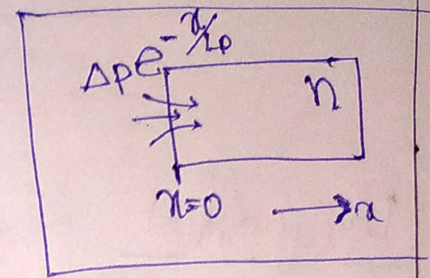
Name :-

Roll No :-

Test 10 :- FULL LENGTH TEST
(Paper I)

(1) (a)

Given that,



$N_D = 1.5 \times 10^{18}\ cm^{-3}$

$\tau_n = \tau_p = 10^{-7}$ sec

$D_p = 12\ cm^2/s$,

$D_n = 36\ cm^2/s$. $J_p(0) = 10\ \mu A/cm^2 = 10^{-5}\ A/cm^2$

For silicon $n_i = 1.5 \times 10^{10}\ cm^{-3}$

Minority hole carrier due to thermal generation

$$P_{no} = \frac{n_i^2}{n} = \frac{n_i^2}{N_D} \quad [\because n_i << N_D,\ n \cong N_D].$$

$$P_{no} = \frac{(1.5 \times 10^{10})^2}{1.5 \times 10^{18}} = 1.5 \times 10^2\ cm^{-3}.$$

Hole concentration at distance x is

$$P_n = P_{no} + \Delta p e^{-\frac{x}{L_p}} \quad \text{——— (1)}$$

Hole diffusion current density

$$J_p(x) = -eD_p \frac{\partial}{\partial x}(P_n).$$

$$J_p(x) = -eD_p \frac{\partial}{\partial x}\left(P_{no} + \Delta p e^{-x/L_p}\right)$$

$$\Rightarrow J_p(x) = +\frac{eD_p}{L_p} \Delta p e^{-x/L_p} \quad \text{——— (2)}$$

$\rightarrow$ At $x=0$ $J_p(x) = 10^{-5}\ A/cm^2$

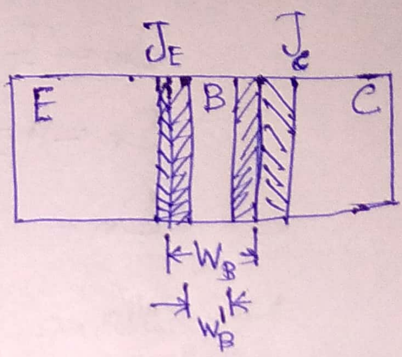
$$J_p(0) = \frac{eD_p}{L_p} \Delta p \quad \left[\text{Diffusion length } \because L_p = \sqrt{D_p \tau_p}\right]$$

$$\rightarrow \Delta p = \frac{J_p(0)\ \sqrt{D_p \tau_p}}{eD_p}$$

$$\Delta p = \frac{J_p(0)}{e}\sqrt{\frac{\tau_p}{D_p}} = \frac{10^{-5}}{1.6 \times 10^{-19}} \times \sqrt{\frac{10^{-7}}{12}} = 5.705 \times 10^{9}\ cm^{-3}$$

$$\boxed{\Delta P_{required} = 5.705 \times 10^{9}\ cm^{-3}}$$

(1)
(b)



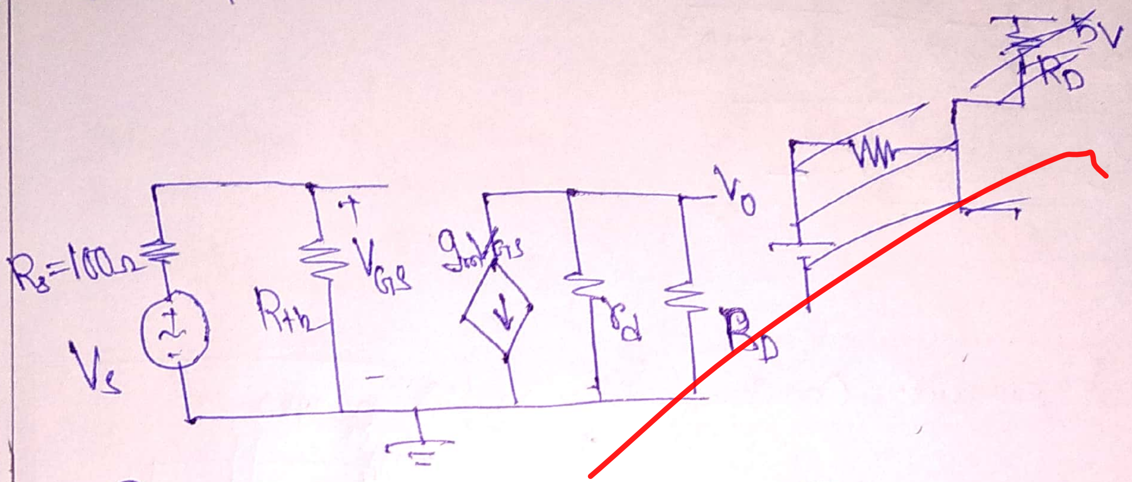
Early effect

For BJT, when we ~~connect~~ baised it in active region i.e. J_E in forward bais and J_C in reverse bais, a depletion region will form as shown in the figure. If we keep on raise the reverse bais voltage then the effective base width (W_B') will keep on decreasing. Which lead to less recombination in base, and rise in small signal current gain α and β.

As a result the value of I_C is also rises.

At a critical value of reverse voltage V_{CB}, effective base width W_B' decreases to zero. This condition is called punch through. which causes a huge current I_C leads to permanent damge of transistor. Due to ~~to~~ early effect transistor gain also rises and makes $V_{CB} - I_C$ output characteristics curve in saturation region stipper instead of flat.

1 (c) AC ~~DC~~ equivalent circuit can be drawn as



Given, $g_m = 2mA/V$, $r_d = 20\,k\Omega$.

Mid band gain $A_v = -30$,

And $R_{th} = (5 \| 1)\,k\Omega$

$R_{th} = \frac{5}{6}\,k\Omega$

Apply KVL in the input loop we get,

$$V_{GS} = V_s \cdot \frac{R_{th}}{R_s + R_{th}}$$ [By using voltage division rule] ——— (1)

$\Rightarrow$ ~~V_{GS}~~

By KVL, in output loop.

$$V_o = -g_m V_{GS} \cdot (r_d \| R_D)$$ ——— (2)

$\Rightarrow$ By using eqn (1) and (2) we get

$$V_o = -g_m \frac{R_{th}}{R_s + R_{th}} (r_d \| R_D) \cdot V_s$$

$$\Rightarrow A_v = \frac{V_o}{V_s} = -\frac{g_m R_{th}}{R_s + R_{th}} (r_d \| R_D)$$

