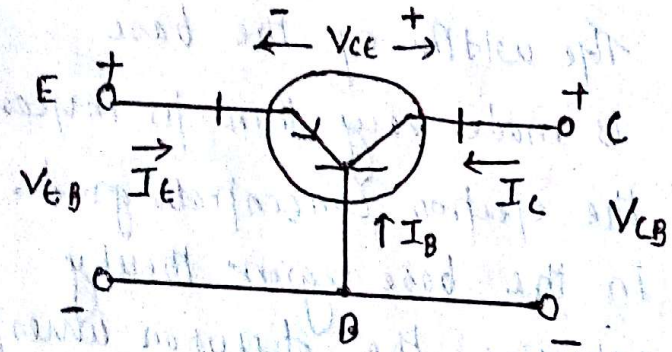
14/9/16
J.

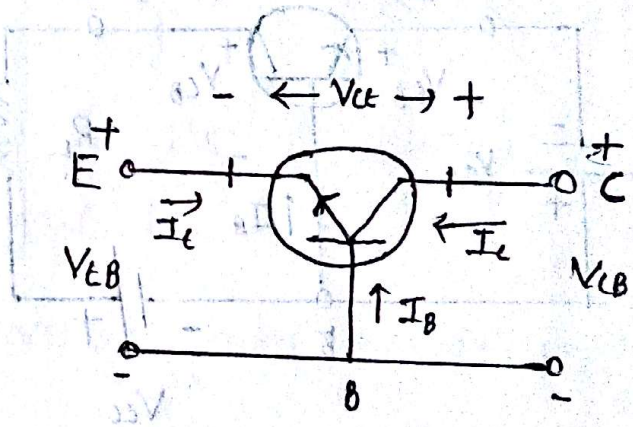
Transistor



Since both the majority and the minority carriers are involved in junction transistors these devices are named bipolar junction transistor (BJT), bipolar transistors or bipolar devices.



