class - 02 20-10-2019

Semiconductor:-

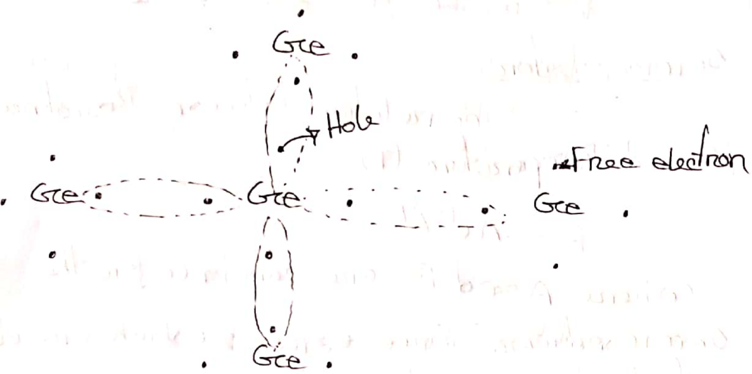
The relation between Resistance R and Temperature (T)

$$R = Ae^{B/T}$$

where A and B are constance for the semiconductor. Three elements which are classified as semiconductor. They are silicon (Si_{14}^{28}) germenium Ge_{32}^{73} and grey tin Sn_{50}^{119}.

Electrical conduction in semiconductor:-

The crystal structure of Ge or Si is two intenpenterating face-centred cubic lattice (also known as Diamond structure. Germenium will be as insulator (অপরিবাহী) at very low temperature (near 0°K) because the crystal structure will be true at very low temperature. 21



Ge represents Ge ionic core Represent valence electron.

Drift current in a Semiconductor:-

$V_h = \mu_h E$ and $V_e = -\mu_e E$ $\boxed{\mu = \frac{1}{neR}}$

here, V_h = Drift velocity of hole
E = Electric field.
V_e = Drift velocity of electron.
μ_h = hole mobility

hole current density 3

$J_h = pq\cancel{E\mu}V_h$

$J_e = -\cancel{nqE}\, nqV_e$

J_h = ~~hole mobility~~ hole current density
p = number of ~~hole~~ free hole
J_e = electron mobility
n = number of free electron

$J = J_h + J_e$
$= pqV_h - nqV_e$
$= pq\mu_h E + nq\mu_e E$
$= (p\mu_h + n\mu_e)qE$
$= \sigma E$

σ = conductivity $= (p\mu_h + n\mu_e)q$

intrinsic semiconductor:- A semiconductor which is pure and contains no impurity is known as an instric semiconductor. For instric semiconductor the number of free electron and free hole is equal.

$n_i = p_i$ and $n_i \times p_i = n_i^2 = p_i^2$

$\Rightarrow$

The conductivity σ for an intrinsic semiconductor $\sigma = n_i q(\mu_h + \mu_e)$

N and p-type semiconductor:-

$n = n_i + N_d$ | N_d = intensity of donor impurity.
n_i = density of intrinsic electrons.

usually
$N_d \gg n_i$
$\therefore n \approx N_d$

p type

$p = p_i + N_a$ | N_a = ~~in~~ density of acceptor atoms.
p_i = density of intrinsic holes.

$p \approx N_a$

Consider N-type semiconductor:
the density of mejority carries (electron).
-the density of minority carries (holes).

EDC class - 03

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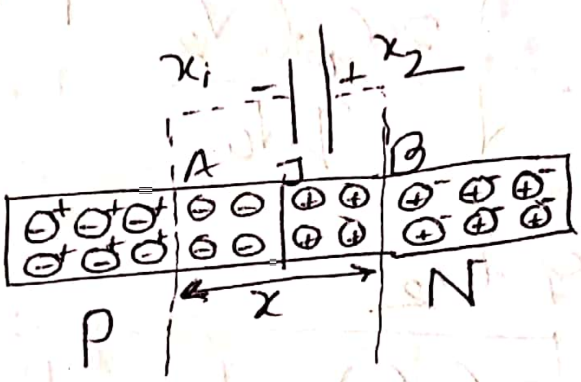
PN Junction:-



⊕ Doner atom
⊖ Acceptor atom
+ Holes
- Electron

I.P.B = Internal potential barrier

The internal potential barrier V_0 =

$$\boxed{V_0 = \frac{KT}{q} \log_e\left(\frac{N_a N_d}{n_i^2}\right)}$$

K = Boltzmen's const

T = absolute temperature

where,

N_a = number of acceptor impurity atom.

