29.11.2023
Thursday.

Semiconductors.

1) Ex: of direct band gap.
Indirect band gap.

At zero Kelvin finding an electron below fermi level is 1.

$\sigma = ne\mu$
↳ mobility.

2) Which has higher mobility
electron /hole

3) How will you find, which has higher mobility?

What makes semiconductor so important.

- Wide choice to alter physical properties.
- Ultra fast response time.
- Multifunctional devices, and tailoring opportunity.

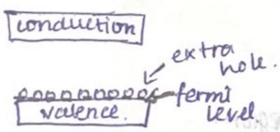
Instrinsic semiconductor.

It is pristine, pure nothing has been added no impurities. It is an equlibrium - number of electrons and number holes has to be exactly same.

N-type (extrinsic) - Pentavalent is added. such as Sb, As or P.
contributes free electrons - increases conductivity

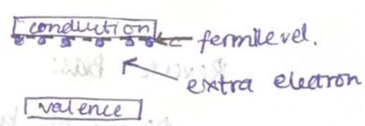
P-type (extrinsic) - Trivalent is added such as Boron, Al or Ga
creates holes - increases conductivity.

Trivalent - P-type

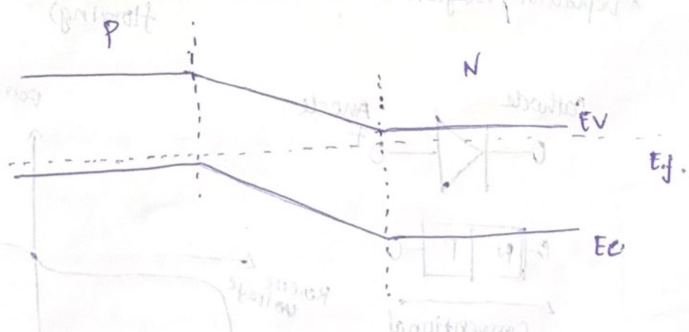


electron - minority carrier

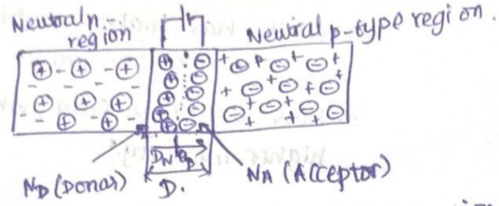
Pentavalent - n-type.



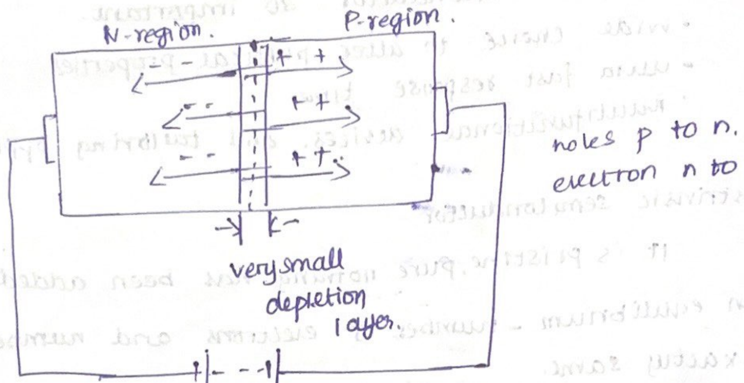
hole - minority carrier.



A pn junction is formed when p type material is ... material creating a semiconductor diode.



P-N junction.



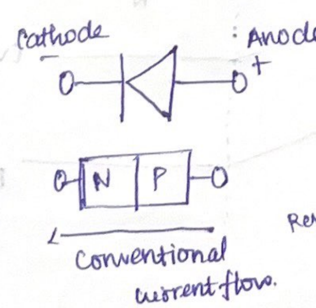
Forward Biasing voltages. [positive of the battery is connected to p-type. Negative of the battery - n-type]

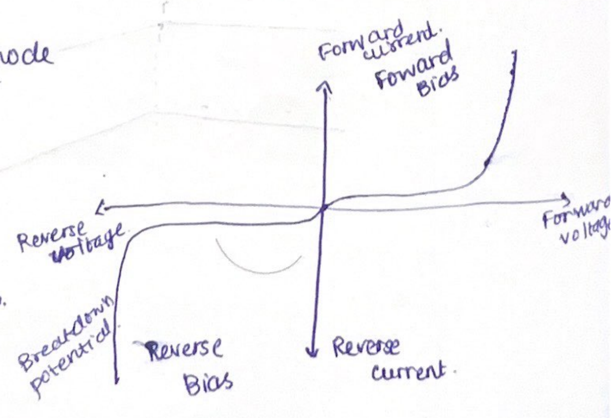
Band diagram.