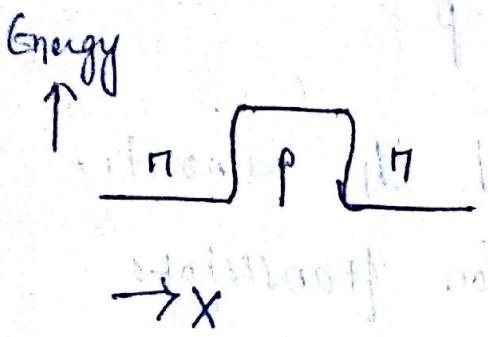
p-n-p

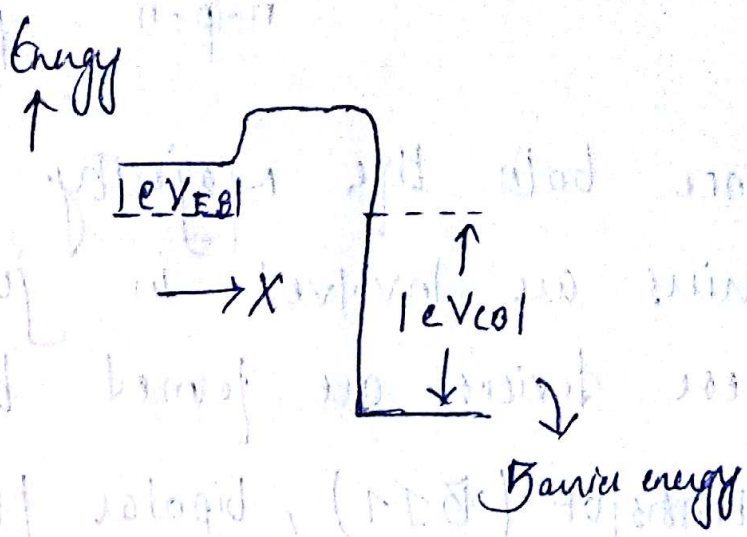


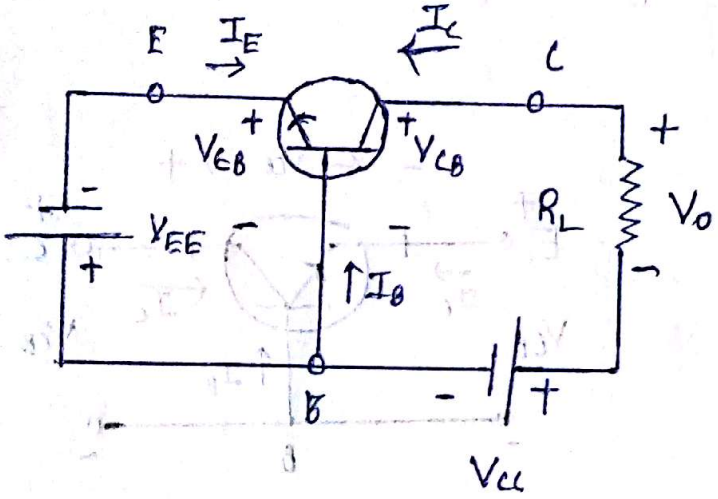
n-p-n

Signs	I_E	I_B	I_C	V_{EB}	V_{CB}	V_{CE}
p-n-p	+	−	−	+	−	−
n-p-n	−	+	+	−	+	+

Mechanism of Transistor Action







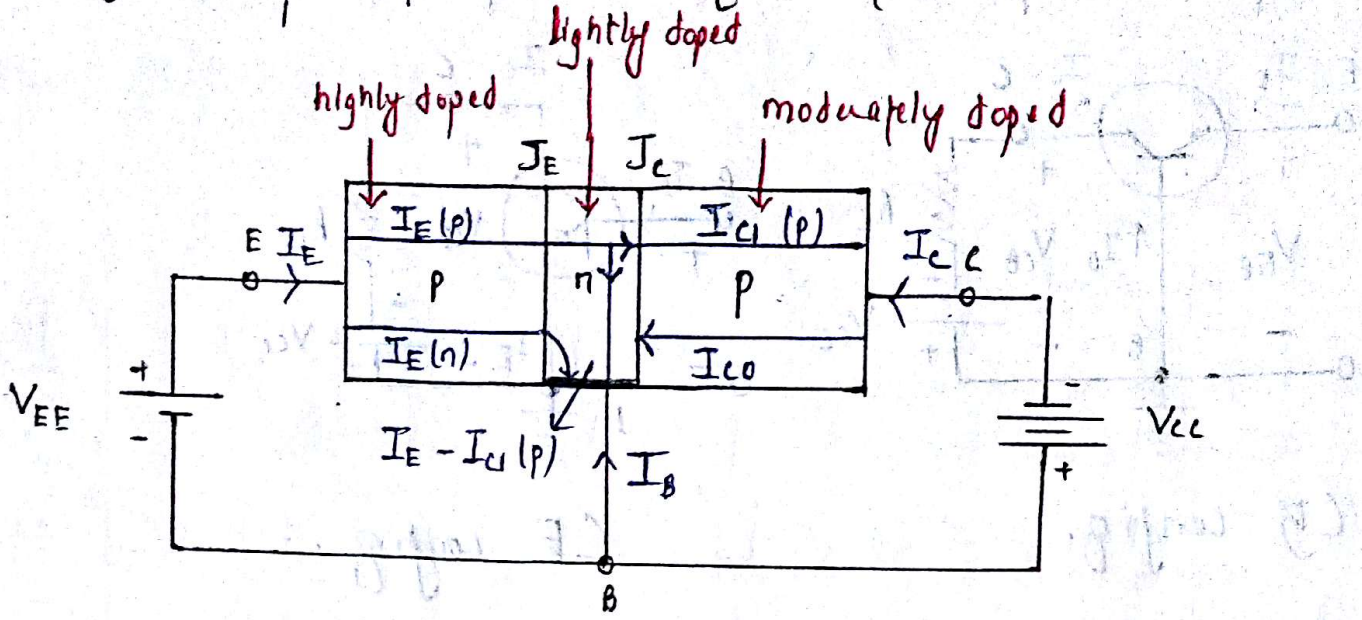
The width of the base is made very thin to increase the electron concentration grad. in the base region thereby enhancing the diffusion current and also to diminish the no. of el lost by recombination in the base.

