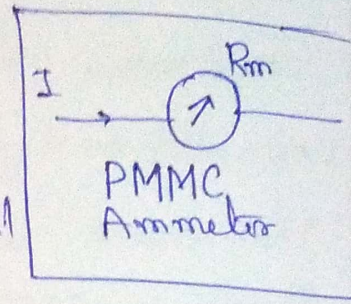
TEST 6:-

SIGNAL SYSTEM & MEASUREMENT

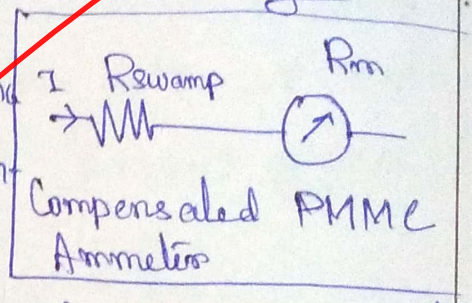
ANALOG1 & MATERIAL SCIENCE1

EDC2 & ADVANCE ELECTRONICS2

(1) a (i) Due to variation of temparature, the meter resistance, R_m varies. As a result we get a error in sensitivity of the meter, which will reflect in the meter reading.

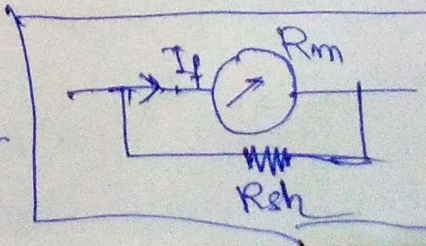


Above error can be minimised by connecting a series swamp resistance made of mangamin and constantan R_{swamp}. The swamp resistance has higher value of resistance and nearly zero temparature coefficient of resistance. Hence, over all $(R_m + R_{swamp})$ resistance change due to temparature change reduced drastically. As a result error in reading due to temperature compensated.

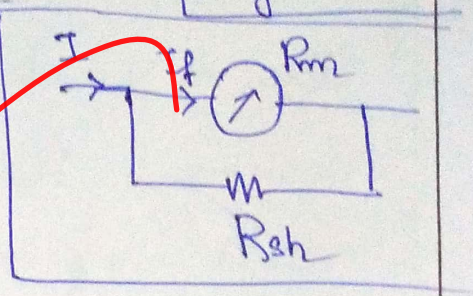


(ii) Moving iron instrument is capable of measuring DC as well as AC current.

The MI instrument is modified as an ammeter by connecting a suitable resistance parallel to it i.e. in shunt arrangement. Rsh has smaller value than R_m.



In order to extend range of a ammeter a small value of ~~resistanted~~ resistance (R_{sh}) connected parallel to the meter. So, that the excess current it can bypass through the shunt ~~resistance~~.



If I_f and R_m are the full deflection current and meter resistance respectively, and range of meter ~~is~~ to be extended to I. Then by using current division rule

$$I_f = \frac{R_{sh}}{R_{sh}+R_m} I$$

$$\Rightarrow R_{sh} = \frac{R_m}{(I/I_f - 1)} \quad \left[\eta = \frac{I}{I_f} = \right]$$

$$\Rightarrow \left[R_{sh} = \frac{R_m}{n-1}\right]$$

(1) (b)

(i) Given differential equation,

$$\frac{d^2y(t)}{dt^2} + 4\frac{dy(t)}{dt} + 3y(t) = \frac{dx(t)}{dt} + 2x(t).$$

$\Rightarrow$ [~~Let the~~ Assume Zero Intial Condition i.e. $y'(0) = y(0) = x(0) = 0$]

By taking Laplace transform we get

$$s^2Y(s) + 4sY(s) + 3Y(s) = sX(s) + 2X(s)$$

$$\Rightarrow \frac{Y(s)}{X(s)} = H(s) = \frac{s+2}{s^2+4s+3} \quad \text{---------- (1)}$$

The frequency response, by putting $s = j\omega$ in eqn (1).

$$H(\omega) = \frac{j\omega+2}{(j\omega)^2+4(j\omega)+3}$$

$$\Rightarrow \boxed{H(\omega) = \frac{j\omega+2}{(3-\omega^2)+j4\omega}}$$

From the eqn (1) we get

$$H(s) = \frac{(s+2)}{s^2+4s+3} = \frac{s+2}{(s+3)(s+1)}$$

$\Rightarrow$ Impulse response of $h(t)$,

$$Y(s) = H(s).X(s) \qquad [\because x(t) = \delta(t) \quad X(s) = 1]$$

$$\Rightarrow Y(s) = \frac{s+2}{(s+1)(s+3)} \cdot 1$$

$$\Rightarrow Y(s) = \frac{(-1+2)}{(-1+3)}\frac{1}{(s+1)} + \frac{(-3+2)}{(-3+1)}\frac{1}{s+3}$$

$\Rightarrow$ Taking inverse Laplace transform we get

$$\boxed{y(t) = \left[\frac{1}{2}e^{-t} + \frac{1}{2}e^{-3t}\right]u(t)}$$

(ii) Given, $x(t) = e^{-t} u(t)$

Taking Laplace transform we get,

$$\Rightarrow X(s) = \frac{1}{(s+1)} \quad \text{---------- (2)}$$

From eqn (1) and eqn (2), we get,

$$Y(s) = \frac{(s+2)}{(s+1)(s+3)} \cdot \frac{1}{(s+1)}$$

$$\Rightarrow Y(s) = \frac{A}{(s+1)^2} + \frac{B}{(s+3)} + \frac{C}{(s+1)}.$$

where,

$$A = (s+1)^2 \cdot Y(s) \Big|_{s=-1}$$

$$\Rightarrow A = \left(\frac{-1+2}{-1+3}\right) = \frac{1}{2}$$

$$B = (s+3) \cdot Y(s) \Big|_{s=-3}$$

$$\Rightarrow B = \frac{(-3+2)}{(-3+1)^2} = -\frac{1}{4}$$

$$C = \frac{d}{ds}(s+1)^2 \cdot Y(s) \Big|_{s=-1} = \frac{(s+3)-(s+2)}{(s+3)^2} \Big|_{s=-1}$$

$$\Rightarrow C = \frac{1}{4}$$

Therefore,

$$Y(s) = \frac{1}{2}\frac{1}{(s+1)^2} - \frac{1}{4}\frac{1}{s+3} + \frac{1}{4}\frac{1}{(s+1)}.$$

Taking inverse Laplace transform,

$$y(t) = \left(\frac{1}{2} te^{-t} - \frac{1}{4} e^{-3t} + \frac{1}{4} e^{-t}\right) u(t)$$

(1) (c) Given Signal

$$x(t) = \cos(100\pi t)$$

$$f_m = \frac{\omega}{2\pi} = \frac{100\pi}{2\pi} = 50\ Hz.$$

$$T_m = \frac{1}{50} = 20\ m\,Sec$$

(i) As per Sampling theorem, minimum sampling rate required to avoid aliasing

$$\boxed{f_s = 2 \times f_m = 2 \times 50 = 100\ Hz}$$

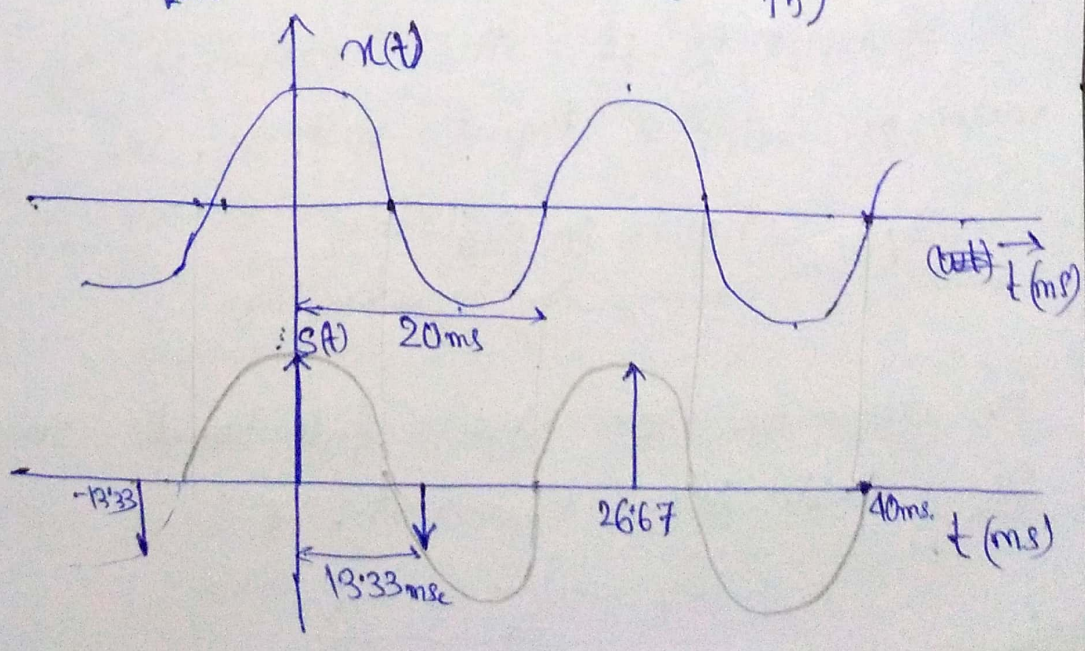
(ii) When the signal is sampled at the rate of $f_s = 75\ Hz$,