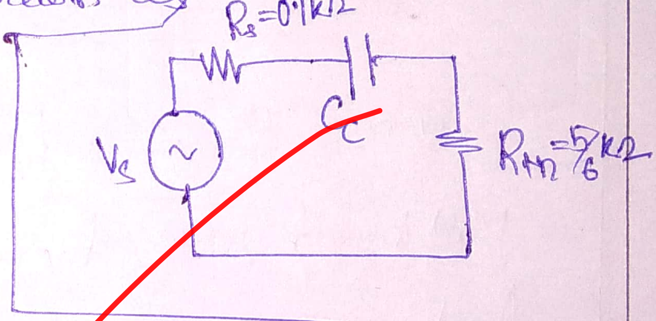
$$-30 = -\frac{2\times10^{-3} \times 5/6 \times 10^3}{(0.1 + 5/6)\times10^3} (r_d \| R_D).$$

$(R_D \| r_d) = 16.8 \times 10^3$

$$\Rightarrow \frac{1}{R_D} + \frac{1}{20 \times 10^3} = \frac{1}{16.8 \times 10^3}$$

$$\Rightarrow \boxed{R_D = 105\ k\Omega}$$

☐ Input circuit can be drawn as



Time Constant

$$\tau = R_{eq} C_{eq} = (R_s + R_{th})\, C_c.$$

Lower cutoff frequency, (Given $f_L = 150\ Hz$)

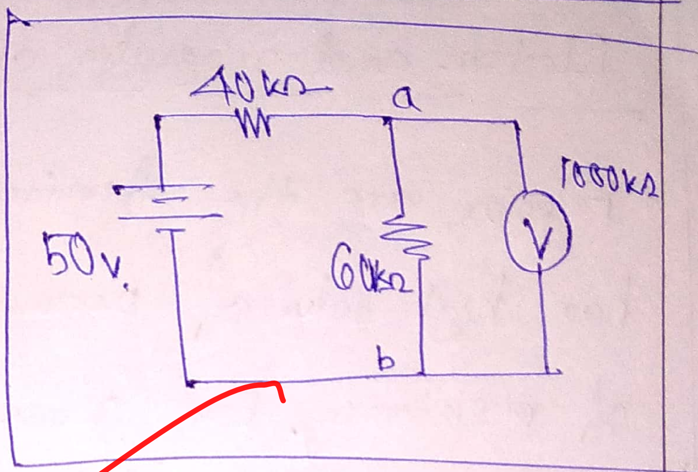
$$f_L = \frac{1}{2\pi\tau} = \frac{1}{2\pi R_{eq} C_c}$$

$$\Rightarrow C_c = \frac{1}{2\pi (R_{th} + R_s) \cdot f_L}$$

$$= \frac{1}{2\pi\, (5/6 + 0.1) \times 10^3 \times 150}$$

$$\boxed{C_c = 1.137\ \mu F}$$

(1)
(d)



True value of voltage by using voltage division rule

$$V_{ab_t} = 50 \times \frac{60}{40+60}$$

$$V_{ab_t} = 30 \text{ V} \quad \text{——— (1)}$$

Equivalent resistance across 'ab'

$$R_{ab} = (60 \parallel 1000)$$

$$R_{ab} = 56.604 \text{ k}\Omega$$

Voltage reading shown by the voltmeter. by using Voltage division rule

$$V_m = \frac{R_{ab}}{R_{ab}+40} \times 50$$

$$V_m = \frac{56.604}{56.604+40} \times 50$$

$$V_m = 29.297 \text{ V} \quad \text{——— (2)}$$

Loading error

$$e_r = \frac{V_m - V_{ab_t}}{V_{ab_t}} = \frac{29.297 - 30}{30} \times 100\%$$

$$\boxed{e_r = -2.343\,\%}$$

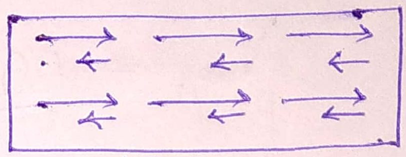
$$\text{Accuracy} = 100 - |\%\,e_r| = 100 - 2.340$$

~~% Acc = 97.656%~~

$$\boxed{\%\ \text{Accuracy} = 97.656\,\%}$$

(1)
(e) Electric and magnetic characteristics of Ferrites

Ferrites are the ferrimagnetic material which has high value of permeability and high value of resistance. For same domain of ferrites dipoles are aligned in anti parallel but they are inequal in magnite due to which we get a existance of net dipole moment.



Ferrites

By application of magnetic field ferrites can be magnetize easily due to its high value of permeability. And also can be demagnetize easily by applying opposite magnetic field. Due to its less hysteresis loss and high permeabity it can be used as transformer core, electromagnet core.

And also, resistance of ferrites is high respectively. And we know eddy current loss is inversely proportional to the resistance.

Due to which eddy current loss of ferrite is comparatively less.

10

(2) (a) (i)

Given that,

$N_D = 1\times10^{17}\ cm^{-3}$, $N_A = 3\times10^{17}\ cm^{-3}$

And $n_i = 10^{10}\ cm^{-3}$

It is a Compensated Semiconductor for which $N_D < N_A$.

Semiconductor will behave as p-type as $N_D < N_A$

Net hole concentration, at equilibrium

$$p \cong (N_A - N_D) = 3\times10^{17} - 1\times10^{17}\ cm^{-3}$$

$$\boxed{p = 2\times10^{17}\ cm^{-3}}$$

Assuming that dopants are fully ionized.

Equivalent electron concentration, at equilibrium by using Newton mass action Law.

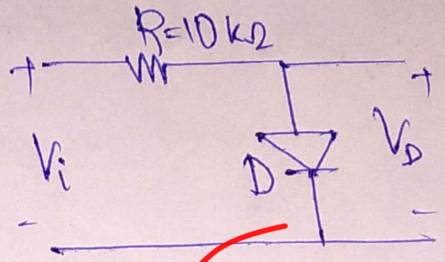
$$n = \frac{n_i^2}{p}$$

$$= \frac{(10^{10})^2}{2\times10^{17}} =$$

$$\boxed{n = 5\times10^2\ cm^{-3}}$$

5

(2) (a) (ii)



Given $V_i = 10 + 0.1 \sin \omega t$

$\gamma = 0.7V$,

$V_T = 25mV$.

DC current through the diode, by using KVL we get

$$10 = R I_{dc} + \gamma$$

$$\Rightarrow I_{dc} = \frac{10-\gamma}{R} = \frac{10-0.7}{10\times10^3}$$

$$I_{dc} = 0.93\ mA$$

Assuming the ideality factor $\eta = 1$ for the diode then small signal resistance of the diode.

$$r_d = \frac{\eta V_T}{I_{dc}} = \frac{1\times25}{0.93}$$

$$\boxed{r_d = 26.88\,\Omega}$$

Therefore AC voltage drop across the diode,

$$V_{Dac} = V_{AC} \times \frac{r_d}{r_d + R}$$

$$= 0.1 \times \frac{26.88}{26.88 + 10\times10^3}$$

$$\boxed{|V_{Dac}|_{peak} = 0.268\ mV}$$

(2) (b) Given, $\cancel{Q'_{ox} = 10^{20}\ cm^{-3}}$

polysilicon gate $N_d = 10^{20}\ /cm^3$

p-type substrate $N_a = 5\times10^{17}\ cm^{-3}$

$eN_{it} = Q'_{ox} = e \times 10^{12}\ cm^{-2}$

$n_i = 1\times10^{10}\ cm^{-3}$

$E_g = 1.12\ eV$, $\varepsilon_{si} = 11.7\ \varepsilon_0$,

$\varepsilon_{ox} = 3.9\ \varepsilon_0$.