↳ *potential is reduced.
*depleation is reduced.

Reverse Bias:

positive of battery to negative region.
negative of batter to positive region.
*·Depleation reagion is thick/broad (so no current will be flowing)





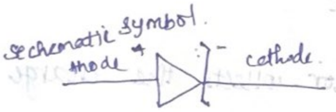
diode:

A diode is a specialized electronic component with two electrode called the anode and the cathode.

Most diodes are made with semiconducting materials such as silicon, germanium or selenium.

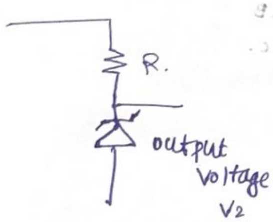
Zener breakdown mechanism

Normal breakdown mechanism.



Backwards current flow too, but only past the 'zener' breakdown voltage'.

- The arrowhead on zener diode points in the direction current when the diode is forward biased.
- The zener diode is normally operated in reverse breakdown and the current direction ——



$$I = \frac{V_2 - V_1}{R}.$$

- Forward bias:

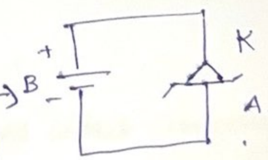
It acts as a normal diode.

P side to '+' ve, N side to negative.

- Reverse bias:

RB current = 0 and at certain voltage which called zener voltage the current increases sharply.

-> Each Zener diode has breakdown rating which specifies the maximum voltage that can be dropped across it.

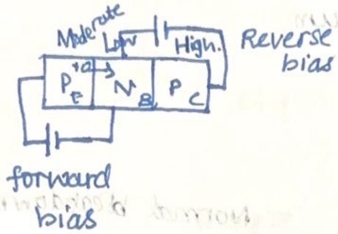


Reverse bias

•In reverse bias, minority increases, resist

Half wave and full wave rectifier and derivation of its efficiency.

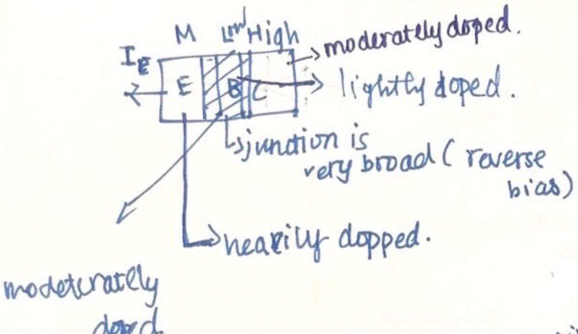
Bipolar Junction Transfer.



E - Emittor - shoots the charge through base

B - Base

C - Collector - collects the charge from base.



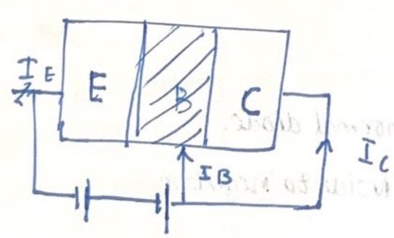
NPN transistions - e^- combines with holes and move towards collector (in emittor.)

PNP transistions - hole. I direction. - moves towards collector after combineing with few electrons in base. (in emittor)

common B - $\Delta I_C / \Delta I_E$

common E - $\Delta I_C / \Delta I_B$

common C - $\Delta I_E / \Delta I_C$.



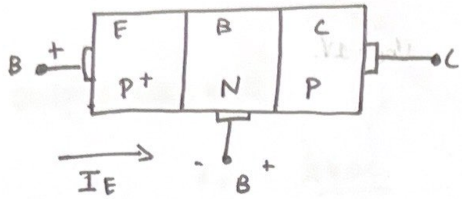
$I_E = I_B + I_C$.