N_d = number of doner impurity atom per unit volume.

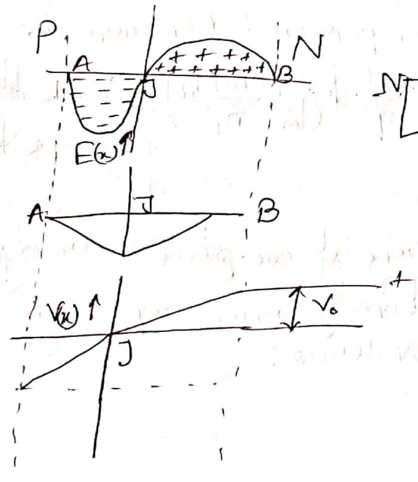
Expressions for P.N Junction:-

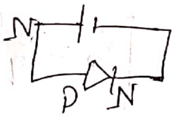
$$x_1 = \sqrt{\frac{2\epsilon_r \epsilon_0 V_1}{q N_d}}$$

ϵ_0 = permitivity of free space
ϵ_r = permitivity of relative space.

$$x_2 = \sqrt{\frac{2\epsilon_r \epsilon_0 V_2}{q N_a}}$$

$$d = x_1 + x_2$$
$$= \sqrt{\frac{2\epsilon_r \epsilon_0 V_0}{q}\left(\frac{1}{N_a} + \frac{1}{N_d}\right)} \quad [\because V_0 = V_1 + V_2]$$





V_1 and V_2 related by,

$$\boxed{\frac{V_1}{V_2} = \frac{N_a}{N_d}}$$

$$\boxed{E_0 = \frac{2V_0}{d}}$$

Forward biased PN Junction:-

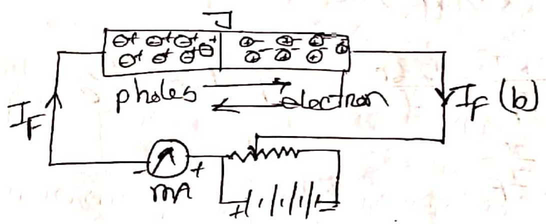


Fig: Forward biase.

when the positive terminal of a battery is connected to the p-region and the negative re terminal connected to the N-region is cal the PN Junction at forward biased.

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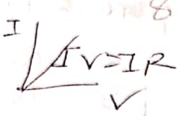
current voltage equation:-

$$I = I_0\left(e^{qV/nKT} - 1\right)$$



$$I_F = I_0\, e^{qV/nKT}$$

$$\frac{dI_F}{dV} = I_0 \frac{q}{nKT} e^{qV/nKT} = \frac{q}{nKT} I_F$$

$$I_R = I_0\left(\frac{1}{e^{qV/nKT} - 1}\right)$$

$$R = \frac{nKT}{qI_F} = \frac{26n}{I} \qquad q = 1.6\times10^{-19}\,C$$

$$R \propto \frac{1}{I_F}$$

where,

I = The diode current in amperes.

I_0 = The reverse current in amperes.