Q15) Two p-n diodes having metal leads and connected back to back will not make a transistor, why?

Ans i) thin base → carriers must diffuse

ii) contact potentials at the metal semiconductor junctions will not give the desired energy diagram.

Current components in a transistor



$$I_E = I_E(p) + I_E(n) \qquad I_E(p) >> I_E(n)$$

Now we have $I_{CO}(n)$ consisting of the e^- moving from the p-side to n side across J_C.

$I_{CO}(p)$ due to the holes travelling from the n-side to the p-side across J_C.

$$\therefore -I_{CO} = I_{CO}(n) + I_{CO}(p)$$

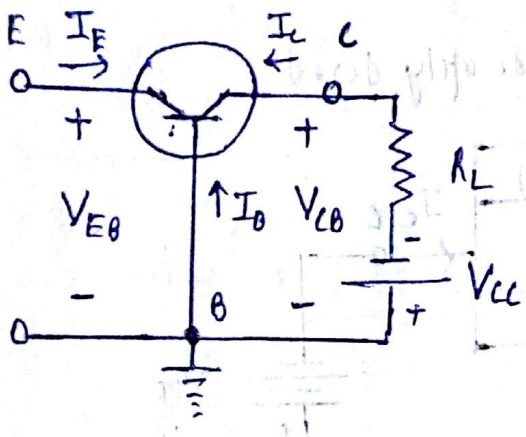
$$\therefore I_C = I_{CO} - I_{C1}(p) = +ve$$

I_C ↓ mA, I_{CO} ↓ μA

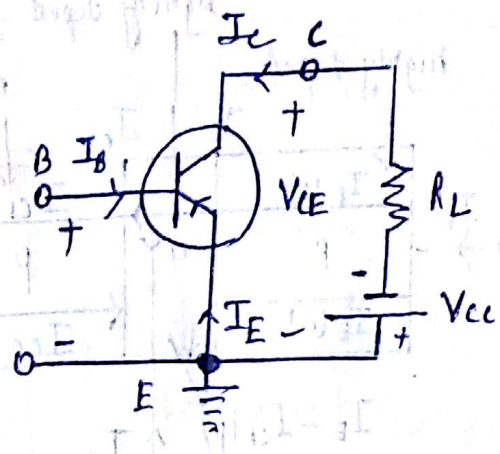
$$\therefore I_{CO} << I_{C1}(p)$$

∴ for p-n-p transistor, I_E is +ve while both I_C and I_{CO} are negative.

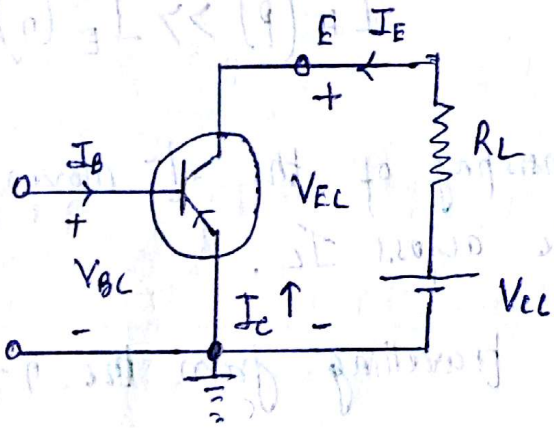
Modes of Transistor Operation



CB config.