$\frac{C_{max}}{C_{min}} = 1.5$,

$$\phi_p = V_T \ln\left(\frac{N_a}{n_i}\right) = 0.026 \times \ln\left(\frac{5\times10^{17}}{10^{10}}\right).$$

$\phi_p = 0.4609\ V.$

Surface potential $\psi_s = 2\times\phi_p = 0.9218\ V.$

(i) At the onset of strong inversion, maximum depletion width for C_{min},

$$W_{max} = \sqrt{\frac{2\ \varepsilon_{si}\ \psi_s}{e N_a}}$$

$$= \sqrt{\frac{2\times11.7\times8.854\times10^{-14}\times0.9218}{1.6\times10^{-19}\times5\times10^{17}}}$$

$W_{max} = 4.89\times10^{-6}\ cm$

Capacitance ~~per~~ due to depletion width,

$$C_{si} = \frac{\epsilon_{si} A}{W_{max}} \qquad [A = \text{area}]$$

$C_{\cancel{max}}$ = Capacitance due to oxide layer

$$C_{ox} = \frac{\epsilon_{ox} A}{t_{ox}}$$

And
$$C_{min} = \frac{C_{si} \times C_{ox}}{C_{si} + C_{ox}} = \frac{\frac{\epsilon_{si} A}{W_{max}} \times \frac{\epsilon_{ox} A}{t_{ox}}}{\frac{\epsilon_{si} A}{W_{max}} + \frac{\epsilon_{ox} A}{t_{ox}}} \quad \text{—— (1)}$$

And
$$C_{max} = \frac{\epsilon_{ox} A}{t_{ox}} \quad [\text{When } C_{si} = 0] \quad \text{—— (2)}$$

Therefore,

$$\frac{C_{max}}{C_{min}} = \frac{\frac{\epsilon_{ox} A}{t_{ox}}}{\frac{\frac{\epsilon_{si} A}{W_{max}} \times \frac{\epsilon_{ox} A}{t_{ox}}}{\frac{\epsilon_{si} A}{W_{max}} + \frac{\epsilon_{ox} A}{t_{ox}}}}$$

$$\Rightarrow 1.5 = \frac{\frac{\epsilon_{ox}}{t_{ox}} \left(\frac{\epsilon_{si}}{W_{max}} + \frac{\epsilon_{ox}}{t_{ox}} \right)}{\frac{\epsilon_{si}\,\epsilon_{ox}}{W_{max}\, t_{ox}}}$$

$$\Rightarrow 1.5 = \left(1 + \frac{W_{max}}{t_{ox}} \frac{\epsilon_{ox}}{\epsilon_{si}} \right)$$

$$\Rightarrow t_{ox} = 2 \frac{W_{max}\, \epsilon_{ox}}{\epsilon_{si}}$$

$$t_{ox} = \frac{2 \times 4.89 \times 10^{-6} \times 11.7 \times 8.854 \times 10^{-14}}{3.9 \times 8.854 \times 10^{-14}}$$

$$\boxed{t_{ox} = 2.93 \times 10^{-5}\ \text{cm}}$$

(ii)

$$\phi_{ms} = \cancel{\phi}\ (E_{vac} - E_{FN}) - (E_{vac} - E_{FP})$$

$$= E_{FP} - E_{FN}.$$

$$= -(E_{Fi} - E_{FP}) - (E_{FN} - E_{Fi})$$

$$= -\phi_P - \phi_N.$$

$$\phi_{ms} = -V_T \ln\left(\frac{N_a}{n_i}\right) - V_T \ln\left(\frac{N_d}{n_i}\right)$$

$$= -0.026 \ln\left(\frac{5\times10^{17}}{10^{10}}\right) - 0.026 \ln\left(\frac{10^{20}}{10^{10}}\right).$$

$$\phi_{ms} = -1.0596\,V$$

Therefore flat-band voltage

$$V_{FB} = \phi_{ms} - \frac{Q'_{ox}}{C_{ox}}$$

$$= \phi_{ms} - \frac{eN_{it}}{\varepsilon_{ox}/t_{ox}}$$

$$= -1.0596 - \frac{10^{12} \times 1.6\times10^{-19} \times 2.93\times10^{-5}}{3.9 \times 8.854\times10^{-14}}$$

$$\boxed{V_{FB} = -14.64\,V}$$

(2)
(C)

Given $Q = 6\times10^{-11}$ C

$A = 100\ mm^2$

$\Rightarrow A = 10^{-4}\ m^2$, $d = 5mm = 5\times10^{-3}$ m.

$\epsilon_r = 4$

(i)

Equivalent capacitance of the parallel plate Capacitor

$$C = \frac{\epsilon A}{d} = \frac{4\times8.854\times10^{-12}\times10^{-4}}{5\times10^{-3}}$$

$$\boxed{C = 7.0832\times10^{-13}\ F}$$

Voltage required to store the charge, Q.

$$V = \frac{Q}{C} = \frac{6\times10^{-11}}{7.0832\times10^{-13}}$$

$$\boxed{V = 84.707\ Volt}$$

(ii)

Value of Capacitance,

$$\boxed{C = 7.0832\times10^{-13}\ F}$$

(iii)

Electric field magnitude

$$|E| = \frac{V}{d} = \frac{84.704}{5\times10^{-3}}\ V/m$$

$$|E| = 16.941\ kV/m$$

Dielectric displacement

$$|D| = \epsilon E = 4\times8.854\times10^{-12}\times16941\ C/m^2$$

$$|D| = 6\times10^{-7}\ C/m^2$$

Polarization,

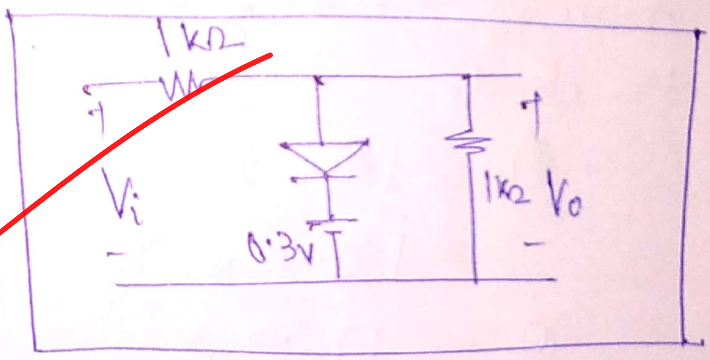
$$P = X_e \epsilon_0 E$$

$$= (\epsilon_r - 1)\epsilon_0 E$$

$$= (4-1) \times 8.854 \times 10^{-12} \times 16941$$

$$\boxed{|P| = 4.5 \times 10^{-7} \ C/m^2}$$

(3)
(a) Given, ~~Circuit~~ that



$V_{i\,pp} = 2V$.