Relactance < 5%

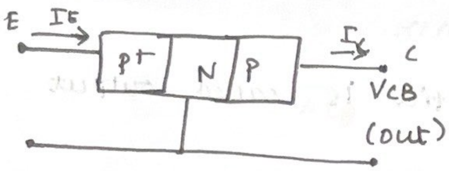
$I_C > 95\%$.

$V_{CE} = V_{EB} + V_{BC}$. → doubt.

Bipolar Junction Transistor : Basics.



BJT configurations:



pnp - hole moving towards base

npn - electron moving away from base.

common base

~~npn → cut~~

Transistor operating Modes

• Active Mode

→ Base - Emitter junction is forward and Base collector junction is reverse biased

• Saturation Mode

→ Base - Emitter junction is forward and Base collector junction is forward biased.

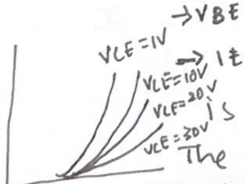
• Cut-off Mode :

→ Both junctions are reversed biased.

Common Base connections

The common-base terminology is derived from the fact that the base is common to both the input and output sides of the configuration.

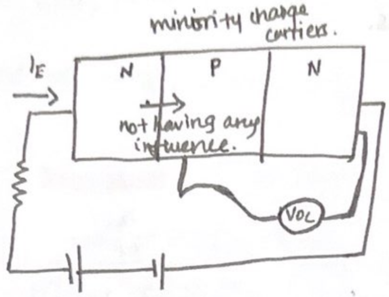
Input characteristics:



→ V_{BE} vs I_E characteristics is called input characteristics

→ It increases rapidly wit V_{BE}. It means Input resistance is very small. * I_E almost independent of V_{CB}.

The input characteristics is independent of collector base voltage.



$V_{OC} = 1V.$

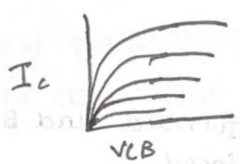
When we apply reverse bias,

Output characteristics:

→ V_{BC} vs I_C characteristics is called output characteristics.

→ I_C varies linearly with V_{BC}, only when V_{BC} is very small

→ As , V_{BC} increases, I_C becomes constant



$I_E = 1mA.$

common base npn system.

common base connection:

current amplification factor (α):

The ratio of change in collector current to the change in emitter current at constant V_{CB} is known as current amplification factor.

$$\boxed{I_E = I_C + I_B}$$

$$\boxed{I_C = \alpha I_E + I_{CBO}}$$

$$I_C = \alpha(I_C + I_B) + I_{CBO}$$

$$I_C(1-\alpha) = \alpha I_B + I_{CBO}$$

$$I_C = \frac{\alpha I_B}{1-\alpha} + \frac{I_{CBO}}{1-\alpha}.$$

input resistance

$$r_i = \frac{\Delta V_{BE}}{\Delta I_E}.$$

Output resistance

$$r_o = \frac{\Delta V_{BC}}{\Delta I_C}.$$

common Emitter Connection.

→ Base current amplification factor.

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

only <u>5%</u> of emitter current flows to base, so amplification factor is greater than 20. usually range varies from 20 to 500.

$$\boxed{\beta = \frac{\alpha}{1-\alpha}} \qquad \beta = \frac{\Delta I_C}{\Delta I_B} \qquad \alpha = \frac{\Delta I_C}{\Delta I_E}$$

$$I_E = I_B + I_C$$

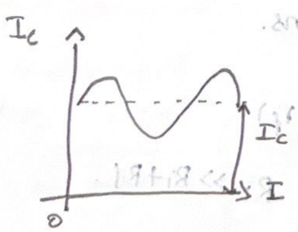
common collector configuration: (γ)

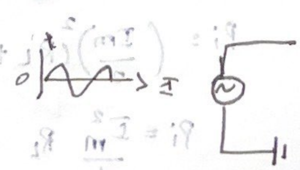
The common collector input current is base current and output current.