V = The potential difference in volts. It is positive forward biase and negative for reverse bias.

q = electric charge $1.6\times10^{-19}\,C$

K = Boltzman constant $1.38\times10^{-23}\,JK^{-1}$

n = 1 for germanion diode 2 for silicon diode

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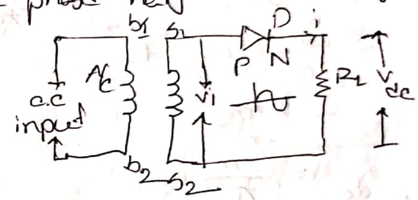
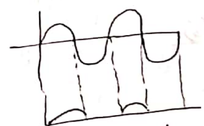
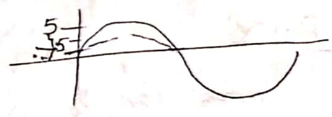
Application of diode:

Rectifire
- Half wave
- full wave
  - Two diode
  - Bridge

Single phase half wave rectifire:-







Calculation half wave rectifire:

$$v_i = V_m \sin\omega t$$

$$i = \frac{V_m}{(R_f + R_L)} \sin\omega t$$

$$= i_m \sin\omega t \quad [0 \le \omega t \le \pi]$$

V_m = maximum voltage

$t = 0 \le t \le 2\pi$

R_f = Foreward Resistor

R_L = load Resistance

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$$\boxed{i = I_m \sin\omega t}$$

when $0 \le \omega t \le \pi$

$i = 0$ when $\pi \le \omega t \le 2\pi$

Average dc current

$$i_{dc} = \frac{1}{2\pi}\int_0^{2\pi} i \, d(\omega t)$$

$$= \frac{1}{2\pi}\left[\int_0^{\pi} I_m \sin\omega t \, d(\omega t) + \int_{\pi}^{2\pi} 0 \, d(\omega t)\right]$$

$$= \frac{i_m}{2\pi}\left(-\cos\omega t\right)_0^{\pi}$$

$$= \frac{2 i_m}{2\pi}$$

$$\boxed{i_{dc} = \frac{i_m}{\pi}}$$

R.m.s

$$i_{rms} = \left[\frac{1}{2\pi}\int_0^{2\pi} i^2 \, d(\omega t)\right]^{1/2}$$

$$\boxed{i_{rms} = \frac{I_m}{2}}$$

power supplied to the circuit

$$P_i = i_{rms}^2 (R_f + R_L) \qquad \boxed{P = i^2 R}$$

$$= \left(\frac{I_m}{2}\right)^2 (R_f + R_L)$$

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average power of dc circuit

$$P_{dc} = I_{dc}^2 \cdot R_L = \left(\frac{I_m}{\pi}\right)^2 \cdot R_L$$

efficiency of rectifier:-

$$\eta = \frac{o/p}{i/p} = \frac{P_{dc}}{P_i} \times 100$$

$$= \frac{i_{dc}^2 \cdot R_L}{(I_m/2)^2 (R_f + R_L)} \times 100\,\%$$

$$\boxed{\therefore \eta = \frac{40.6}{1 + R_f/R_L}}$$

$\therefore \eta_{max} = 40.6\,\%$

Ripal factor:

EDC class-5

$$r = \frac{\text{r.m.s value of all a.c component}}{\text{average or d.c current}}$$

$$= \frac{I'_{rms}}{I_{dc}}$$

$$I_{dc}^2 + I'^2_{rms} = I^2_{rms}$$

$$\Rightarrow 1 + \frac{I'^2_{rms}}{I^2_{dc}} = \frac{I^2_{rms}}{I^2_{dc}}$$

$$\Rightarrow \frac{I'^2_{rms}}{I^2_{dc}} = \frac{I^2_{rms}}{I^2_{dc}} - 1$$

$$= r^2$$

$$\boxed{\Rightarrow r^2 = 1.21}$$

Peak Inverse voltage (PIV):

$$\boxed{PIV = V_m}$$

Regulation:

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

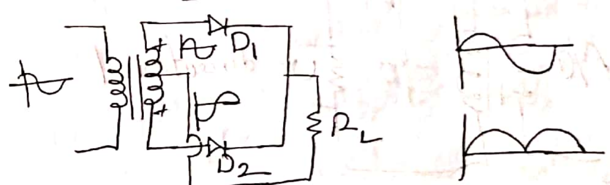
$$\Rightarrow I_{dc} = \frac{1}{\pi}\left(\frac{V_m}{R_f + R_L}\right)$$

$$\Rightarrow I_{dc} \cdot R_L + I_{dc} \cdot R_f = \frac{V_m}{\pi}$$

$$\Rightarrow I_{dc} \cdot R_L = \frac{V_m}{\pi} - I_{dc} \cdot R_f$$

$$\Rightarrow V_{dc} = \frac{V_m}{\pi} - I_{dc} \cdot R_f$$

Single phase Full-wave rectifier:



{when D_1 is on D_2 is off
and D_1 is off D_2 is on}

class-04 EDC

Application of Diode:-

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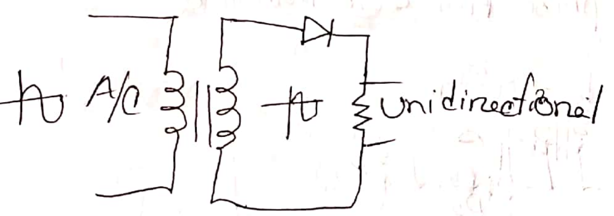
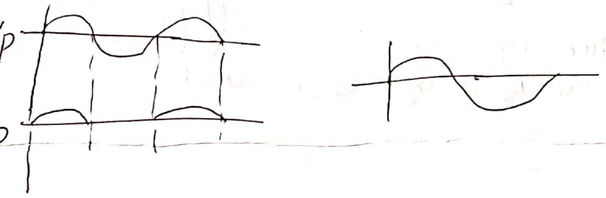
Rectifire

- Half wave
- Full wave
  - Two diode
  - Bridge

Single phase half wave rectifire:-





Calculation half wave Rectifire:-

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$V_i = V_m \sin(\omega t)$

V_m = maximum voltage

$t = 0 \le t \le 2\pi$

R_f = Foreward Resistance

R_L = load resistance

$i = \frac{V_m}{(R_f + R_L)} \sin(\omega t)$

$= i_m \sin\omega t \quad [0 \le t \le 2\pi]$

if $i = i_m \sin\omega t$ when $0 < t < \pi$

$i = 0$ when $\pi \le t \le 2\pi$

average dc current, $i_{dc} = \frac{1}{2\pi}\int_0^{2\pi} i_{dc}(\omega t)$

$= \frac{1}{2\pi}\left[\int_0^{\pi} i_m \sin\omega t \, d(\omega t) + \int_{\pi}^{2\pi} 0\right]$

$= \frac{i_m}{2\pi}[\cos\omega t]_0^{\pi}$

$= \frac{i_m}{2\pi}\{-(\cos\pi - \cos 0)\}$

$= \frac{2 i_m}{2\pi} = \frac{i_m}{\pi}$

R.m.s

$i_{rms} = \left[\frac{1}{2\pi}\int_0^{2\pi} i^2 d(\omega t)\right]^{1/2}$

after calculation, $i_{rms} = \frac{I_m}{2}$

power supplied to the circuit:-

$$P_i = i^2_{rms}(R_f + R_L)$$

$$= \left(\frac{I_m}{2}\right)^2 (R_f + R_L) \quad \Big| \; \because P = i^2 R$$

average power in dc current:

$$P_{dc} = i^2_{dc} \cdot R_L$$

efficiency of rectifine:

$$\eta = \frac{O/P}{I/P} = \frac{P_{dc}}{P_i} \times 100$$

$$= \frac{i^2_{dc} \cdot R_L}{(I_m/2)^2 (R_f + R_L)} \times 100\%$$

$$\eta = \boxed{\frac{40.6}{1 + R_f/R_L}}$$

$$\eta_{max} = 40.6\%$$

Full wave Rectifire:

$$i_p = \frac{V_m}{R_f + R_L} \sin\omega t$$

$$i_1 = I_m \sin\omega t \quad 0 < \omega t \leq \pi$$

$$i_2 = 0$$

$$i_2 = i_m \sin\omega t \quad \pi < \omega t < 2\pi$$

$$i_1 = 0$$

i_1 i_2

Average current Dc circuit,

$$I_{dc} = \int_0^{\pi} i_m \sin\omega t \, d(\omega t) + \int_{\pi}^{2\pi} i_m \sin(\omega t - \pi) \, d(\omega t)$$