And $f = 100$ Hz.

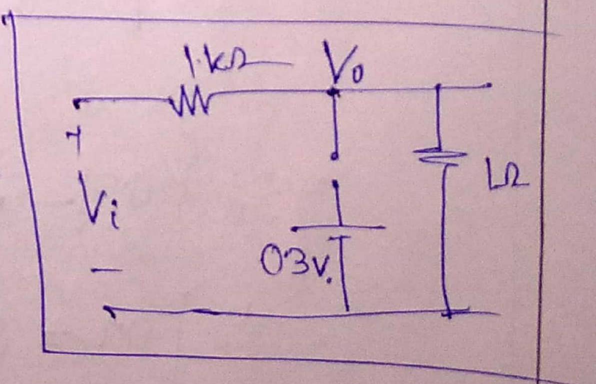
$$T = \frac{1}{100} = 10 \text{ ms}$$

Let assume the input voltage with $f = 100$ Hz and $V_{ipp} = 2V$.

$$V_i = \frac{2}{2} \sin(2\pi 100 t)$$

$$V_i = \sin(200\pi t).$$

~~As~~ Redrawn the Circuit when the diode is not conducting,



By using voltage division rule,

$$V_o = \frac{1}{1+1} \times V_i$$

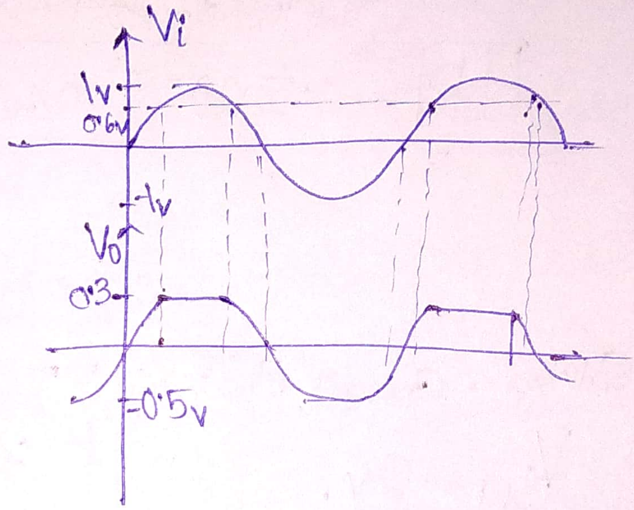
$$\Rightarrow V_o = \frac{V_i}{2}$$

And when the diode is conducting, i.e. for $V_i/2 > 0.3 \Rightarrow V_i > 0.6$, then $V_o = 0.3V$.

Therefore,

$$V_o = \begin{cases} V_i/2 & \text{for } V_i \leq 0.6 \\ 0.3 & \text{for } V_i > 0.6. \end{cases}$$

Output waveform can be drawn as



$V_{o_{AV}} = \frac{1}{2\pi}\int_0$

~~Period of~~
Angle of conducting the diode

$$\theta_c = 180 - 2\alpha$$

$$= 180 - 2 \times \sin^{-1}\left(\frac{0.6}{1}\right).$$

$$\theta_c = 106.26^\circ$$

And, $\alpha = \sin^{-1}(0.6) = 36.87^\circ$

Average output voltage,

$$V_{o_{AV}} = \frac{1}{2\pi}\left[\int_0^{36.87} \cancel{0.3}\ 0.5 \sin(\omega t)\ \cancel{\omega t}\ d(\omega t) + \int_{36.87}^{143.13} 0.3\ d(\omega t) + \int_{143.13}^{360^\circ} 0.5 \sin \omega t\ d(\omega t)\right]$$

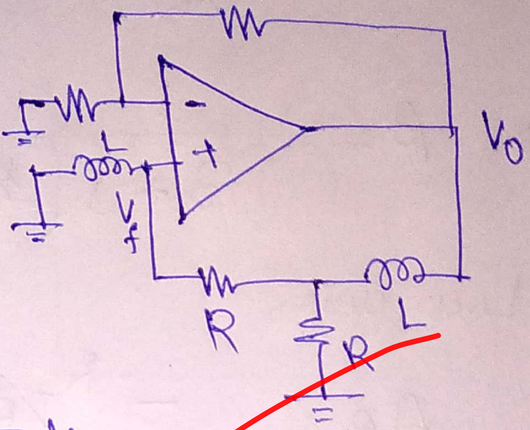
$$= \frac{1}{2\pi}\left\{0.5\left[-\cos \omega t\right]_0^{36.87} + \frac{0.3 \times 106.26}{180}\pi + 0.5\left[-\cos\omega t\right]_{143.13}^{360}\right\}$$

$$= \frac{1}{2\pi}\left[0.1 + 0.55637 + (-0.90)\right]$$

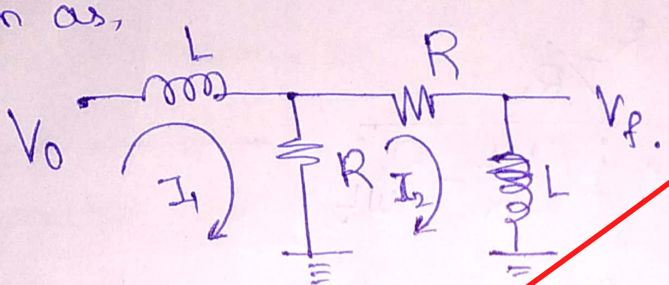
$$V_{o\,AV} = -0.038774 \text{ Volt}$$

$$\boxed{V_{o\,Avg.} = -38.774 \text{ mV}}$$

(3)(b) Given Circuit



Feedback circuit can be redrawn as,



By KVL equations, given by,

$$\cancel{V_0 =}\ I_1(X_L+R) - I_2R = V_0. \qquad (1)$$

$$I_1 = \frac{V_0 + I_2R}{X_L+R} \qquad (2)$$

where $[X_L = j\omega L]$

And also,

$$(2R+X_L)I_2 - RI_1 = 0. \qquad (3)$$

By substituting the value of I_1 in the eqn (3) we get,

$$(2R+X_L)I_2 - R\left(\frac{V_0+I_2R}{X_L+R}\right) = 0.$$

$$\Rightarrow \frac{(2R+X_L)(X_L+R)I_2}{R} - RI_2 = V_0$$

$$\Rightarrow I_2 = \frac{V_0 \quad R}{2R^2+3RX_L+X_L^2} V_0 \qquad (4)$$

Therefore feedback factor

$$\beta = \frac{V_f}{V_0} = \frac{I_2 X_L}{V_0} = \frac{RX_L}{R^2+3RX_L+X_L^2}$$

$$\beta = \frac{1}{\left(\frac{R}{X_L}\right) + 3 + \left(\frac{X_L}{R}\right)} \qquad \left[\because X_L = j\omega L\right]$$

$$\Rightarrow \beta = \frac{1}{3 + j\left(\cancel{R}\frac{\omega L}{R} - \frac{R}{\omega L}\right)} \quad \text{———} \quad (5)$$