$$T_s = \frac{1}{75}\ Sec. = 13.33\ m\,Sec.$$

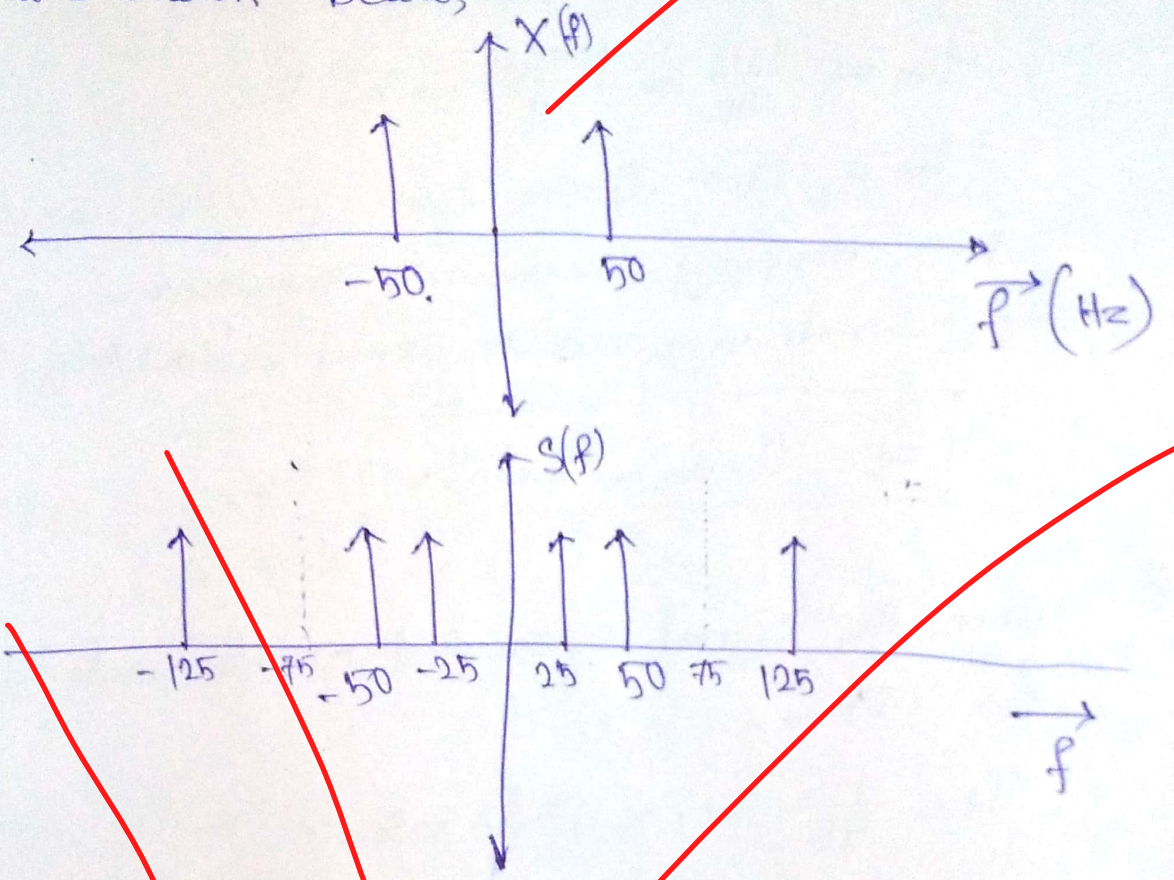
Then the obtained discrete signal obtained after Sampling,

$$g(t) = \sum_{k=-\infty}^{\infty} x(t) \cdot \delta(t - kT_s).$$

$$g(t) = \sum_{k=-\infty}^{\infty} \cos(100\pi t) \cdot \delta\left(t - \frac{k}{75}\right)$$



(iii) Spectrum diagram of X(f) and S(f), are shown below,



In the range, $0 < f < f_s/2 \Rightarrow 0 < f < 37.5$ Hz yields samples frequency $f = 25$ Hz.

(1) (d)

Sensitivity

Sensitivity is the response of the meter on applied input voltage. is ~~$S_V = \Delta$~~

$$S_V = \frac{\text{Change in deflection}}{\text{Change in input voltage}}$$

S_V, depends on the full ~~load~~ ~~curre~~ scale deflection current, I_f

$$S_V = \frac{1}{I_f} \ \Omega/V$$

Loading effect

For measuring a physical quantity, the measuring instrument absorb some quantity of measurant, as a result we get lowered value in measurement. This phenomenon called loading effect.

As the Sensitivity of the meter decreases, loading effect increases.

(ii) Advantages of digital instrument

Low input signal level :- Due to high input impedance of digital instrument it required low value of input signal to response Compare to analog instrument.

High input impedance :- the digital instrument shows high input impedance, which allows it to consume low input signal into it as compare to analog instrument

High frequency response Due to low value of MOSFET capacitance, the digital instrument can be operated upto in MHz range, which is a great advantage of digital instrument

Accuracy

Digital instrument shows high greater accuracy as compared to to analog instrument. And also, data can be read from digital display which remove gross error.

Data storage capacity

Most of the digital instrument containing storage memory, which makes it capable to store measured data as per requirement. which is not possible in analog instrument.

(1)(e)

Given $|H(w)| = \begin{cases} 1 & -w_c < w < w_c \\ 0 & \text{otherwise} \end{cases}$

and $\angle H(w) = \begin{cases} \pi/2 & , w > 0 \\ -\pi/2 & , w < 0 \end{cases}$

By combining magnitude and phase response

$$H(w) = \begin{cases} j & \text{for } 0 < w < w_c \\ -j & \text{for } -w_c < w < 0 \\ 0 & \text{otherwise.} \end{cases}$$

Impulse response of the system, for $X(s) = 1$

$$Y(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} H(w)\, e^{jwt}\, dw.$$

$$y(t) = \frac{1}{2\pi}\int_{-w_c}^{0}(-j)e^{+jwt}\,dw + \frac{1}{2\pi}\int_{0}^{w_c} j e^{jwt}\,dw$$

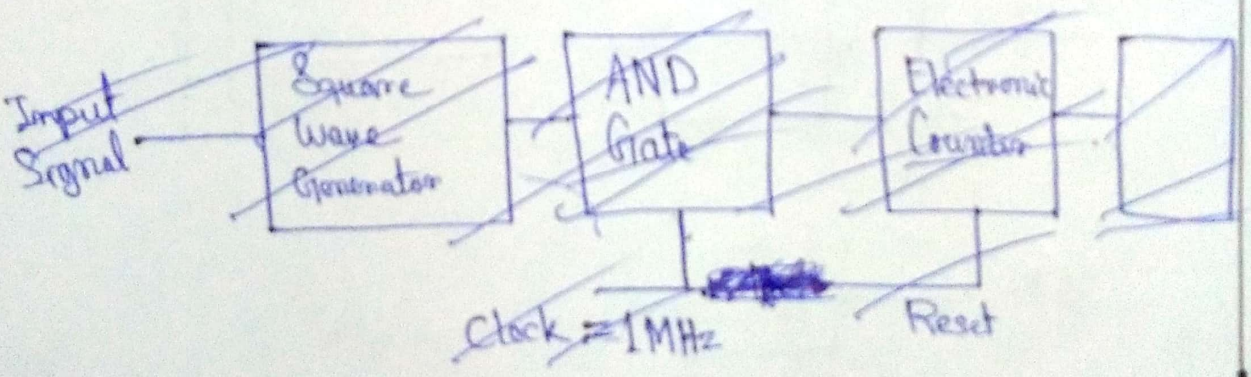
$$= \frac{1}{2\pi}\frac{(-j)}{(jt)}\left[e^{jwt}\right]_{w_c}^{0} + \frac{1}{2\pi}\frac{j}{(jt)}\left[e^{jwt}\right]_{0}^{w_c}$$

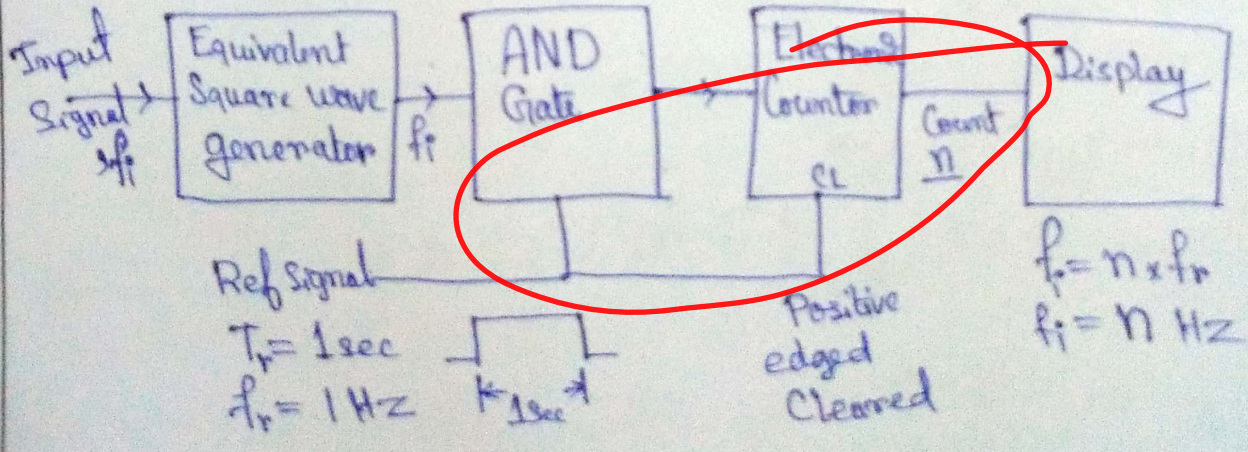
$$= \frac{1}{2\pi t}\left[e^{-jw_c t} - 1\right] + \frac{1}{2\pi t}\left[e^{jw_c t} - 1\right]$$

$$= \frac{1}{2\pi t}\left[e^{jw_c t} + e^{-jw_c t} - 2\right]$$

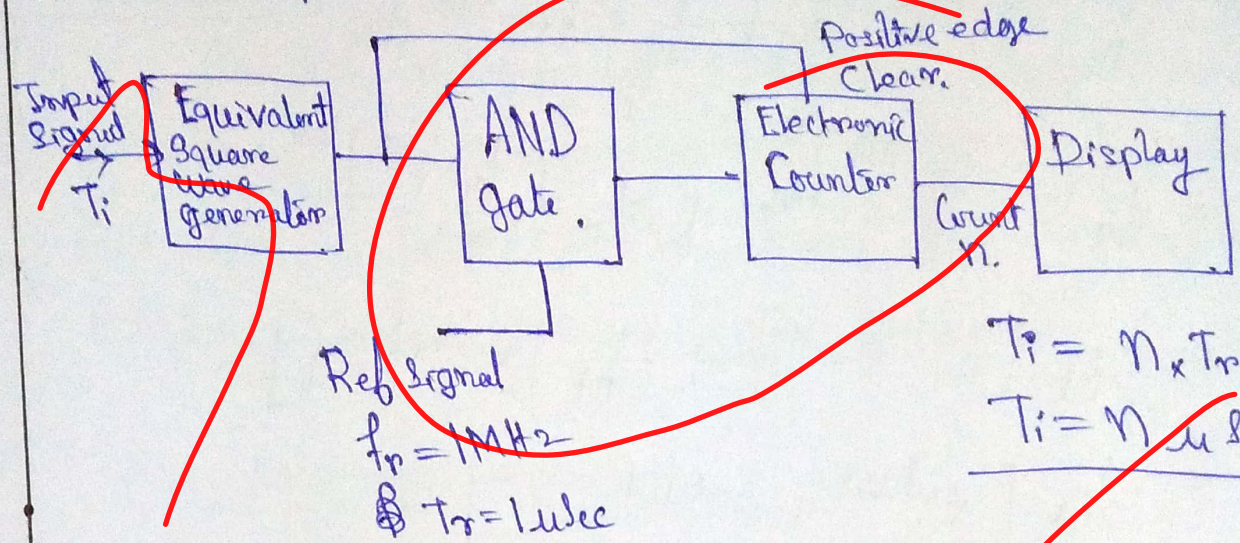
$$y(t) = \frac{1}{\pi t}\left[\cos w_c t - 1\right]$$