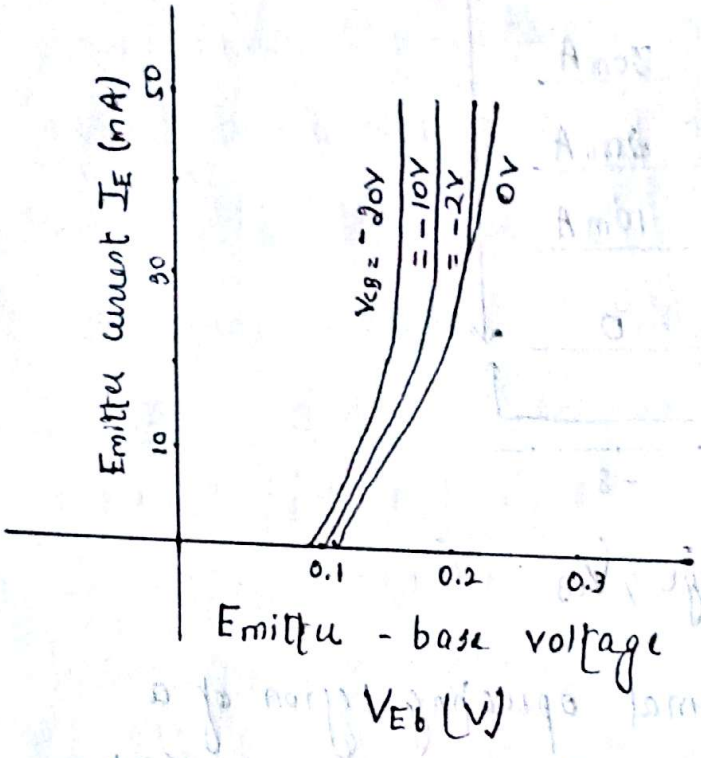
CE config.



CC config.

Common Base Characteristics

Input characteristics

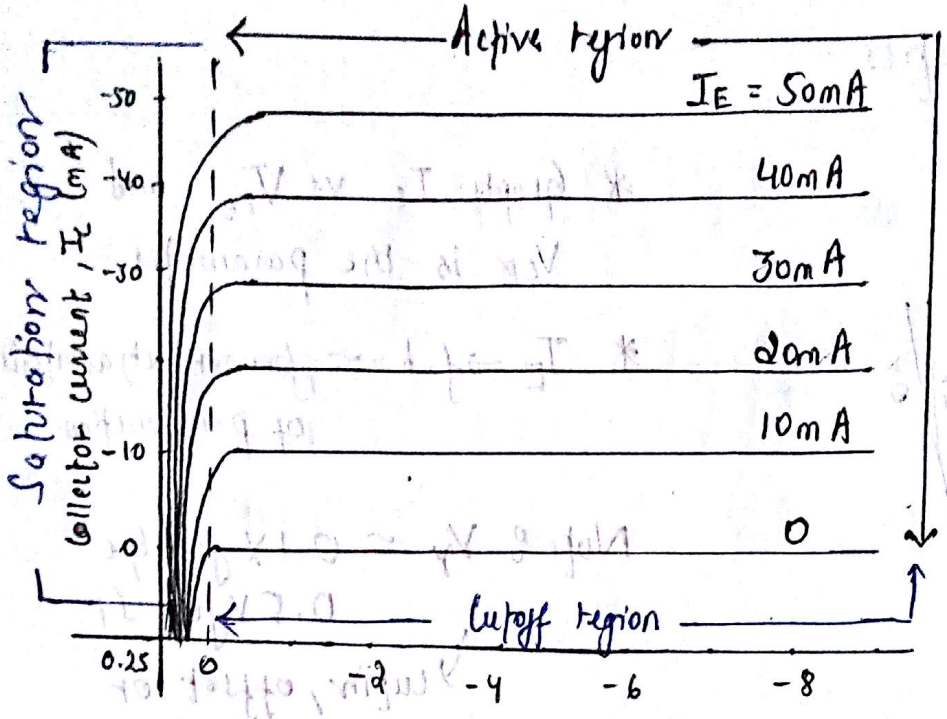


* Graph I_E vs V_{EB} and V_{CB} is the parameter
* $I_E \rightarrow$ f.b $\approx$ forward characteristic of p-n junction