Loop gain,

$$A\beta = \frac{-R_2/R_1}{3 + j\left(\frac{\omega L}{R} - R/\omega L\right)} \quad \text{———} \quad (6)$$

For oscillation, $A\beta$ should ~~be purely~~ not contain imaginary part.

therefore,

$$j\left(\frac{\omega_r L}{R} - \frac{R}{\omega_r L}\right) = 0.$$

$$\Rightarrow \omega_r^2 = \frac{R^2}{L^2}$$

$$\Rightarrow \boxed{f_r = \frac{R}{2\pi L}}$$

And also, to sustain oscillation,

$$|A\beta| \geq 1$$

$$\Rightarrow \frac{R_2/R_1}{3} \geq 1$$

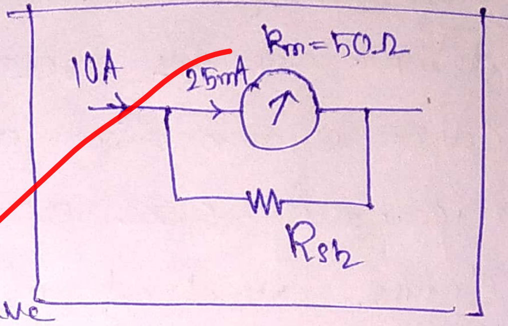
$$\Rightarrow \boxed{R_2 \geq 3R_1}$$

3 (c)

Given that,

$I_{fs} = 25\,mA$. $R_m = 50\,\Omega$

(i) Ammeter 0-10A range



To convert the given PMMC as 0-10A ammeter we have to connect a shunt resistance Rsh, parallel to the meter as shown in figure.

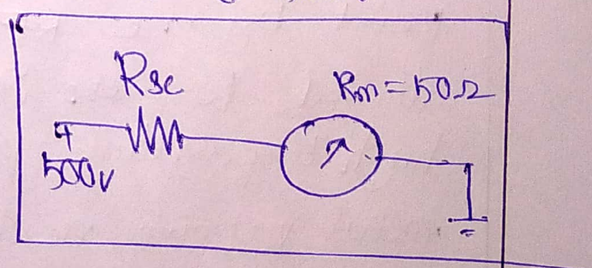
$$\eta = \frac{I}{I_{fs}} = \frac{10}{25\times10^{-3}} = 400.$$

$$R_{sh} = \frac{R_m}{\eta - 1} = \frac{50}{400-1} =$$

$$\boxed{R_{sh} = 0.1253\,\Omega}$$

(ii) Voltmeter (0-500v).

To convert the given PMMC into a 0-500v voltmeter we have to connect a high value of resistance, series with the meter as shown in figure.



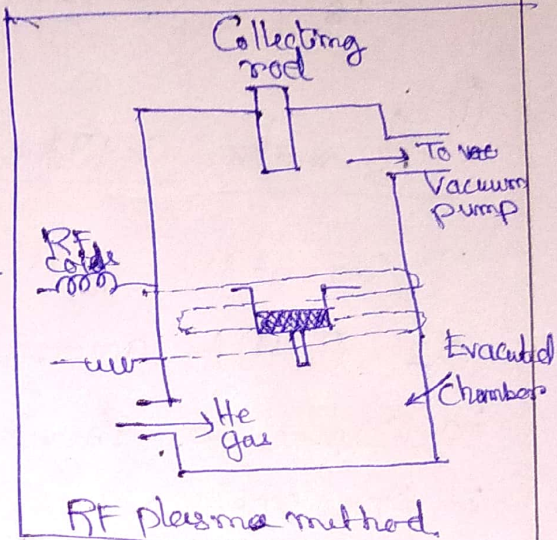
$$\eta = \frac{V}{R_m I_{fs}} = \frac{500}{50\times25\times10^{-3}} = 400.$$

$$R_{se} = (\eta - 1) R_m = (400-1)\,50$$

$$\boxed{R_{se} = 19.95\,k\Omega}$$

(3) (d) RF plasma method for preparing nano material

Thermal plasma can also deliver energy necessary to cause evaporation of small micrometer size particles. Fig shows a method of Nano particle synthesis utilizing plasma generated by radio

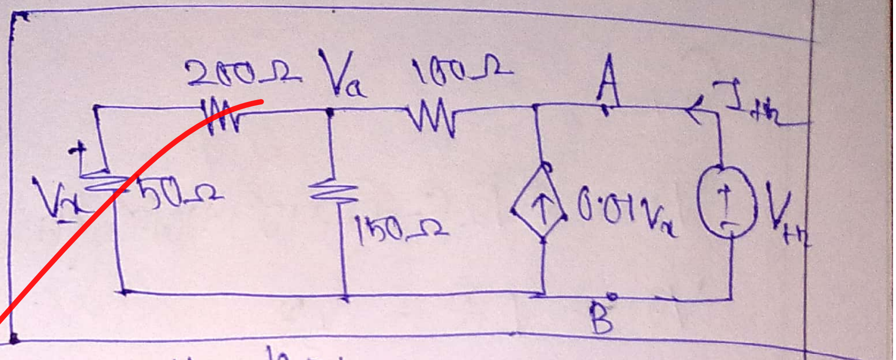


RF plasma method.

frequency heating coil. The metal is contained in a pestle in an evacuated chamber. The RF Coils are wrapped around the evacuted system in the vicinity of the pestle. The evacuated chamber is provided with an opening to enter helium Gas. The evacuated chamber is also provided with a cluster collection device of liquid nitrogen filled cold finger scrapper assembly.

The metal is heated above the evaporation point by the ~~RF~~ RF coils. Now helium gas is allowed to pass into evacuated chamber which forms high temperature plasma in the region of coils. The metal vapour nucleates on the helium gas atoms. It is important to mention here ~~tose~~ those ultra fine particle formed by collision of evaporated atoms with residual gas molecules. They now diffuse to colder collector rod where Nano particle are formed.

(5) (a) ~~Given network~~



To find the R_{th} we have connected a voltage source V_{th} with current I_{th} across ~~the~~ 'AB'.