(4) (a) (i) Frequency measurement





2) Time period measurement



$T_i = n \times T_r$

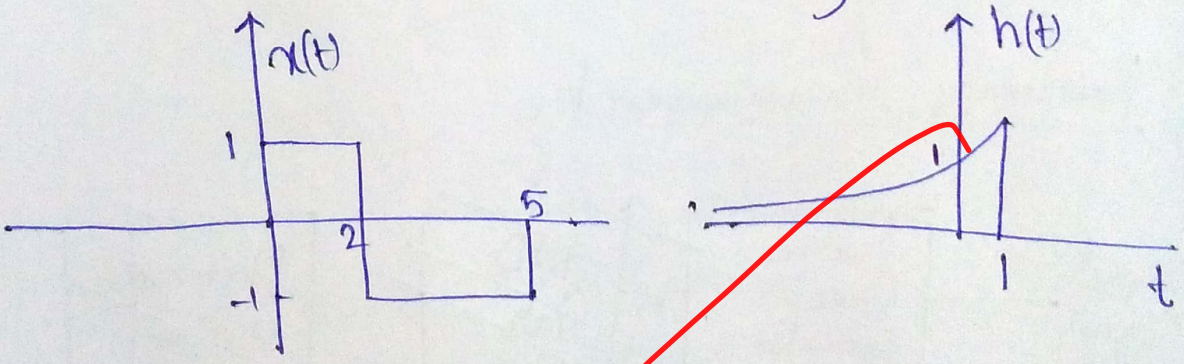
$T_i = n\ \mu sec$

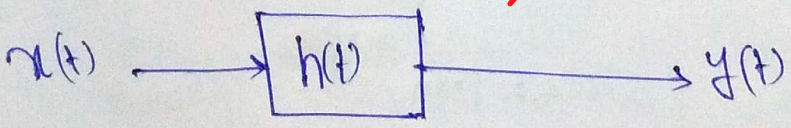
(A)

(b)

Given $h(t) = e^{2t}\, u(1-t)$

And $x(t) = U(t) - 2u(t-2) + U(t-5)$

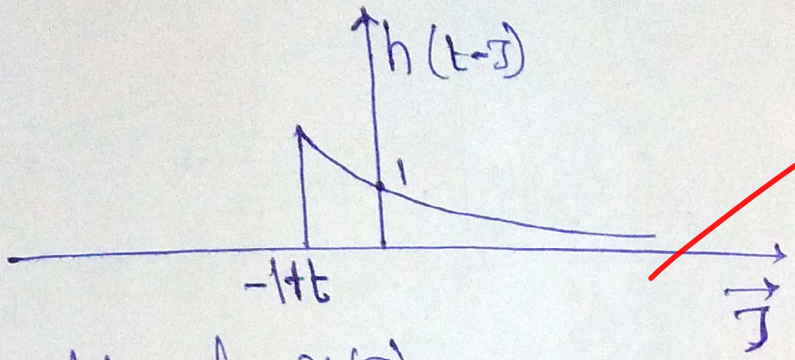




- The output $y(t) = x(t) * h(t)$

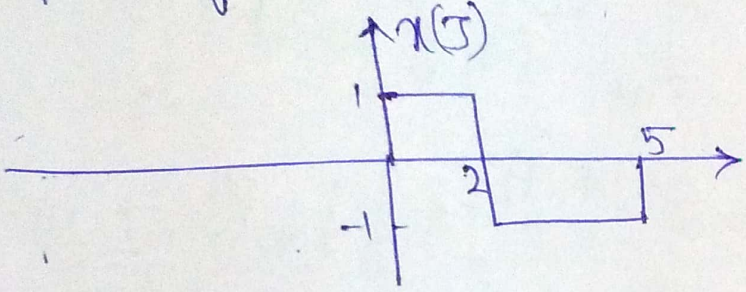
$$y(t) = \int_{-\infty}^{\infty} x(\tau)\, h(t-\tau)\, d\tau \quad \text{---------- 1)}$$

plot of $h(t-\tau)$ given by



$$h(t-\tau) = e^{2(t-\tau)} U(\tau-t+1)$$
$$= e^{2(t-\tau)} \cdot U\{\tau-(t-1)\}$$

plot of $x(\tau)$



For ~~$-1+t<0$~~ i.e. ~~$t<1$~~

We will get non zero, multiplication of $h(t-\tau) \cdot x(\tau)$ for the range

$$-\infty < t-1 < 5, \text{ i.e. } -\infty \le t \le 6$$

Therefore from equation, (1) we get, for ~~$-\infty \le t \le 0$~~ $(-\infty \le t-1 \le 0)$

$$y(t) = \int_{-\infty}^{\infty} x(\tau) \cdot h(t-\tau)\, d\tau.$$

$$y(t) = \int_0^2 (1) \cdot e^{2(t-\tau)}\, d\tau + \int_2^5 (-1) e^{2(t-\tau)}\, d\tau.$$

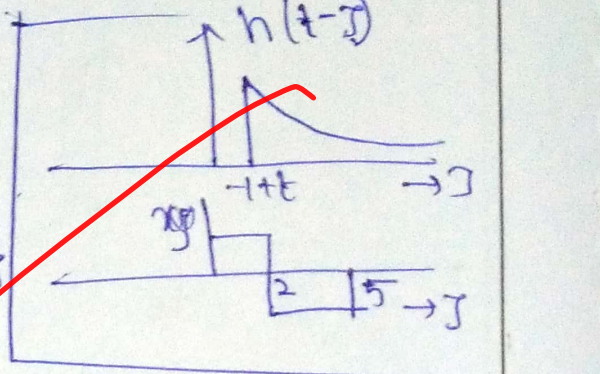
$$= \frac{1}{-2}\left[e^{2(t-\tau)}\right]_0^2 + \frac{(-1)}{-2}\left[e^{2(t-\tau)}\right]_2^5$$

$$= \frac{1}{-2}\left[e^{2(t-2)} - e^{2t}\right] + \frac{1}{2}\left[e^{2(t-5)} - e^{2(t-2)}\right]$$

$$y(t) = -e^{+2(t-2)} + \tfrac{1}{2}e^{2t} + e^{2(t-5)}, \text{ for } -\infty \le t \le 1$$

For, $0 \le -1+t \le 2$

i.e. $1 \le t \le 3$



$$y(t) = \int_{-1+t}^{2} (1).\, e^{2(t-\tau)}\, d\tau + \int_{2}^{5} (-1)\, e^{2(t-\tau)}\, d\tau$$

$$= \frac{1}{-2}\left[e^{2(t-\tau)}\right]_{-1+t}^{2} - \frac{1}{(-2)}\left[e^{2(t-\tau)}\right]_{2}^{5}$$

$$= -\frac{1}{2}\left[e^{2(t-2)} - e^{2(t+1-t)}\right] + \frac{1}{2}\left[e^{2(t-5)} - e^{2(t-2)}\right]$$

$$= -e^{2(t-2)} + \frac{1}{2}e^{2} + \frac{1}{2}e^{2(t-5)}$$

for $1 \le t \le 3$

And for, $2 \le -1+t \le 5$, i.e. $3 \le t \le 6$

$$y(t) = \int_{-1+t}^{5} (-1).\, e^{+2(t-\tau)}\, d\tau$$

$$= -\frac{1}{(-2)}\left[e^{2(t-\tau)}\right]_{-1+t}^{5}$$

$$= \frac{1}{2}\left[e^{2(t-5)} - e^{2(1)}\right]$$

$$= \frac{1}{2}e^{2(t-5)} - \frac{1}{2}e^{2} \quad \text{for } 3 \le t \le 6$$

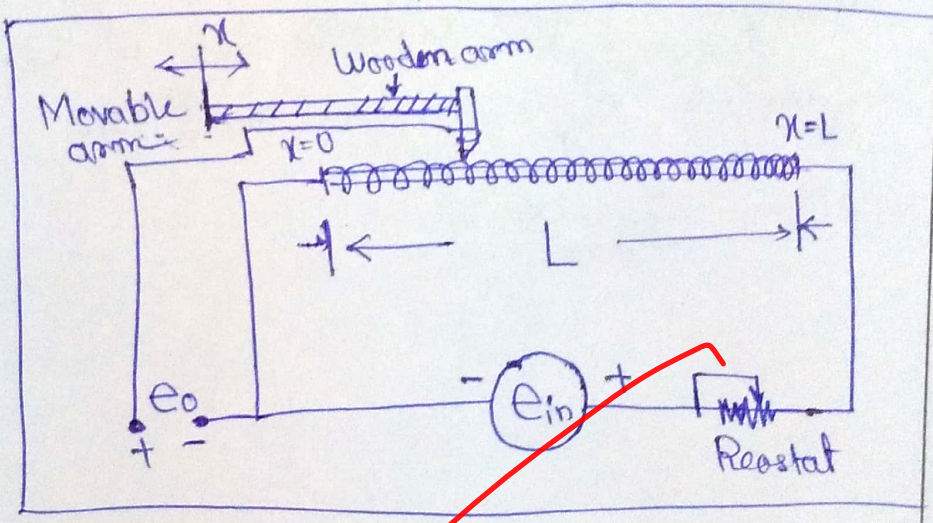
for for $t > 6$, $y(t) = 0$, because there will be no common area ~~in bet~~ of $x(\tau)$ and $h(t-\tau)$.

