Name-
Roll No-
Test No-
Full Syllabus (Paper-1)

Section-A

Qus-(1) (a)

Solution→ In a Semiconductor Sample,

Concentration of electron

$$n = N_c e^{-(E_c - E_v)/KT}$$

Conc. of hole, $(P) = N_v e^{-(E_F - E_v)/KT}$

from the law of mass action,

$np = n_i^2$ where n_i is intrinsic carrier conc.

$$\therefore N_c N_v e^{\frac{-(E_c - \cancel{E_F} + \cancel{E_F} - E_v)}{KT}} = n_i^2$$

$$\boxed{n_i^2 = N_c N_v e^{-E_g/KT}}$$

where $N_c = 2\left(\frac{2\pi m_n \bar{K} T}{h^2}\right)^{3/2}$

$N_v = 2\left(\frac{2\pi m_p \bar{K} T}{h^2}\right)^{3/2}$

$$\therefore n_i^2 = A_0 T^3 e^{-E_{g0}/KT}$$

where A_0 is material constant.

$$\therefore \boxed{n_i = \sqrt{A_0}\, T^{3/2} e^{-E_{g0}/2KT}}$$

Take log on both sides,

$$\log n_i = \log \sqrt{A_0} + \log T^{3/2} + \log e^{-E_{g0}/2KT}$$

Differentiating with respect to T (Temprature)

$$\frac{1}{n_i}\frac{dn_i}{dT} = 0 + \frac{3}{2T} - \frac{E_{go}}{2K}\left(\frac{-1}{T^2}\right)$$

$$\frac{1}{n_i}\frac{dn_i}{dT} = \frac{3}{2T} + \frac{E_{go}}{2KT^2}$$

$$\left(\frac{dn_i}{n_i}\right)\frac{1}{dT} = \frac{3}{2T} + \frac{E_{go}}{2KT^2}$$

for every 1°C rise in temprature,

% rise in intrinsic carrier conc. is given by

$$\left(\frac{dn_i}{n_i}\right) \times 100 = \left(\frac{3}{2 \times 300} + \frac{1.2}{2 \times 8.6 \times 10^{-5} \times (300)^2}\right) \times 100\%$$

$$\therefore \frac{dn_i}{n_i} \times 100 = 0.0825 \times 100$$

$$\boxed{\therefore \text{ \% Increase in Intrinsic carrier Conc. /°K rise} = 8.25\%}$$

Ans.

Qus-(1) d.

Solution- Critical magnetic field for a superconductor

H_c at 4K $H_c(4K) = 0.02$ T.

& H_c at 3K, $H_c(3K) = 0.03$ T.

we have to Calculate

H_c at 2K ie $H_c(2K) = ?$

for Superconductors, critical magnetic field & Temprature are related as

$$\boxed{H_c = H_0\left[1 - \left(\frac{T}{T_c}\right)^2\right]}$$

$$0.02 = H_0\left(1-\left(\frac{4}{T_c}\right)^2\right) \quad \text{—— (1) Given}$$

& $$0.03 = H_0\left(1-\left(\frac{3}{T_c}\right)^2\right) \quad \text{—— (2) Given.}$$

Put $\frac{1}{T_c} = x$ we have,

$$H_0[1-16x^2] = 0.02 \quad \text{—— (1.1)}$$

& $$H_0[1-9x^2] = 0.03 \quad \text{—— (2.1)}$$

Dividing, $\frac{1-16x^2}{1-9x^2} = \frac{2}{3}$

$$3-48x^2 = 2-18x^2$$

$$1 = 30x^2$$

$\therefore \boxed{x^2 = \frac{1}{30}}$ ie $\boxed{\frac{1}{T_c^2} = \frac{1}{30}}$

from (1.1), $H_0 = \frac{0.02}{1-16x^2}$

~~Put In (2.1)~~

$$\cancel{\frac{0.02}{(1-16x^2)}(1-9x^2) = 0.0}$$

Put $x^2 = \frac{1}{30}$ in eqn (1.1) to get H_0

$$\therefore H_0\left[1-\frac{16}{30}\right] = 0.02$$

$$\therefore H_0 = \frac{0.02}{\left(1-\frac{16}{30}\right)} = 0.04286\,T$$

$\therefore$ Critical magnetic field at Temp 2 K

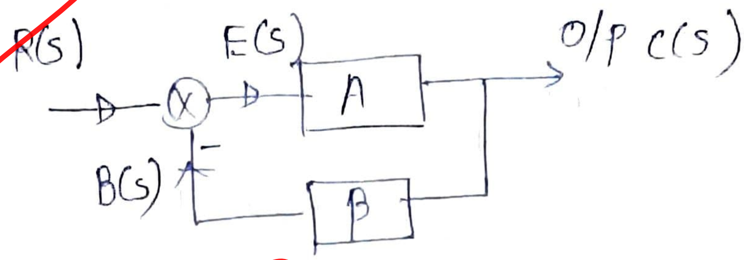
$$H_c(2) = 0.04286\left[1-2^2 \times \frac{1}{30}\right]$$

$$\boxed{H_c(2) = 0.03714 \text{ Tesla}}$$

← Ans.