By KCL ~~on~~ at node 'a'

$$\frac{V_a - V_{th}}{100} + \frac{V_a}{200+50} + \frac{V_a}{150}$$

$$\Rightarrow V_a\left(\frac{1}{100} + \frac{1}{250} + \frac{1}{150}\right) = \frac{V_{th}}{100}$$

$$\Rightarrow V_a = 0.4839\, V_{th} \quad \text{———— (1)}$$

By KCL at node 'A'.

$$\frac{V_{th} - V_a}{100} = 0.01\, V_x + I_{th}$$

$$\Rightarrow V_{th} - V_a = 0.01 \times 100\left(\frac{V_a}{5}\right) + 100 I_{th} \quad \left[\because V_x = \frac{V_a \times 50}{50+200} \Rightarrow V_x = \frac{V_a}{5}\right]$$

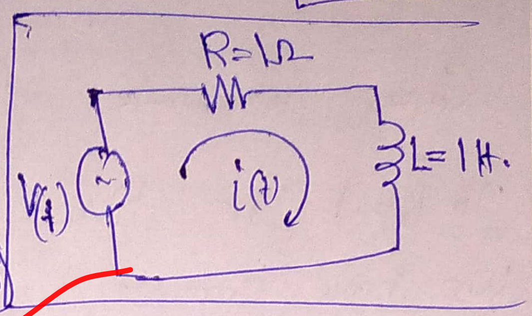
$$\Rightarrow V_{th} = (1+0.2)\, V_a + 100 I_{th}$$

$$\Rightarrow V_{th}(1 - 1.2 \times 0.4839) = 100\, I_{th} \quad [\because V_a = 0.4839\, V_{th}]$$

$$\Rightarrow \frac{V_{th}}{I_{th}} = R_{th} = \frac{100}{1 - 1.2 \times 0.4839}$$

$$\boxed{R_{th} = 238.46\, \Omega}$$

5 (b)



Given,

$V(t) = 10\sqrt{2}\cos(t+10^\circ) + 10\sqrt{5}\cos(2t+10^\circ)$

$V(t) = V_1(t) + V_2(t)$

Current will be the sum of ~~2~~ current due to ~~Compound~~ voltage component $V_1(t)$ and $V_2(t)$.

For input voltage $V_1(t) = 10\sqrt{2}\cos(t+10^\circ)$.

$W = 1$ rad/sec.

Impedence $Z_1 = (R + jWL) = (1 + j\times1\times1)$

$Z = \sqrt{2}\angle 45^\circ$

Therefore current

$i_1(t) = \frac{V_1(t)}{Z} = \frac{10\sqrt{2}\cos(t+10^\circ)}{\sqrt{2}\angle 45^\circ}$

$i_1(t) = 10\cos(t-35^\circ)$ ——— (1)

For input voltage, $V_2(t) = 10\sqrt{5}\cos(2t+10^\circ)$.

$W = 2$ rad/sec.

~~Curr~~ Impedence, $Z = R + jWL = 1 + j\times2\times1$

$Z = \sqrt{5}\angle 45^\circ$

Current $i_2(t) = \frac{V_2(t)}{Z} = \frac{10\sqrt{5}\cos(2t+10^\circ)}{\sqrt{5}\angle 45^\circ}$

$i_2(t) = 10\cos(2t-35^\circ)$ ——— (2)

Net current

$$i(t) = i_1(t) + i_2(t)$$

$$\Rightarrow \boxed{i(t) = 10\cos(t - 35^\circ) + 10\cos(2t - 35^\circ)} \text{ A.}$$

5) (c)

Given that,

$P_I \big|_{f = 50\text{ Hz}, E = 300\text{ V}} = 2000$ W.

$P_I \big|_{f = 25\text{ Hz}, E = 150\text{ V}} = 800$ W.

We know, $E = 4.44 f N \phi_m$.

~~As,~~ $\frac{E_1}{f_1} = \frac{300}{50} = 6,$

$\frac{E_2}{f_2} = \frac{150}{25} = 6.$

As, $\frac{E_1}{f_1} = \frac{E_2}{f_2}$ therefore flux ϕ_m is constant

here, And we know,

Hysteresis loss $P_h = \phi_m^{1.6} f$ ie

$P_h = K_1 f$ ——— (1) [$\because \phi_m$ = constant]

K_1 = Constant

And Eddy current loss,

$P_e = \phi_m^2 f^2 v t^2$

$P_e = k_2 f^2$ ——— (2) [k_2 = constant]

There fore,

$$P_I|_{f=50\,Hz} = P_h|_{f=50\,Hz} + P_e|_{f=50\,Hz}$$

$$\Rightarrow \quad 2000 = K_1\, 50 + K_2\, 50^2$$

$$\Rightarrow \quad K_1 + 50K_2 = 40 \quad \text{———} \quad (3)$$

And also,

$$P_I|_{f=25} = P_h|_{f=25\,Hz} + P_e|_{f=25\,Hz}$$

$$\Rightarrow \quad 800 = 25K_1 + K_2\, 25^2$$

$$\Rightarrow \quad K_1 + 25K_2 = 32 \quad \text{———} \quad (4)$$

By eq^n (3) − eq^n (4) we get,

$$25K_2 = 8$$

$$K_2 = 0{\cdot}32$$

Substituting the value of K_2 into eq^n (3) we get,

$$K_1 = 40 - 50 \times 0{\cdot}32$$

$$K_1 = 24$$

Hence, Hysteresis loss at 300V, 50 Hz

$$P_h|_{f=50\,Hz} = K_1 \times f = 24 \times 50$$

$$\boxed{P_h|_{\substack{f=50\,Hz \\ E=300V}} = 1200\ W.}$$

And Eddy current loss,

$$\boxed{P_e|_{\substack{f=50\,Hz \\ E=300V}} = 2000 - 1200 = 800\ W}$$

(5) (d)

(i) Given,

$$F = \bar{A}B\bar{C} + A\bar{C}D + BC + \bar{A}\bar{B}D + A\bar{B}CD.$$

$\cancel{F = \bar{A}B\bar{C} + A\bar{C}}$

$$F = \bar{A}B\bar{C}(D+\bar{D}) + A(B+\bar{B})\bar{C}D + (A+\bar{A})BC(D+\bar{D}) + \bar{A}\bar{B}(C+\bar{C})D + A\bar{B}CD$$

$$F = \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}CD + \cancel{\bar{A}B\bar{C}\bar{D}} + \bar{A}B\bar{C}D + \bar{A}BC\bar{D} + \bar{A}BCD + AB\bar{C}D + ABCD + ABC\bar{D} + A\bar{B}\bar{C}D + A\bar{B}CD.$$

By using k-map. to minimize

AB \ CD	00	01	11	10
00		1	1	
01	1	1	1	1
11		1	1	1
10		1	1	

$$\boxed{F = D + \bar{A}B + BC}$$ Minimised boolean equation.