Therefore the value of $y(t)$

$$y(t) = \begin{cases} -e^{t+2(t-2)} + \frac{1}{2}e^{2t} + \frac{1}{2}e^{2(t-5)} & \text{for } -\infty < t \le 1 \\ -e^{2(t-2)} + \frac{1}{2}e^{2} + \frac{1}{2}e^{2(t-5)} & \text{for } 1 < t \le 3 \\ \frac{1}{2}e^{2(t-5)} - \frac{1}{2}e^{2} & \text{for } 3 < t \le 6 \\ 0 & \text{Otherwise.} \end{cases}$$

(4)

(a) (ii) Potentiometer as Linear displacement measurement meter



By using above arrangement linear displacement can be measure by using potentiometer.

For the potentiometer, & meter resistance R_m with length L shown. A reastat is connected in the loop to adjust the range of loop current. Current in the potentiometer is given by $I = \frac{e_{in}}{R_e + R_m}$.

A movable arm is used to measure displacement in terms of output voltage.

Equivalent resistance for displacement x is $\frac{x}{L} R_m$.

Therefore output voltage,

$$e_o = \frac{x}{L} \times R_m \times \frac{E_{in}}{R_e + R_m}$$

$$\Rightarrow e_o = kx$$

k = constant

$$\left[k = \frac{e_{in}}{L} \frac{R_m}{(R_e + R_m)} \right]$$

Therefore output voltage e_o is linear function of displacement x.

$$\underline{e_o \propto x}$$

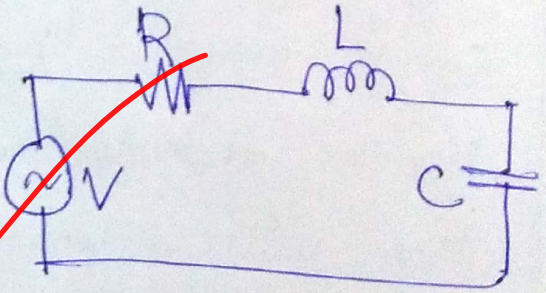
(4)

(c) (i) Given,

$R = 2400 \pm 240\ \Omega$

$L = 240\ \mu H$

$C = 240\ pF$



(1) Resonance frequency, when components has error 0%.

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{240 \times 10^{-6} \times 240 \times 10^{-12}}} \text{ Hz}$$

$$\boxed{f_r = 663.145 \text{ kHz}}$$

3) Given, $L = 240\,\mu H \pm 5\% = 252\,\mu H$

$C = 240\,pF \pm 5\% = 252\,pH$

Resonance frequency,

$$f_r' = \frac{1}{2\pi\sqrt{252\times10^{-6}\times252\times10^{-12}}}\ Hz$$

$$\boxed{f_r' = 631.567\ kHz}$$

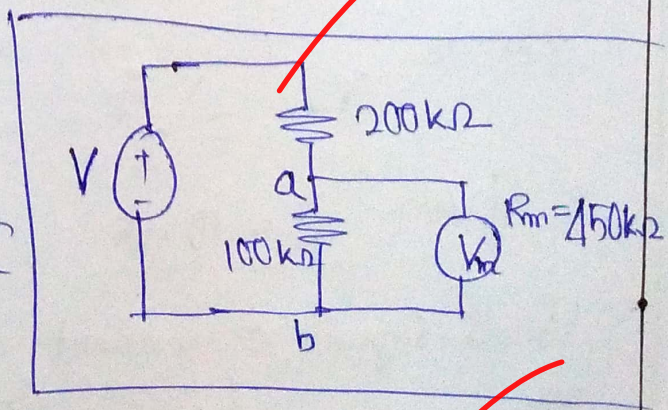
Percentage error,

$$\%e_r = \frac{f_r' - f_r}{f_r} = \frac{631.567 - 663.145}{663.145}\times100\%$$

$$\boxed{\%e_r = -4.76\%}$$

4) (ii)

(c) As per given statement equivalent circuit can be drawn as



True reading, by using voltage division rule

$$V_t = \frac{100}{200+100}\times V$$

$$V_t = \frac{V}{3} \quad \text{——— (1)}$$

Equivalent resistance across ab of the figure,

$$R_{ab} = 100 \| 450 = \frac{900}{11}\ k\Omega$$

Therefore voltmeter reading

$$V_m = \frac{R_{ab}}{200 + R_{ab}} \cdot V$$

$$\Rightarrow V_m = \frac{\frac{900}{11}}{\frac{900}{11} + 200} \cdot V$$

$$\Rightarrow V_m = 0.29V = \frac{9}{31} V$$

Error,

$$e_r = \frac{V_m - V_t}{V_t} \times 100\ \%$$

$$e_r = \frac{\frac{9}{31} V - \frac{V}{3}}{\frac{V}{3}} \times 100\ \%$$

$$\boxed{e_r = -12.9\ \%}$$

SECTION - B

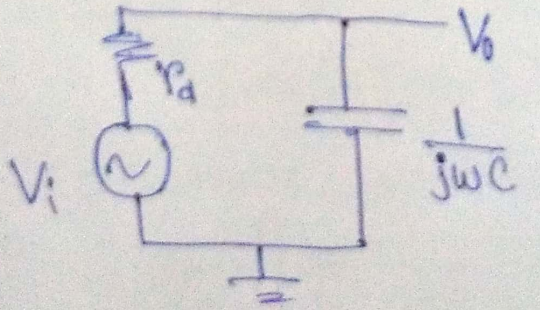
(5) (a)

Small signal equivalent resistance of the diode

$$r_d = \frac{nV_T}{I} = \frac{V_T}{I} \quad \text{---------- (1)}$$

Given $C = 10\ nF$, $f = 10^6\ Hz$

Small signal equivalent circuit can be drawn as



$$\left[\frac{1}{j\omega C} = \frac{1}{j \times 10^6 \times 2\pi \times 10^{-8}} = -j15.92\ \Omega\right]$$

(i) Small signal voltage gain

By using voltage division rule we get,

$$\frac{V_o}{V_i} = \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + r_d} = \frac{1}{1 + j\omega r_d C}$$

$$\Rightarrow A_v = \frac{V_o}{V_{in}} = \frac{1}{1 + j \times 2\pi \times 10^6 \times \frac{25 \times 10^{-3}}{I} \times 10^{-8}} = \frac{1}{1 + j\,\frac{157 \times 10^{-5}}{I}}$$

$$\Rightarrow \left|\frac{V_o}{V_{in}}\right| = |A_v| = \frac{1}{\sqrt{1 + \left(\frac{157 \times 10^{-5}}{I}\right)^2}}$$

(ii) $$A_v = \frac{1}{\sqrt{1 + \left(\frac{157 \times 10^{-5}}{I}\right)^2}} \angle -\tan^{-1}\left(\frac{157 \times 10^{-5}}{I}\right)$$

When, phase shift of the output voltage signal is -45° with respect to input signal

i.e. $$\tan^{-1}\left(\frac{157 \times 10^{-5}}{I}\right) = 45^\circ$$

$$\Rightarrow \boxed{I = 1.57\ mA}$$

(5) (b) Given, $\beta = \frac{I_C}{I_B} = 10$, $\alpha_F = 0.985$, $\alpha_R = 0.72$

Let assume $\frac{KT}{q} = 0.0259\ V$ at room temp,

Therefore,

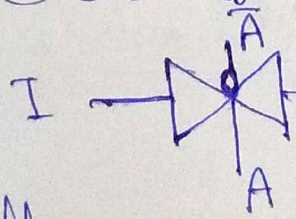
$$V_{CEsat} = \frac{KT}{q} \ln\left[\frac{1 + \frac{I_C}{I_B}(1-\alpha_R)}{\alpha_R\left[1 - \frac{I_C}{I_B}\left(\frac{1-\alpha_F}{\alpha_F}\right)\right]}\right]$$

$$= 0.0259 \ln\left[\frac{1 + 10\times(1-0.72)}{0.985\left[1 - 10\times\left(\frac{1-0.985}{0.985}\right)\right]}\right]$$

$$V_{CEsat} = 0.0392\ V$$

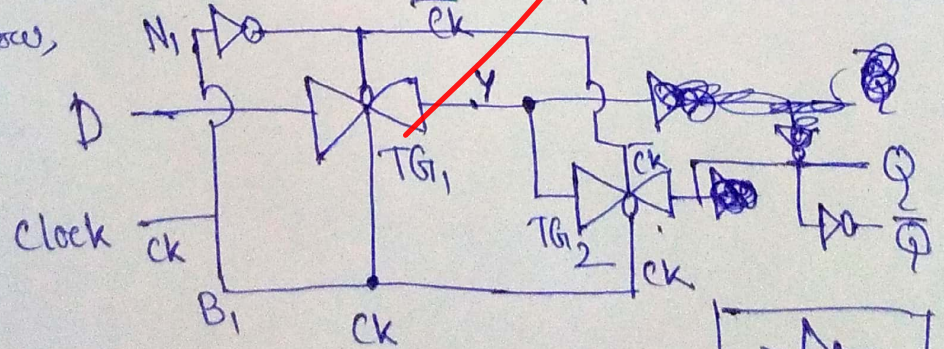
(5) (c) D-flip-flop using transmission gate

Transmission gate



$Y = IA$

D-flip-flop can be implemented as shown below,



shown, D-flip-flop is implemented by using 2 TG, 2 ~~3~~, NOT Gate ~~and~~

Working principle

The TG_1 is activated by the ~~the~~ positive edge of the clock and the input is transmitted to point y. Then the input of TG_2 i.e. y is transmitted to output by activating TG_2 on negative edge (falling) of clock pulse. Thus, the input is transmitted to output ~~in~~ on a single clock cycle.