$\because A\sin(\omega t - \theta) \quad \theta =$ phase difference

$0 \quad \pi \quad \sin(\omega t - \pi)$

$$= \frac{2I_m}{\pi}$$

I.r.m.s

$$= \sqrt{\frac{1}{2\pi}\left[\int_0^{\pi} i_m^2 \sin^2\omega t \, d(\omega t) + \int_0^{2\pi} I_m \sin^2(\omega t - \pi) \, d(\omega t)\right]}$$

$$\boxed{I_{rms} = \frac{I_m}{\sqrt{2}}}$$

$$P_{in} = I^2_{rms}(R_f + R_L)$$

$$= \frac{I_m^2}{2}(R_f + R_L)$$

$\cancel{P_{dc} = I_m}$

$P_{dc} = I_{dc}^2 R_L$

$$\boxed{P_{dc} = \frac{4I_m^2}{\pi^2} R_L}$$

efficiency, $\eta = \frac{P_{dc}}{P_{in}} \times 100\%$

$$= \frac{4I_m^2/\pi^2 \, R_L}{\frac{I_m^2}{2}(R_f+R_L)} \times 100\%$$

$$= \frac{4\times 2 R_L}{\pi^2(R_f+R_L)} \times 100\%$$

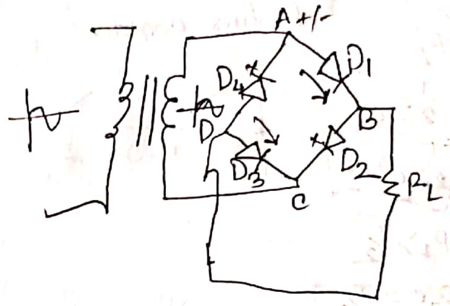
$$\boxed{\eta = \frac{81.2}{1+\frac{R_f}{R_L}}\%}$$

Ripple factor: $\frac{I_{rms}}{I_{dc}} = \frac{I_m}{\sqrt{2}} \cdot \frac{\pi}{2I_m} = \frac{\pi}{2\sqrt{2}}$

$\therefore r = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{(1.11^2-1)}$

$= 0.482$

Bridge Rectifier:



Capacitor filter for a full wave rectifier.

$$V = \frac{V_m}{\pi}\left[1 + \frac{\pi}{2}\sin\omega t - \frac{2}{1\times3}\cos 2\omega t - \frac{2}{3\times5}\cos 4\omega t - \frac{2}{5\times7}\cos 6\omega t + \cdots\right]$$

capacitor impedance

$X_C = \frac{1}{2\pi f C}$

$V_L = 2\pi f L$

Charging Voltage eqn   Class-06   04-11-2019

$V_e = V_m e^{-t/CR_L}$ τ = time constant

$= V_m\left(1 - \frac{T}{2R_LC}\right)$

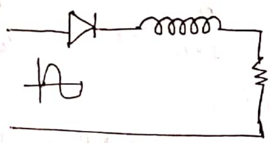
$\because \boxed{\frac{T}{2R_LC} < 1}$

$CR_L > T/2$

$\Rightarrow R_LC = T/2$

ripple: $r = \frac{1}{4\sqrt{3} f R_L C}$

Inductor:

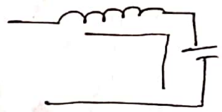


$X_L = 2\pi f L$, $f \to 0$

$X_L = 0$

$r = \frac{R_L}{3\sqrt{2}\,\omega L}$

L section filter,



~~π-section filter:~~

Variation of filter:

i) capacity (C)

ii) inductor (L)

iii) CLC   CLC [connect full wave rectifier] chapter-3 15-12-19

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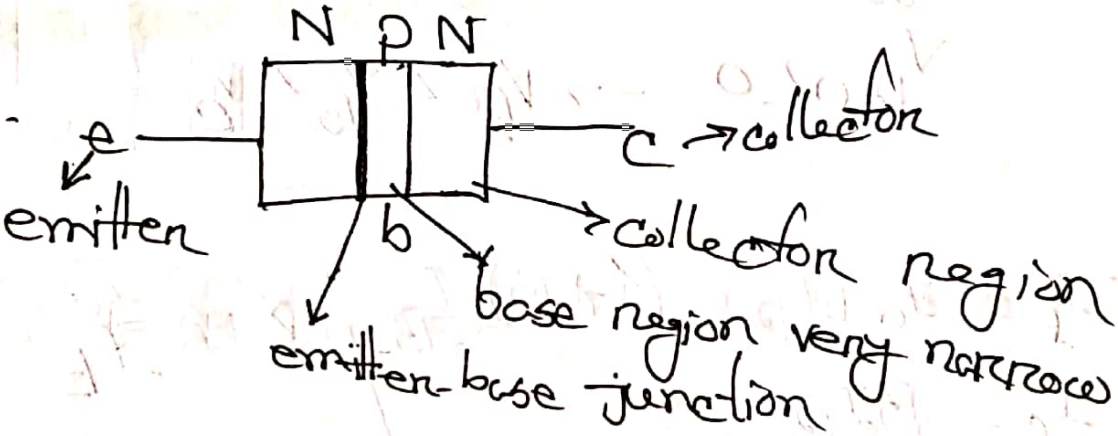
Bipolar Junction Transistor

construction of Bipolar Junction transistor



$I_E = I_C + I_B$

$\alpha = \frac{I_C}{I_E}$ (common base current gain)

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

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

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

19/12/19

exam- 07-01-20

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BJT DC Analysis:

$V_{BE} > 0$

$V_{BC} < 0 \rightarrow V_E < V_B < V_C$

$I_E = I_C + I_B = (1+\beta) I_B$ / $\alpha = \frac{I_C}{I_E}$

$I_C = \beta I_B$

$I_C = \alpha I_E$

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

Comon - base and common collector curve difference and similarity

input characteristic curve

BJT

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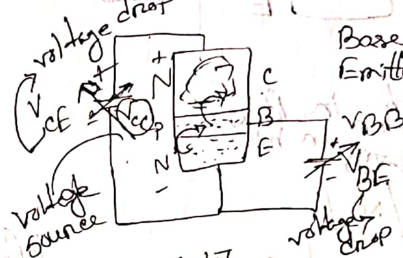
configaration

i) collector কে all time reverse biase যুক্ত থাকতে হবে।

ii) Emitter foreword biase.



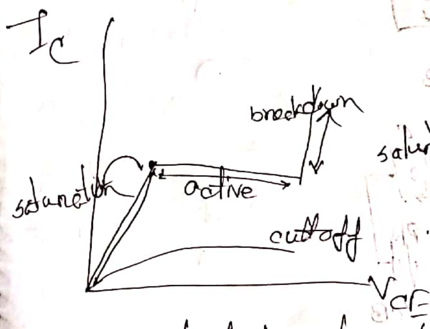
Base → majority hole

Emitter → majority electron

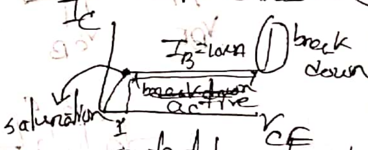
V_{BB} → source

$I_E = I_B + I_C$

input characteristic



Output characteristic

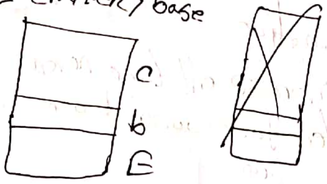


output characteristic

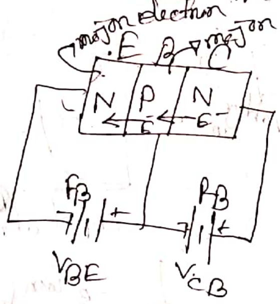
cutoff → অল্প পরিমাণ I_B current এর জন্য যে পরিমাণ I_C current পাওয়া যায়