$$\gamma = \frac{1}{1-\alpha}.$$

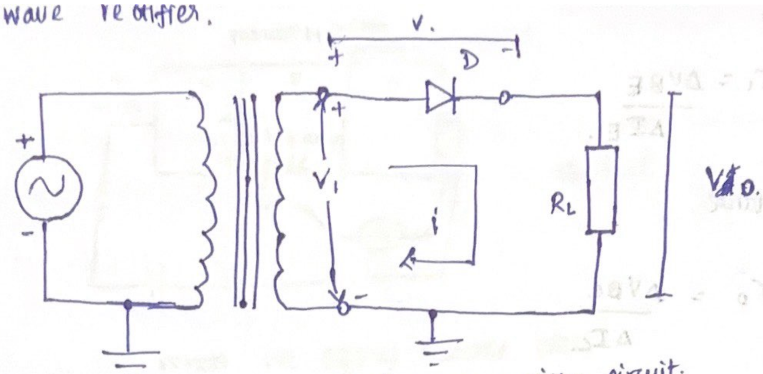
Common base used for a voltage amplification common emitter used for a current amplification.

Transistor as an amplifier in CE conf.





Half wave rectifier.

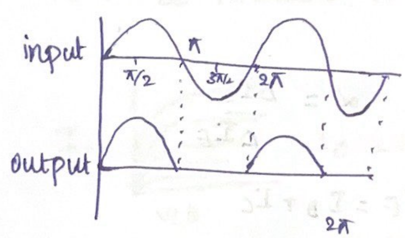


Half wave rectifier circuit.

$$\eta = \frac{P_{dc}}{P_i} \qquad P = I^2 R.$$

$$P_i = P_{AC} = I_{ac}^2 \, (R_L + r_f + R_i)$$

$$P_o = P_{dc} = I_{dc}^2 \, R_L.$$



$$I_{dc} = \frac{1}{\pi} \int_{0}^{2\pi} i \, d\alpha$$

$$I_{dc} = \frac{1}{2\pi} \int_0^{\pi} I_m \sin\alpha \, d\alpha.$$

$$I_{dc} = \frac{I_m}{\pi} = I_{avg}$$

Output current.

$$I = I_m/2.$$

$$I = \left[\frac{1}{2\pi} \int_0^{2\pi} i^2 \, d\alpha \right]^{1/2}$$

$$I = \left[\frac{1}{2\pi} \int_0^{\pi} I_m^2 \sin^2 \alpha \, d\alpha \right]^{1/2}$$

$$I_{ac} = \frac{I_m}{2} = I_{rms}.$$

$$P_i = \left(\frac{I_m}{2} \right)^2 (R_L + R_i + r_f)$$

$$P_i = \frac{I_m^2}{4} R_L \qquad R_L >> R_i + R_f.$$

$$P_0 = \frac{I_m^2}{\pi^2} R_L$$

~~$R_L >> R_f + R_f$.~~

$$\eta = \frac{4}{\pi} \times 100\%$$

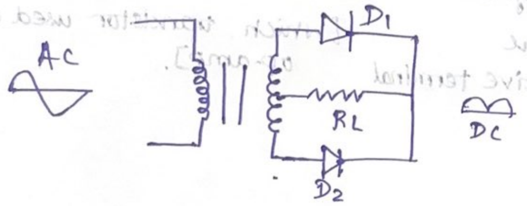
Full wave:

$$P_0 = \frac{4 I_m^2}{\pi^2} R_L$$

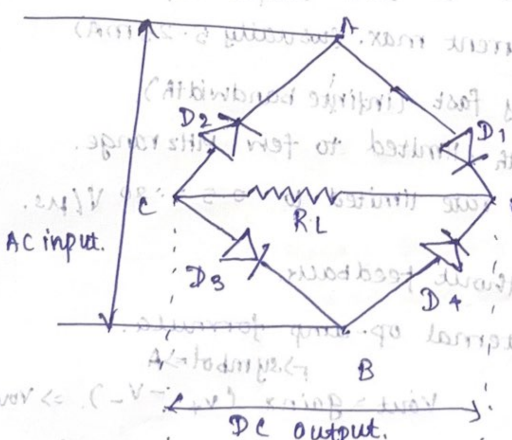
$$P_i = \frac{I_m^2}{2} R_L$$

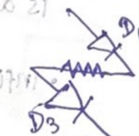
$$\eta = \frac{P_0}{P_i} = \frac{4 \cancel{I_m^2}}{\pi^2} \times \frac{2}{\cancel{I_m^2}} = \frac{8}{\pi^2} \times 100$$

$= 80\ \%.$



Bridge rectifier





First half cycle - D1 and D3 diodes are used.

Second half cycle - D2 & D4 diodes are used.