(5)(d) (i) **Characteristics of Ceramic material**

~~Th~~ Ceramic materials has unique characteristics which are discussed below.

→ High value of resistant of heat and electricity

→ Comparative hard is, brittle and low ductility

→ Due to high young modulus, low deformation on application of ~~high~~ large value of force

→ ~~Chemi~~ Chemically inert i.e. most of the ceramic materials do not react with other materials.

→ High melting point

→ Considerable durability i.e. long lasting and hard wearing.

(ii) Factors affecting the resistivity of electrical materials

Resistivity of any material depends on temparature and residual strain.

Due to raise in temparature material lattice atoms vibrate more frequently, as a result average mean time for collision decreases which is responsible to reduction of mobility, as a result conductivity decreases and resistivity increases.

$$\rho_{thermal} \propto T \text{ (temparature)}$$

And due to residual stress that may be due to interstitutional impurity, the electron faced obstaction to flow. Thus mobility decreases. As a result Conductivity decreases and resistivity increases.

$P_{residual} \propto$ (Residual Stress).

(5)

(e) Crystal Defect

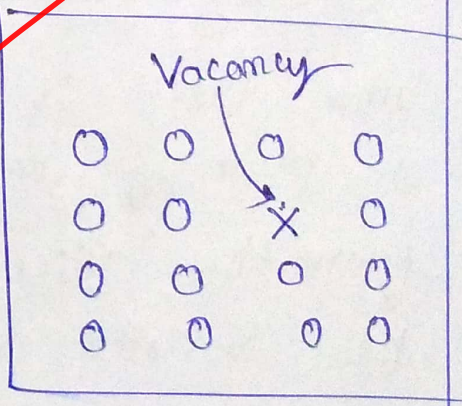
Any imperfection of periodic structure of ~~crystal~~ unit cell in crystal is said crystal defect.

Point defect (0-D)

This kind of defect occured in 0-D, which are discussed below.

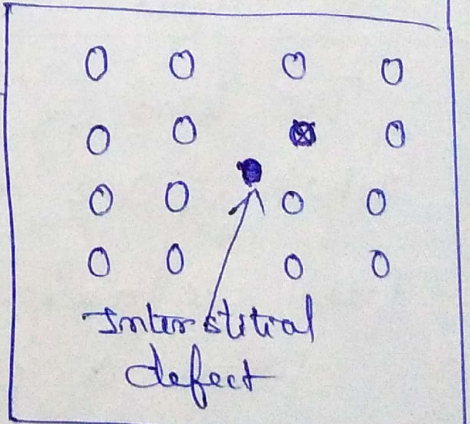
Vacancy defect

When there is a absent of any atom from lattic it is called vacancy defect.



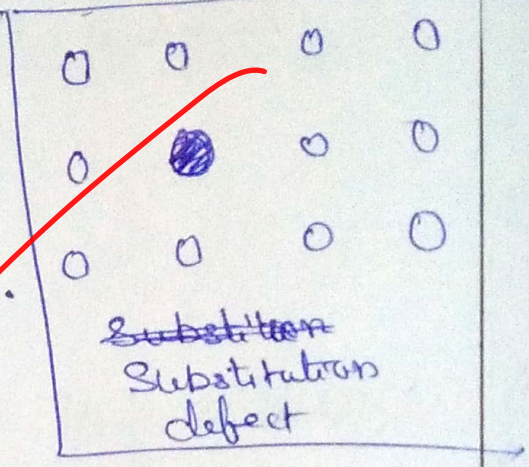
Interstitial defect

When a atom displaced from its regular lattice point to interstitial position it is called interstitial defect.



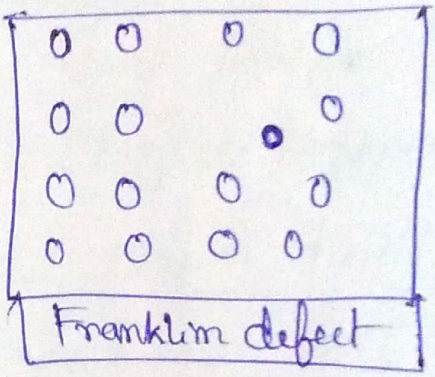
Substitution

When a regular atom in lattice is replaced by a foreign atom, this is called as substitutional defect.



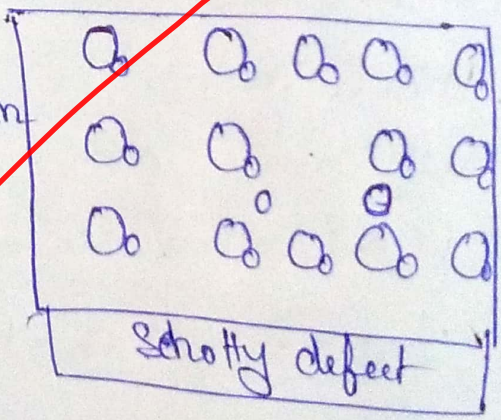
Franklin defect

When a regular lattice atom displaced from its regular atom to interstitial point, said as Franklin defect.



Schotty defect

When there is absent of a pair of anion and cation from the lattice is said to be Schotty defect.

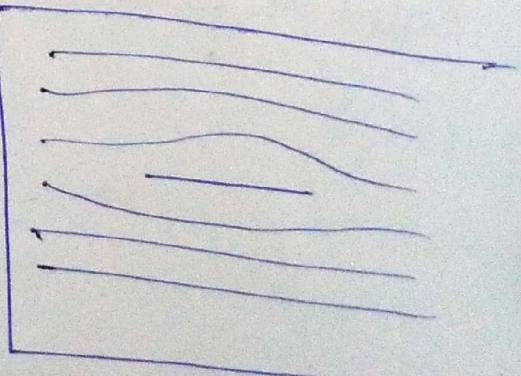


Line defect (1-D)

This kind of defect occures in 1-D, which are discussed below.

Edge dislocation

When a plane is inserted in a regular lattice it is called edge dislocation.



Screw dislocation

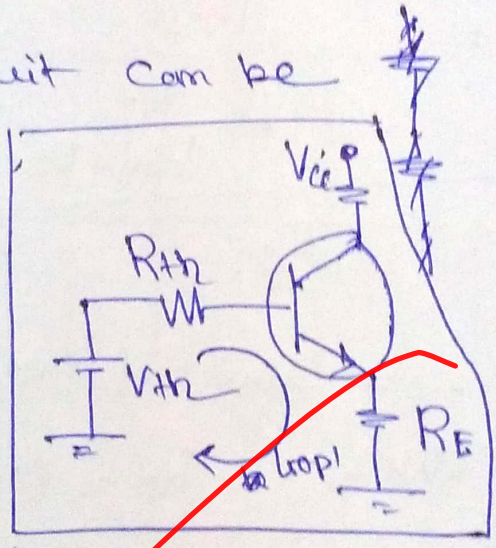
Due to absent of a regular plane in a lattice of a crystructure is it is said to be as screw dislocation.

Mixed dislocation

Combination of edge and screw dislocation formed mixed dislocation.

(6) (a)

The given circuit can be modified as



where,

$$R_{th} = (R_1 \| R_2)$$

$$V_{th} = \frac{R_2}{R_1 + R_2} V_{cc}.$$

By KVL in the input loop1 ~~can be drawn~~

$$V_{th} = I_B R_{th} + V_{BE} + (I_B + I_C) R_E$$

$\Rightarrow$ Differentiating both side w.r.t I_B, I_C, by assuming V_{BE} = Constant.

$$\Rightarrow \quad 0 = \frac{\partial I_B}{\partial I_C} R_{th} + R_E \frac{\partial I_B}{\partial I_C} + R_E$$

$$\Rightarrow \quad \frac{\partial I_B}{\partial I_C} = -\frac{R_E}{R_{th} + R_E} \qquad (1)$$

(i)

And we know,

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

Differentiating both sides w.r.t I_C, by assuming β = Constant.

$$1 = \beta \frac{\partial I_B}{\partial I_C} + (1+\beta) \frac{\partial I_{CO}}{\partial I_C}$$

$$\Rightarrow \frac{\partial I_C}{\partial I_{CO}} = S = \frac{1+\beta}{1-\beta \frac{\partial I_B}{\partial I_C}} \quad \text{——— (2)}$$

From eqn (1) and (2) we get,

$$\boxed{S(I_{CO}) = \frac{1+\beta}{1+\beta \dfrac{R_E}{R_{th}+R_E}}}$$ where $R_{th} = R_1 \| R_2$

(ii)

Given $I_C = 2mA$ at $25^\circ C$. and $I_{CO} = 1\mu A$

$R_1 = R_2 = 10k\Omega$, $R_E = 0.5k\Omega$ $\beta = 100$.