Note: $V_\gamma \approx 0.1V$ for Ge
$0.5V$ for Si
↳ cut-in, offset or threshold voltage
Below it I_E is very small.

However with an ↑ of $|V_{CB}|$, I_E ↑ for a fixed V_{EB}. When $|V_{CB}|$ ↑, the width of the depletion layer/region at the J_C ↑, thereby reducing the effective base width. The change of the effective base width by the collector voltage is termed as Early effect. The ↓ of the EBW enhances the conc. grad of holes in the base region. Since the hole current injected across the J_E is $\propto$ to the hole conc grad at the junction I_E ↑ with increasing reverse collector voltage.

Output characteristics



Active region: It is the normal operating region of a transistor used as an amplifier. In this region I_E is forward biased and I_C is reversed biased.

When $I_E = 0$, $I_C = I_{CO}$ (uA for ge & nA for si)

When I_E is f.b I_E flows. $I_C \approx I_{CO}$ and $I_E > I_C$

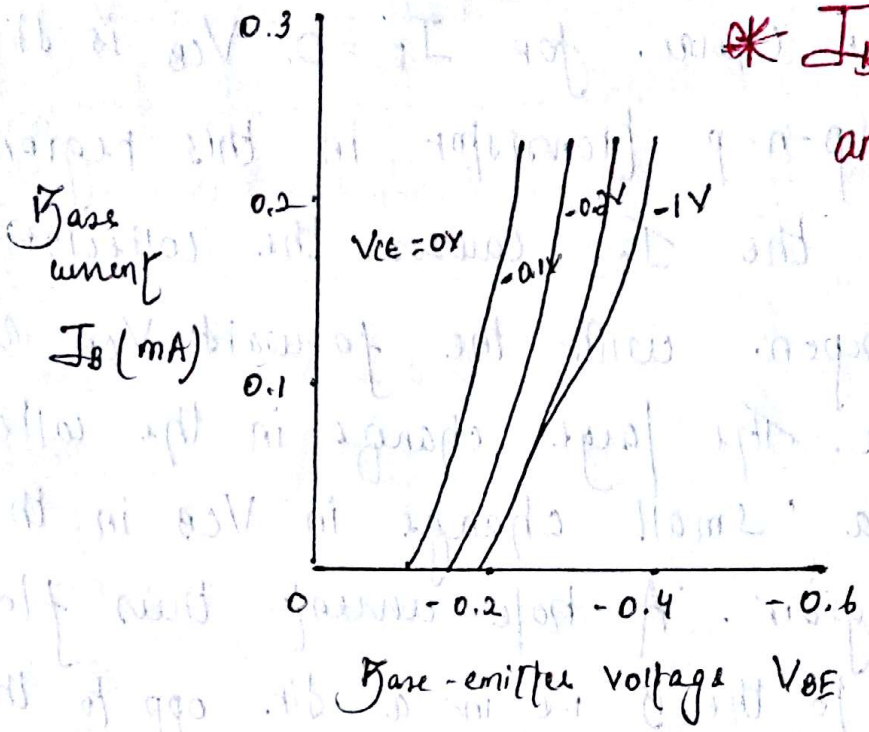
I_C is practically independent of V_{CB} and determined only by I_E. Owing to the Early eff $|I_C|$ rises slightly with an increase of $|V_{CB}|$. In the active region the output charac. are nearly // lines which are equispaced for equal changes in the I_E.