The size of emitter, base and collector

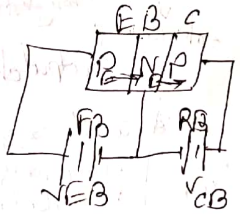
collector > emitter > base



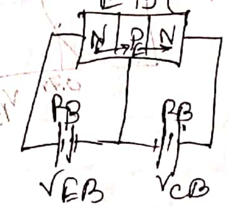
Active mode in BJT



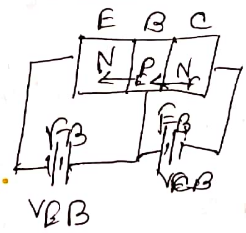
[works on amplifier]

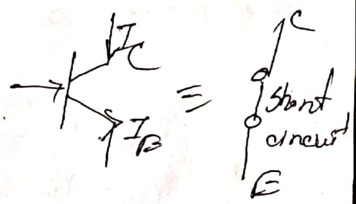


cutt-off mode BJT

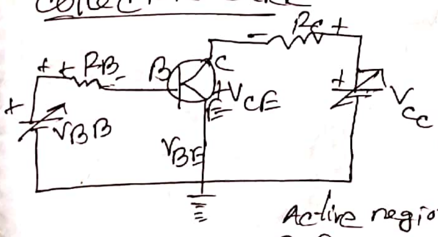


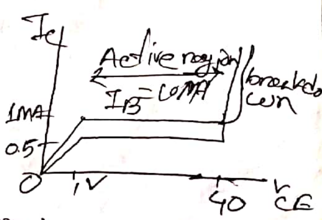
Saturation mode





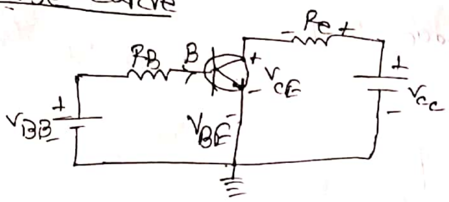
collector curve

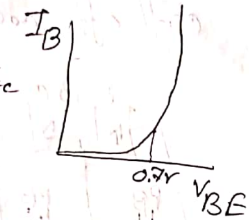




Active region B-E & C-B FB RB } Amplification operation.

Base curve





01.01.2020

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Transistor Biasing

parameter variation

$\alpha = 0.98 / 0.99$

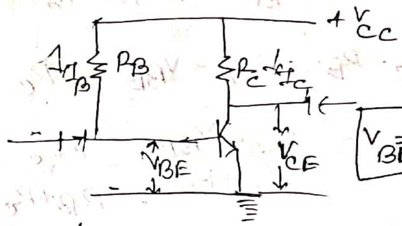
$\beta = 49 / 99$

$T \uparrow I_{CBO} \uparrow I_C \uparrow T$

stability factor, $S = \frac{\delta I_C}{\delta I_{CBO}}$

$\boxed{\text{S বাড়লে circuit burnt out হবে}}$

fixed biasing circuit



$\boxed{V_{BE} = 0.7 \text{ (around}}$

capacitance impedence

$$X_C = \frac{1}{2\pi f C}$$

$$V_{CC} = I_B R_B + V_{BE}$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

we know,

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

$$\delta I_C = \beta\left(\frac{V_{CC} - V_{BE}}{R_B}\right) + (1+\beta) I_{CBO}$$