Then,

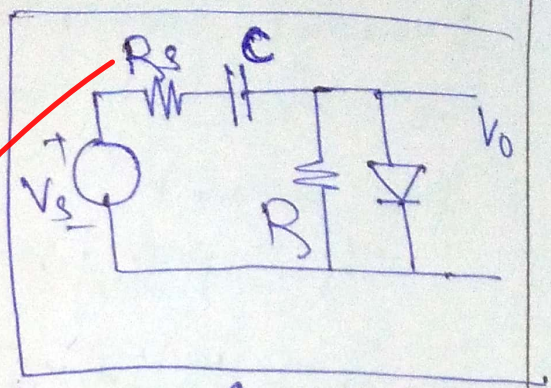
$$S(I_{CO}) = \frac{1+\beta}{1+\beta\left(\dfrac{R_E}{R_{th}+R_E}\right)}$$

$$= \frac{1+100}{1+100 \times \dfrac{0.5}{(10\|10)+0.5}} \simeq 10$$

$$\Rightarrow \boxed{S(I_{CO}) = 10}$$

(6)

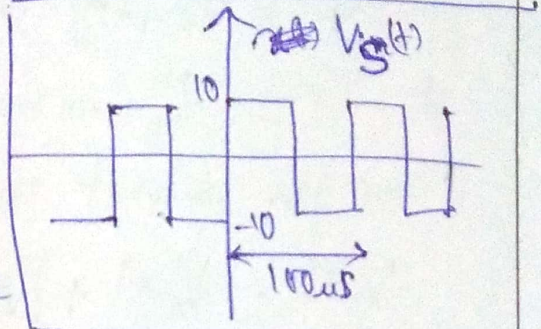
(b) (i) Given $R_s = 10k\Omega$, $C = 1\mu F$



For input waveform

$f_m = 10kHz$

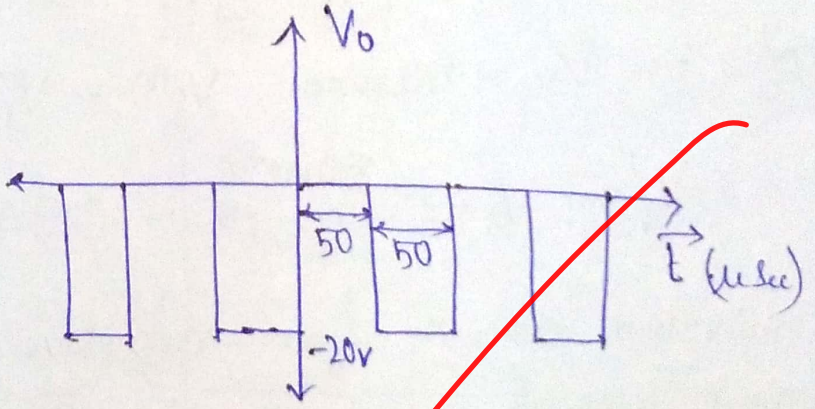
$T = 100 \times \mu s$.



$R_s = 0$, $R_r = \infty$, $R_f = 0$

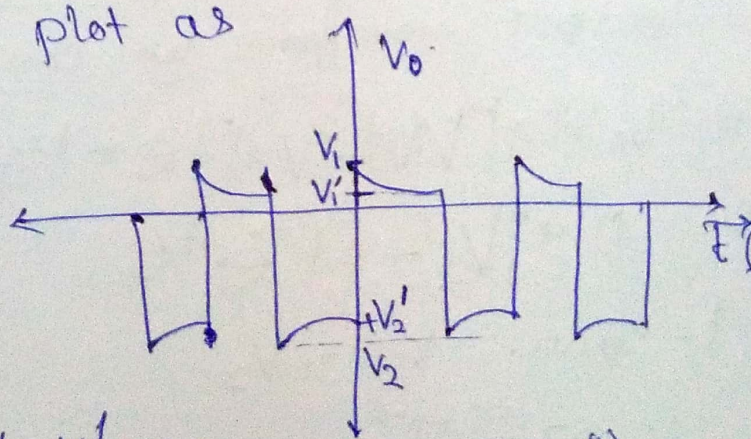
and $V_\gamma = 0\,V$

Given circuit is a negative clamper circuit, therefore output waveform shown as



(ii)

As the diode has non zero forward resistance we will get distorted output during positive cycle and negative cycle. Distorted output can be plot as

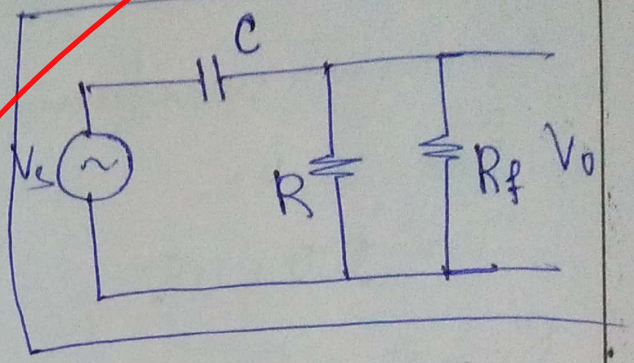


Where $V_1 - V_2' = 20v$ ——— (1)

$V_2 - V_1' = 20$ ——— (2)

Assume, $R_r = \infty$, $R_s = 0\ \Omega$

Equivalent circuit for positive cycle of input signal



Time constant

$$T_1 = (R \| R_f) C$$

$$T_1 = (10 \| 1\text{k}) \times 10^3 \times 10^{-6}\ s$$

$$\Rightarrow T_1 = \frac{10}{11}\ m\text{sec.}$$

From the output waveform, we can write,

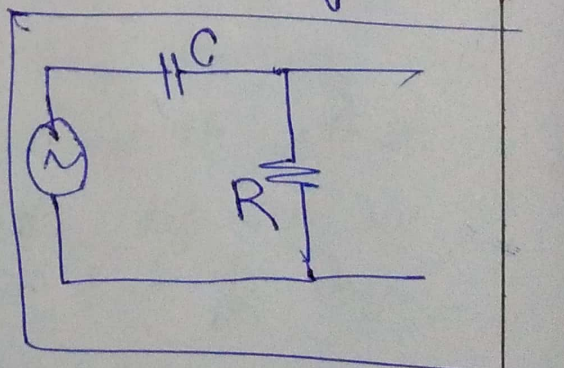
$$V_0(t) = V_0(\infty) + [V(0) - V(\infty)]\, e^{-t/T_1}$$

$$\Rightarrow V_0(t) = 0 + [V_1 - 0]\, e^{-t/T_1}$$

at $t = T/2 = 50\ \mu sec$ $\quad V_0(t) = V_1'$

$$\Rightarrow V_1' = V_1 e^{-\frac{50\times10^{-6}}{\frac{10}{11}\times10^{-3}}} = 0.946\, V_1 \quad \text{——— (3)}$$

Equivalent circuit for negative cycle of input signal



Time Constant

$$T_2 = RC = 10^4 \times 10^{-6}\ sec$$

$$= 10\ m\text{sec.}$$

From the output waveform we can write,

$$V_0(t) = V_0(\infty) + [V(0) - V(\infty)]\, e^{-t/T_2}$$

$$\Rightarrow V_0(t) = 0 + [V_2 - 0]\, e^{-t/T_2}$$

$\Rightarrow$ At $t = 50\ \mu sec.$ $\quad V_0(t) = V_2'$

$$\Rightarrow V_2' = V_2 e^{-\frac{50\times10^{-6}}{10\times10^{-3}}} = 0.995\, V_2$$

$$V_2 = 1.005\, V_2' \quad \text{——— (4)}$$

By equation (2), eqn (3) and eqn (4) we get.

$(V_2 - V_1') =$

$(V_2 - V_1') = 1.005 V_2' - 0.946 V_1$

$\Rightarrow -20 = 1.005 V_2 - 0.946 (20 + V_2')$

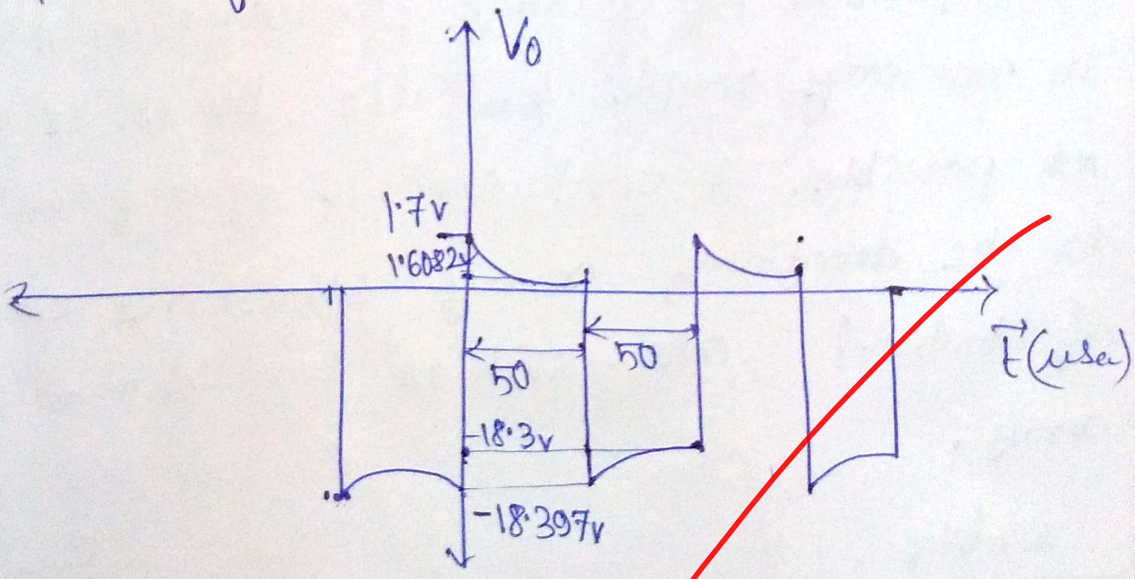
$\rightarrow V_2' = -18.3\ V$ $\quad [\because V_1 - V_2' = 20]$

$V_2 = 1.005 \times V_2' = -18.397 V$

$V_1 = 20 + V_2' = 1.7\ V$

$V_1' = V_1 \times 0.946 = 1.6082 V$

Output wave form



(6)
(c)

Modularity

Modularity allows that each block or module can be designed relatively independently from each other, since there is no ambiguity about the function and the signal interface of these blocks. All of the blocks can be combined with ease at the end of design process to form the large system.