(ii) Given,

$$F = (AC + A\bar{C}D)(AD + AC + BC).$$

$$= A(C + \bar{C}D)(AD + AC + BC)$$

$$= A(C+D)(AD + AC + BC) \quad [\because (C + \bar{C}D) = C+D]$$

$$= A(C+D)[A(C+D) + BC]$$

$$= A(C+D) + A(C+D)BC$$

$$= A(C+D)[1 + BC] \quad [\because 1 + BC = 1]$$

$$\boxed{F = AC + AD}$$

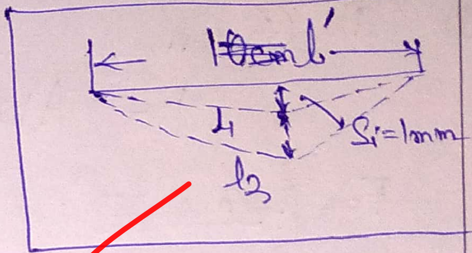
(5) (e)

Given that

$S_i = 1mm$

$l_1 = 10\,cm$

$\alpha = 20\times10^{-6}$ $\Delta t = 100°C$



~~Lntt~~ length of the wire ~~at~~ ~~100°C~~ due to rise of temperature $\Delta t = 100°c$.

$$l_2 = l_1(1+\alpha\Delta t)$$
$$= 10(1+20\times10^{-6}\times100).$$
$$l_2 = 10.02\ cm$$

When, Sag $S_i = 1mm$, for length $l_1 = 10\,cm$.
$l_1 = 100\,mm$

Therefore,
$$S_i^2 + (l'/2)^2 = \left(\frac{l_1}{2}\right)^2$$
$$\Rightarrow (l'/2)^2 = (l_1/2)^2 + S_i^2$$
$$= \left(\frac{100}{2}\right)^2 + 1^2$$
$$\Rightarrow (l'/2)^2 = 2501 \quad \text{——— (1)}$$

For length, $l_2 = 10.02\,cm = 100.2\,mm$, Sag S' is

$$\left(\frac{l'}{2}\right)^2 + (S')^2 = \left(\frac{l_2}{2}\right)^2$$

$$\Rightarrow 2501 + (S')^2 = \left(\frac{100.2}{2}\right)^2$$

from eqn(1) $\left[(l'/2)^2 = 2501\right]$

$$\boxed{S' = 3.0017\,mm}$$

(5)
(F)

Count the number of bytes

DS: 52000

Mnemonics	Algorithm
MOV DS, 5200 H.	Defining the Data Segment address.
MOV CX,00 H	
MOV AL,[000] H.	Loading the contain of [52000+000 H] into AL.
MOV AH, AL	Copy the contain of AL to AH.
AND AL, OF H	Anding of with OF and AL
JNZ S1	Jump to S1 on result not zero
S3: AND AH, FO H	
JNZ S2	
S4: MOV A, C	Move the Count to Acc.
MOV [001], A;	Store the Count to the location [52000+001 H],
HLT	
S1 INC C	
~~RET S2~~	
Jmp S3	
S2 INC C	
Jmp S4	

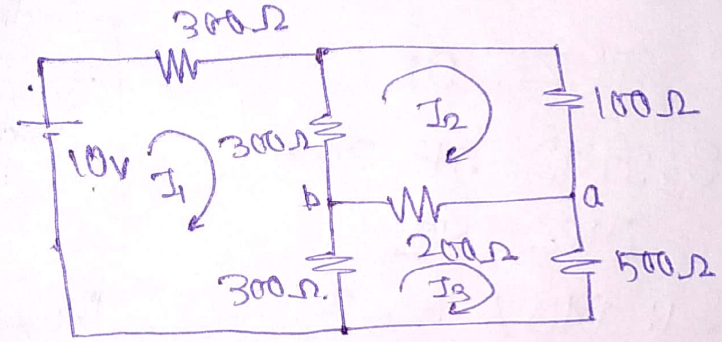
(6)
(a)

For the given problem a dc source of $V_1 = 10v$ and ac source of $V_2 = 10 \sin 100t$ are acting together.
We can find the current through 200 Ω resistance by using superposition theorem,

Case I

When, 10v source is acting alone, redrawn the circuit

inductor → S.C.
Capacitor → O.C



KVL equations

$$(300+300+300)I_1 - 300I_2 - 300I_3 = 10$$

$$900I_1 - 300I_2 - 300I_3 = 10 \quad \text{---------- (1)}$$

$$-300I_1 + (300+100+200)I_2 - 200I_3 = 0$$

$$\rightarrow -300I_1 + 600I_2 - 200I_3 = 0 \quad \text{---------- (2)}$$

$$-300I_1 - 200I_2 + (300+200+500)I_3 = 0$$

$$\rightarrow -300I_1 - 200I_2 + 1000I_3 = 0 \quad \text{---------- (3)}$$

By solving eq^n (1), (2) and (3) we get,

$$I_1 = \frac{7}{405}A, \; I_2 = \frac{1}{90}A, \; I_3 = \frac{1}{135}$$

$$I_{ab_1} = I_2 - I_3 = \frac{1}{90} - \frac{1}{135}$$

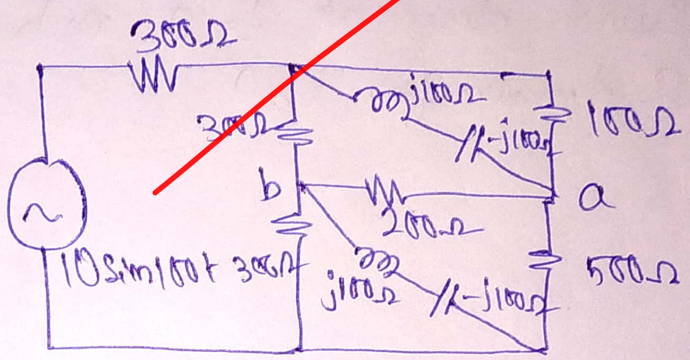
$$I_{ab_1} = 3.7037 \, mA$$

Case II

When ac voltage $10 \sin 100t$ acting is alone,

$\omega = 100$ rad/sec.

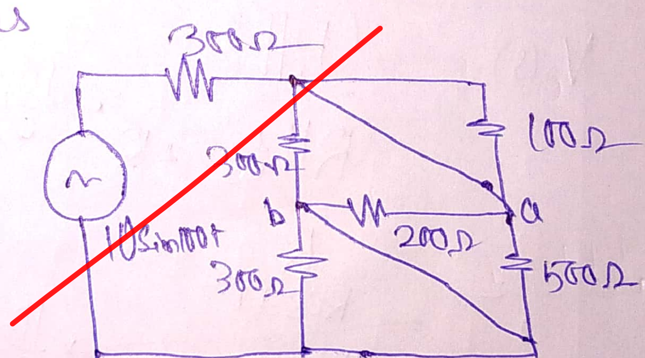
Redrawn the circuit, we get.