Saturation region: The region of the output char. where both the J_E and J_C are forward biased. It is located to the left of the ordinate $V_{CB} = 0$ and above the char. for $I_E = 0$. V_{CB} is slightly +ve for a p-n-p transistor in this region. This f.b of the J_C causes the collector current to change expon. with the forward V_{CB} as in a p-n diode. The large change in the collector current for a small change in V_{CB} in the saturation region. A hole current thus flows from the C to the B i.e in a dir. opp to the original hole current due to a transistor action. When the f.b is sufficiently large, the hole flow from the collector to the base predominates forcing I_C to be +ve.

Cutoff region: J_E and J_C both are reversed biased.
The region is located to the right of the ordinate $V_{CB} = 0$ and below the chara. for $I_E = 0$.

Common Emitter Characteristics

a) Input characteristics.

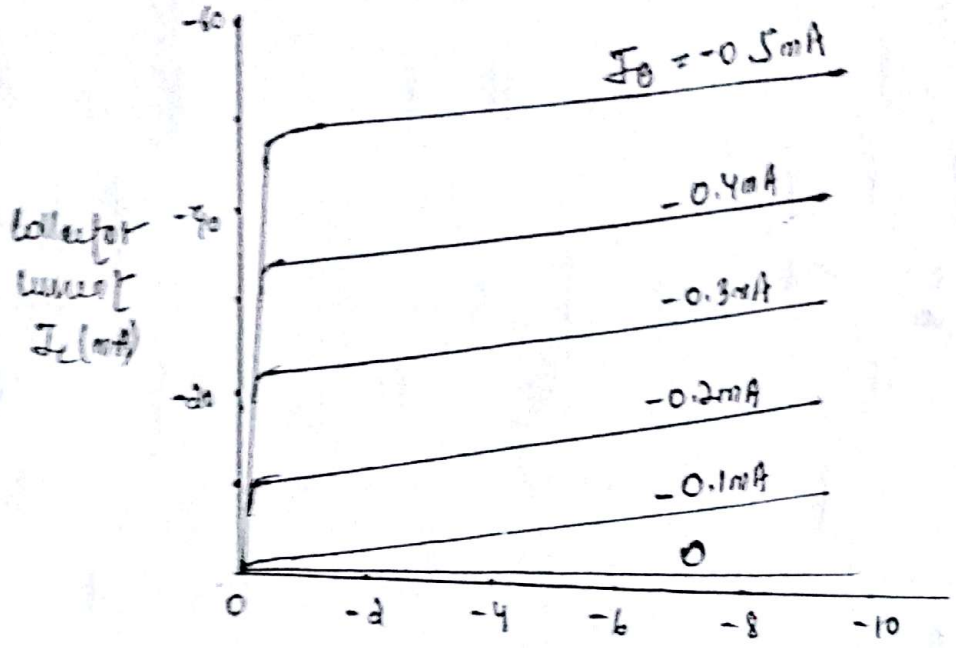


* I_B Vs V_{BE} and V_{CE} is the parameter.

CE input characteristics of a typical p-n-p transistor

For the CE mode, I_B is the input current, V_{BE} is the input vol. and V_{CE} is the output voltage. The characteristics are similar to that of a forward-biased p-n diode. With ↑ $|V_{CE}|$ for a constant V_{BE} the effective base width decreases, consequently the recombination base current diminishes as shown.

Output characteristics



CE output characteristics of a typical p-n-p transistor.

Active region: J_C is reversed biased and the J_E is forward biased.

The curves in the active region are not horizontal. For a fixed I_B, $|I_C|$ increases with $|V_{CE}|$ due to the base width modulation or the Early effect.

Cutoff region: $I_B = 0$; J_C has to be reverse-biased slightly. Ge = 0.1V, Si = 0V → reverse bias.

Saturation region: J_C, J_E are forward biased by at least cutin voltage.

I_C is nearly independent of the I_B.