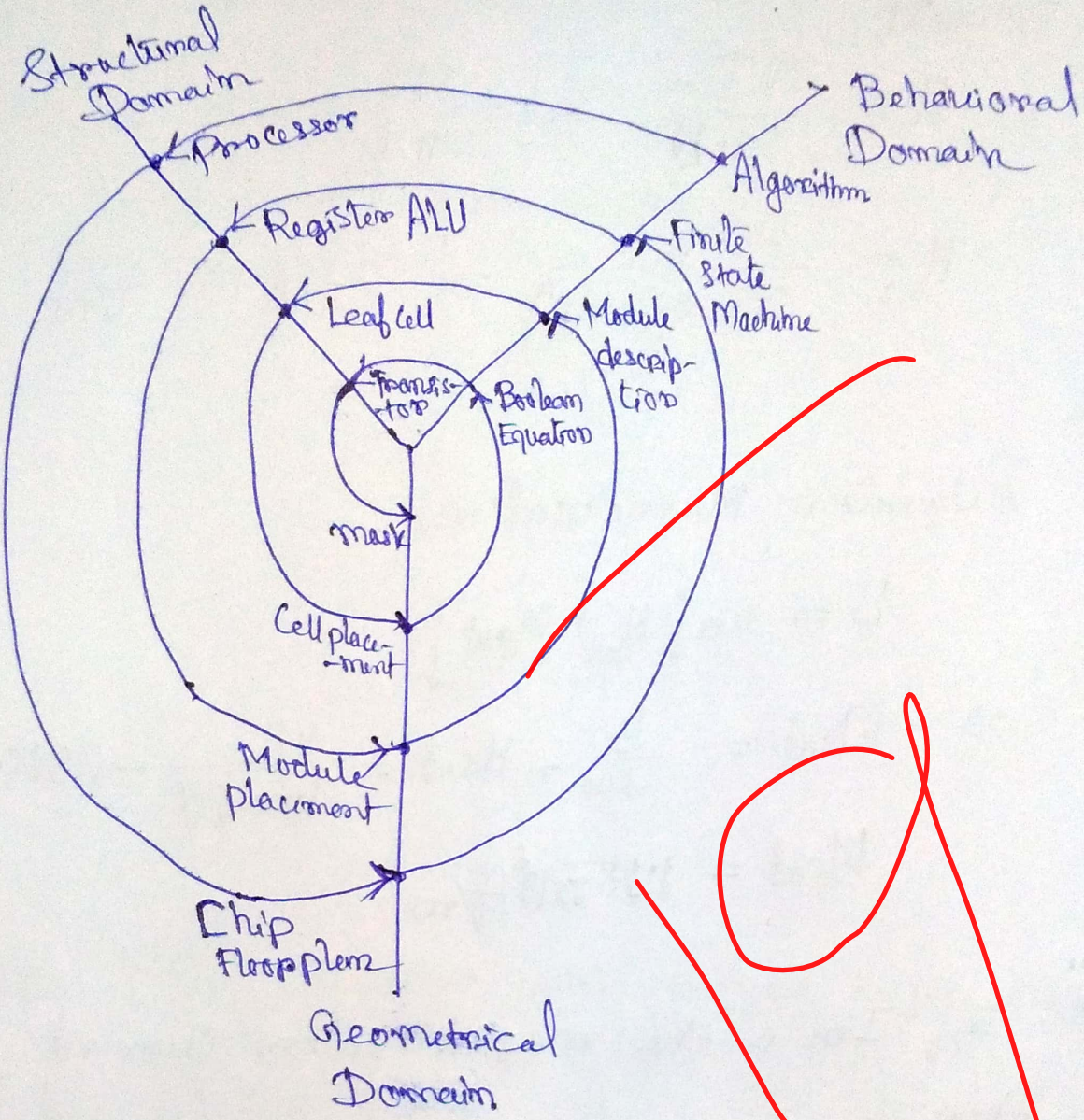
Regularity

Regularity means that the hierarchical decomposition of a large system should result in not only simple, but also blocks, as much as possible. A good example of regularity is the design of array structures consisting of identical cells - such as parallel multiplication array.

Locality

The concept of locality also ensures that connections are mostly between neighboring modules, avoiding long distance connection as much as possible.

(6) (c) (ii) Gajski Y-chart for HDL based design



(8) (a)

Given

Length $L = 20\text{cm}$

Diameter $d = 2\text{ cm}$

Turn $N = 200$

Current $I = 2\text{A}$.

Saturated Magnetic field $B = 1.5\text{T}$

(i) Magnetic field intensity at the centre of the solinoid

$$H = \frac{NI}{2\pi r_0} = \frac{NI}{2\pi d/2}$$

$$H_{sat} = \frac{200 \times 2}{2\pi \times \left(\frac{2\times10^{-2}}{2}\right)} = 6366.19 \text{ A/m.}$$

(ii) Saturation Magnetization,

$$B = \mu_0 [H_{sat} + M_{sat}]$$

$$\Rightarrow M_{sat} = \frac{B}{\mu_0} - H_{sat} = \frac{1.5}{4\pi\times10^{-7}} - 6366.19$$

$$M_{sat} = 1.187\times10^6 \text{ A/m.}$$

(iii) If Im is the magnetization current, then,

$$I_m = \frac{M \times 2\pi(d/2)}{N} = \frac{1.187\times10^6 \times 2\pi \times \left(\frac{2\times10^{-2}}{2}\right)}{200}$$

$$I_m = 373 \text{ A.}$$

(iv) If we remove the magnetic core the $M = 0$,

Required current

$$I = \frac{\left(\frac{B}{\mu_0}\right) \times 2\pi(d/2)}{N} = \frac{1.5}{4\pi\times10^{-7}} \times \frac{2\pi \times \left(\frac{2\times10^{-2}}{2}\right)}{200}$$

$$\boxed{I = 375 \text{ A}}$$

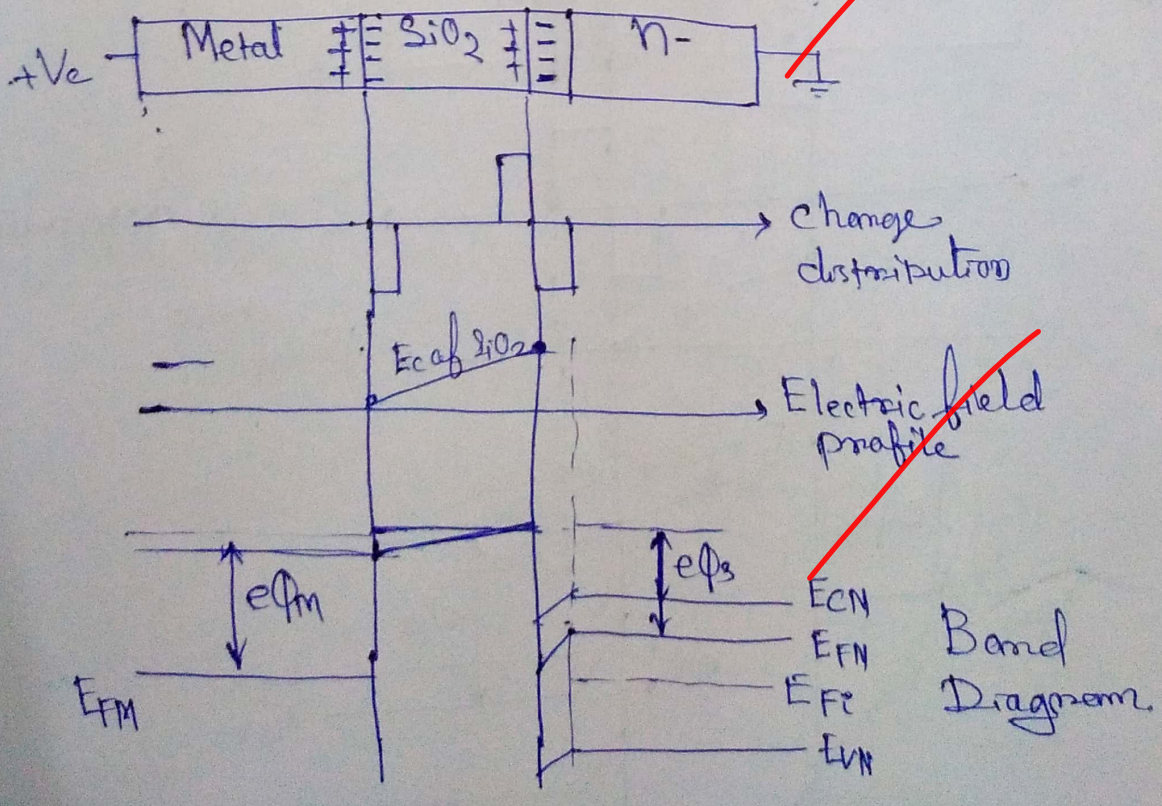
It is impossible to do in normal condition with normal material.

This is possible, only with material in superconducting state.

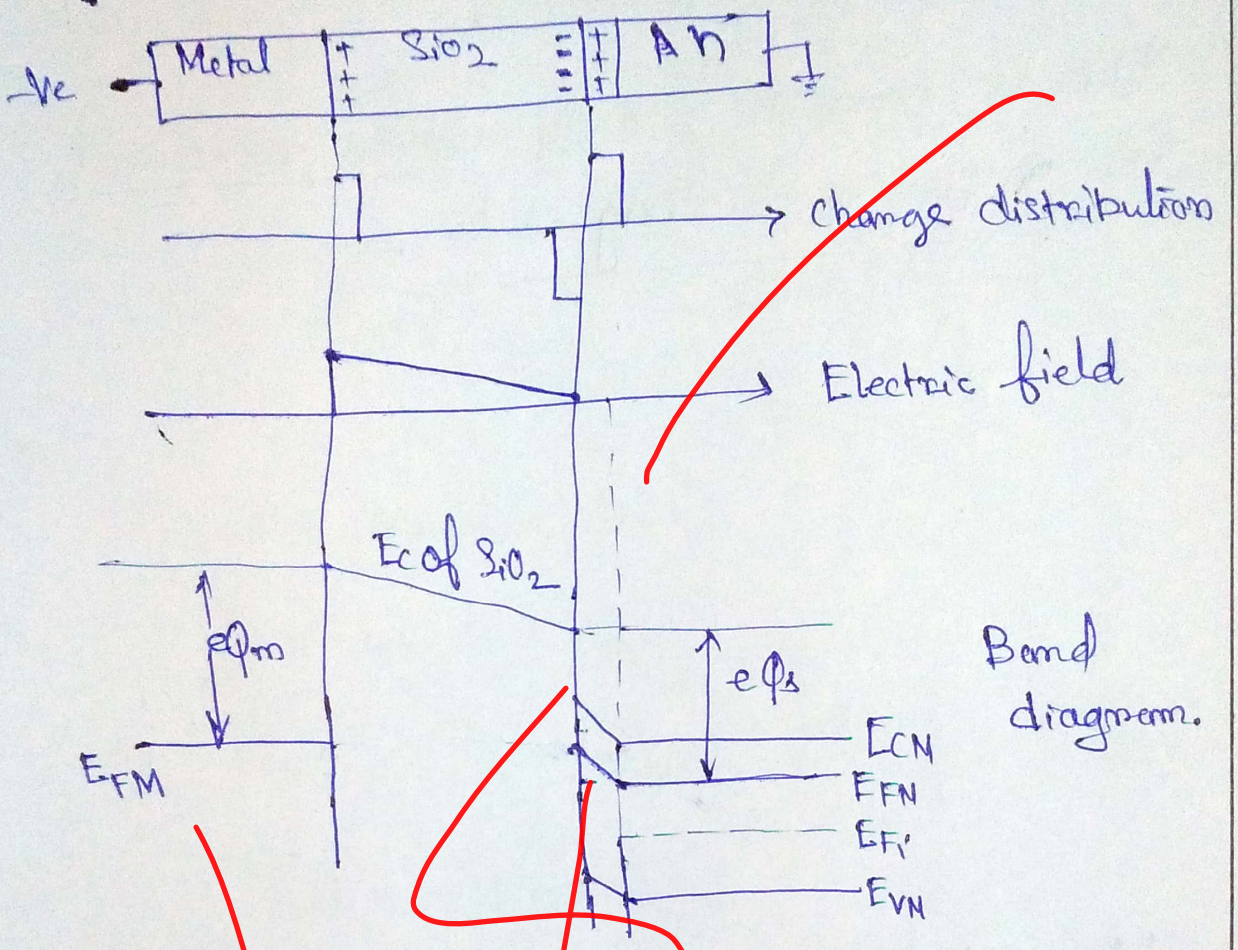
(8)
(b)