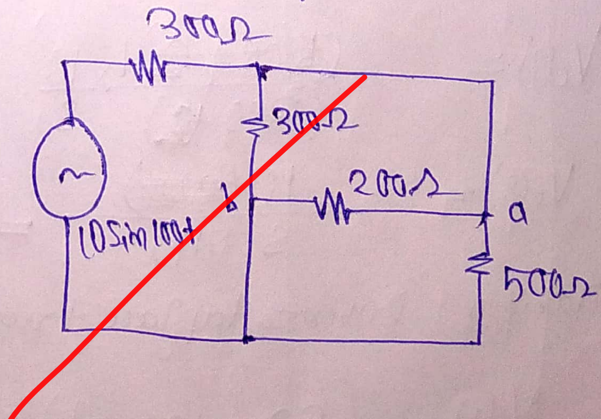
$$X_L = j\omega L = j\,1 \times 100 = j100\,\Omega$$

$$X_C = \frac{1}{j\omega C} = \frac{1}{j \times 100 \times 100 \times 10^{-6}} = -j100\,\Omega$$

Therefore the given circuit can be reduce as



|||



Hence voltage drop across the 200Ω resistor, by using voltage division rule

$$V_{ab} = \frac{(300 \| 200 \| 500)}{(300 \| 200 \| 500) + 300} \times V_s$$

$$V_{ab} = 0.2439 \times 10 \sin 100t$$

$$V_{ab} = 2.439 \sin 100t$$

Current through the 200Ω resistor.

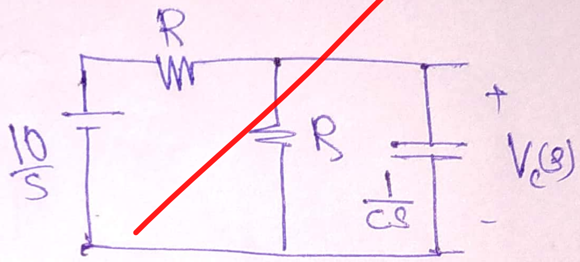
$$I_{ab_2} = \frac{V_{ab}}{200} = 12.195 \sin 100t \text{ mA} \quad \text{------ (2)}$$

Net Current $i(t) = I_{ab_1} + I_{ab_2} =$

$$\boxed{i(t) = 3.7037 + 12.195 \sin 100t \text{ mA}}$$

(6)(b) As ~~th~~ for the $t<0$, switch was in closed condition, Hence there is no change in the capacitor. i.e. $V_c(0^-) = 0\,V$.

Switch closed at $t=0$, redrawn the circuit in S-domain for $t \geq 0$



Where $R = 10^6\,\Omega$
$C = 10^{-6}\,F$
$RC = 10^6 \times 10^{-6}$ sec
$RC = 1$ sec ——(1)

By using voltage division rule,

$$V_c(s) = \frac{(R \| \frac{1}{CS})}{(R \| \frac{1}{CS}) + R} \cdot \frac{10}{S}$$

$$= \frac{\frac{R}{RCS+1}}{\frac{R}{RCS+1} + R} \times \frac{10}{S}$$

$$V_c(s) = \frac{(\cancel{RCS+2})\,1}{(RCS+2)} \times \frac{10}{S} \quad [\text{And } RC = 1]$$

$$V_c(s) = \frac{10\,(\cancel{s+2})}{s(s+1)} = \frac{10}{S} - \frac{10}{S+1}$$

Taking inverse laplace transform we get,

$$\cancel{V_c(t) = (20 - 10e^{-t})\,u(t)}.$$

$$V_c(t) = (10 - 10e^{-t})\,\cancel{u(t)}. \quad \text{for } \cancel{t \geq 0}\ 0 \leq t \leq 1$$

At $\underline{t=1}$

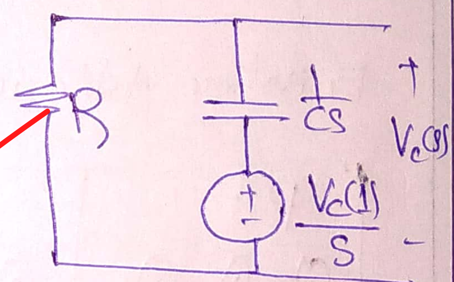
$$V_c(1) = (10 - 10e^{-1})$$

$$V_c(1) = 6.3212 \text{ V}$$

Now, at $t = 1$ sec the switch 8 is opened and $V_c(1) = 6.3212$ v.

Now redrawn the circuit for $t \geq 1$ in s-domain

By using voltage division rule,



$R = 10^6\ \Omega$
$C = 10^{-6}$ F
$RC = 1$ sec.

$$V_c(s) = \frac{R}{\frac{1}{Cs} + R} \cdot \frac{V_c(1)}{s}$$

$$V_c(s) = \frac{RCs}{RCs + 1} \cdot \frac{V_c(1)}{s}$$

$$\Rightarrow V_c(s) = \frac{V_c(1)}{(s+1)} \qquad [\because RC = 1 \text{ sec}]$$

By taking inverse laplace transform we get,

$$V_c(t) = V_c(1)\, e^{-(t-1)} \quad \text{for } \cancel{t>2}\ t>1$$

$$V_c(t) = 6.3212\, e^{-(t-1)} \quad \text{for } t>1$$

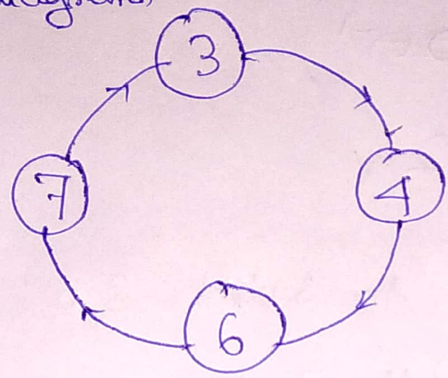
At $t = 2$,

$$V_c(2) = 6.3212\, e^{-(2-1)}$$

$$\Rightarrow \boxed{V_c(2) = 2.3254 \text{ V}}$$

(6)
(c)

Given state, diagrams



As the maximum Count is 7, We required $n \geq \log_2(7) \Rightarrow n = 3$ numbers of JK flip-flops.

Excitation table with considering all invalid state

PS			NS			Excitation		
Q_2	Q_1	Q_0	Q_2'	Q_1'	Q_0'	J_2K_2	J_1K_1	J_0K_0
0	0	0	1	1	0	1d	1d	0d
0	0	1	1	1	0	1d	1d	d1
0	1	0	1	1	0	1d	d0	0d
0	1	1	1	0	0	1d	d1	d1
1	0	0	1	1	0	d0	1d	0d
1	0	1	1	1	0	d0	1d	0d
1	1	0	1	1	1	d0	d0	d0
1	1	1	0	1	1	d1	d0	d0

00	0d
01	1d
10	d1
11	d0

Minimization

For J_2

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	1	1	1	1
1	d	d	d	d

$$\boxed{J_2 = 1}$$

For K_2

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	d	d	d	d
1			1	

$$\boxed{K_2 = Q_1 Q_0}$$

For J_1

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	1	1	d	d
1	1	1	d	d

$$\boxed{J_1 = 1}$$

For K_1

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	d	d	1	
1	d	d		

$$\boxed{K_1 = \bar{Q}_2 Q_0}$$

For J_0

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0		d	d	
1			d	d

$$\boxed{J_0 = 0}$$

For K_0

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	d	1	1	d
1	d	d		

$$\boxed{K_0 = \bar{Q}_2}$$

Implementation