MOS capacitor with n-type substrate

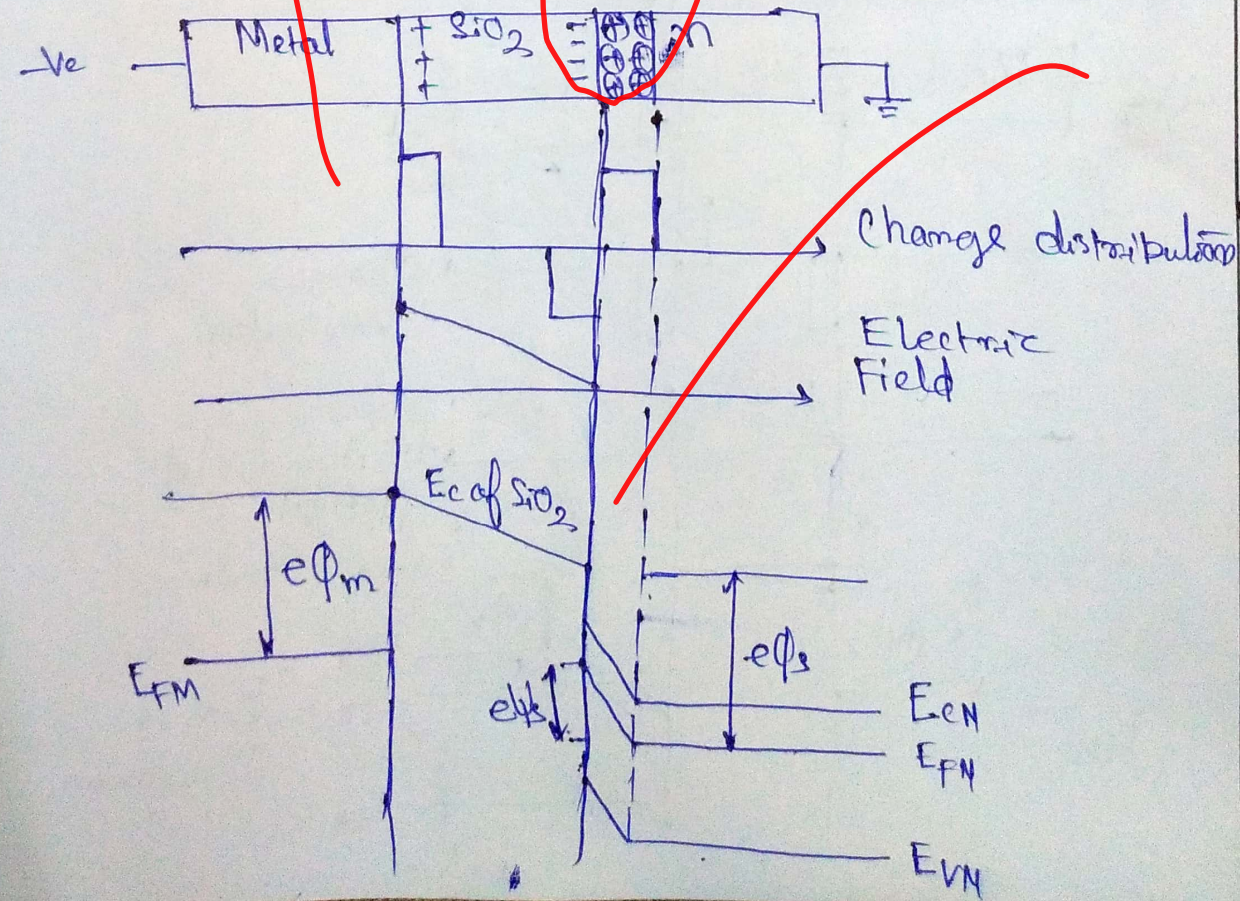
1) Accumulation mode.



(2) Depletion mode

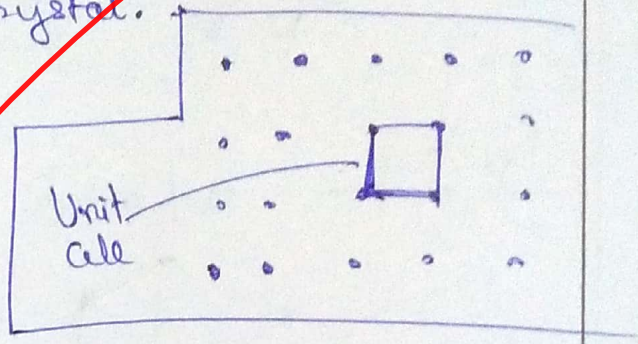


(3) Inversion mode



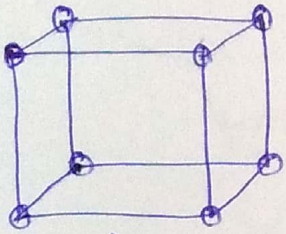
(8)(c) **Unit cell**

A unit cell is defined as the basic structure of crystal which is repeated periodically to to form crystal.

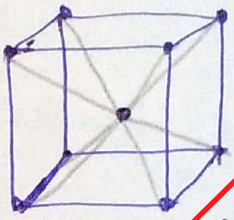


Bravais' unit cell

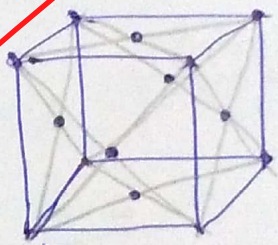
Cubic $a=b=c$, $\alpha=\beta=\gamma=90°$



Simple Cubic (P)

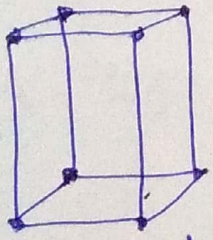


Body Centred Cubic (I)

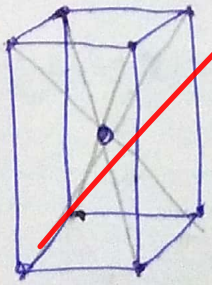


Face Centred Cubic (F)

Tetragonal $a=b\neq c$, $\alpha=\beta=\gamma=90°$

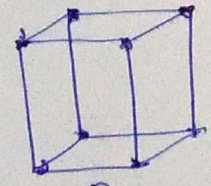


Tetragonal P

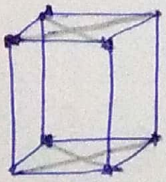


Tetragonal I

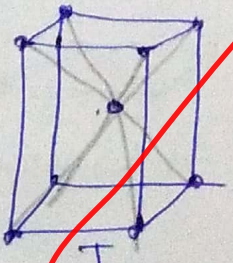
Orthorhombic $a\neq b\neq c$ $\alpha=\beta=\gamma=90°$



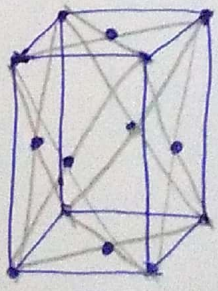
P



C



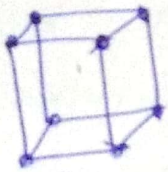
I



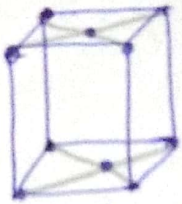
F

Monoclinic

$a \neq b \neq c, \quad \alpha = \gamma = 90 \neq \beta$



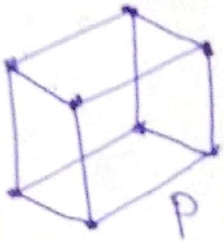
P



C

Triclinic

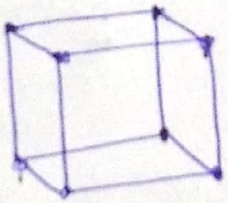
$a \neq b \neq c \quad , \quad \alpha \neq \beta \neq \gamma \neq 90^\circ$



P

Trigonal

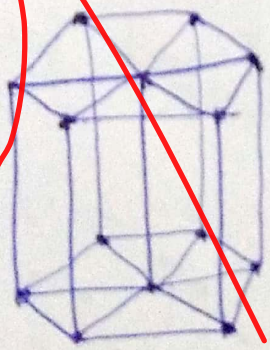
$a = b = c, \quad \alpha = \beta = \gamma \neq 90^\circ$



R.

Hexagonal

$a_1 = a_2 = a_3 \neq c \quad \alpha = \beta = 90^\circ, \gamma = 120^\circ$



Hexagonal e (or P)