Qus - 1 (e)

Solution - Consider a block Diagram of feedback amplifier with open loop gain A & feedback factor β as shown



$$\frac{C(s)}{E(s)} = A$$

$$\frac{B(s)}{E(s)} = A\beta$$

$$\frac{C(s)}{R(s)} = A_f$$

$$E(s) = R(s) - B(s)$$

$$E(s) + B(s) = R(s)$$

$$E(s) + A\beta\, E(s) = R(s)$$

$$E(s)\,[1 + A\beta] = R(s)$$

from (1) Put $E(s) = \frac{C(s)}{A}$

$$\therefore \frac{C(s)}{A}[1 + A\beta] = R(s)$$

$$\therefore \boxed{\frac{C(s)}{R(s)} = A_f = \frac{A}{1 + A\beta}} \quad \text{—— (A)}$$

Sensitivity of feedback amplifier is defined as Quantitative measure of change in gain of f/B amplifier due to internal parameter ~~go~~ variation either due to temprature or due to component ageing. mathmetically

$$S^{A_f}_{A} = \frac{dA_f/A_f}{dA/A} = \frac{dA_f}{dA} \cdot \frac{A}{A_f}$$

from eqn (A) Differentiate (A) w.r.t A.

$$\frac{dA_f}{dA} = \frac{(1 + A\beta) - A\beta}{(1 + A\beta)^2} = \frac{1}{(1 + A\beta)^2}$$

$$\& \ \frac{A}{A_f} = (1 + A\beta)$$

$$\therefore \frac{dA_f/A_f}{dA/A} = \frac{1}{(1+A\beta)^2} \times (1+A\beta) = \frac{1}{(1+A\beta)}$$

$$\therefore \boxed{\frac{dA_f}{A_f} = \left(\frac{1}{1+A\beta}\right)\frac{dA}{A}}$$

Proved

where A is gain of feedback amplifier & β is feedback gain.

Given $A = 1000 \pm 100$

& $\frac{dA_f}{A_f} = \frac{\pm 0.1}{100}$

$\frac{dA}{A} = \frac{100}{1000} = \frac{1}{10}$.

$\therefore$ Put in Derived eq^n we have,

$$\frac{0.1}{100} = \frac{1}{1+1000\beta} \times \frac{1}{10}$$

$$1+1000\beta = 100$$

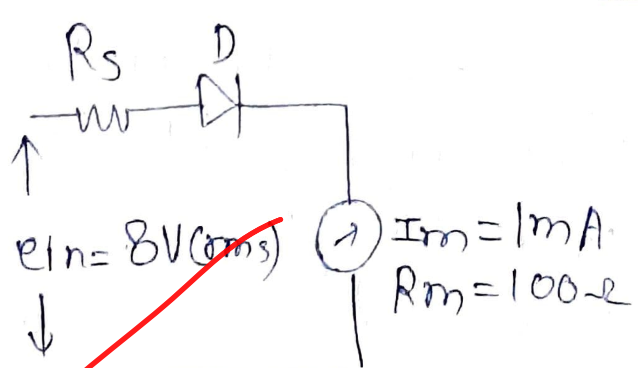
$$\therefore \beta = \frac{100-1}{1000} = \frac{99}{1000}$$

$\boxed{\beta = 0.099}$ ie 9.9 % feedback required.

Ans.

Ques-1(b)

Solution -

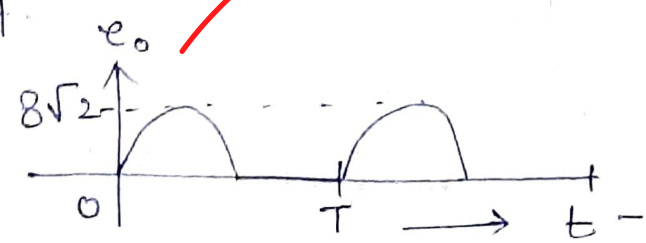


$V_{rms} = 8$

$\frac{V_m}{\sqrt{2}} = 8V$

$\therefore V_m = 8\sqrt{2}$ Volt

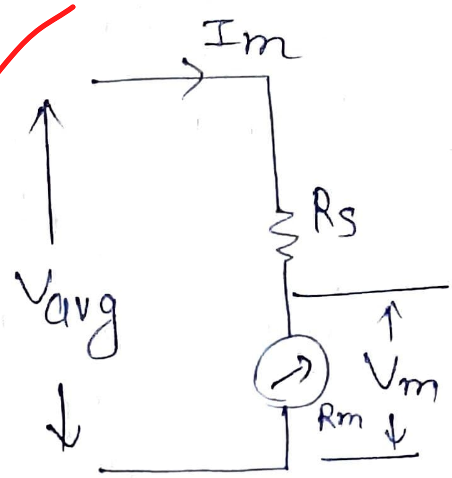
O/P of HWR is



Since voltmeter is PMMC Type instrument that measures avg. value.

Therefore, average value of waveform,

$$V_{avg} = \frac{V_m}{\pi} = \frac{8\sqrt{2}}{\pi}$$



Value of multiplier, (m) given by

$$m = \frac{V_{avg}}{V_m} = \frac{8\sqrt{2}/\pi}{100 \times \frac{1}{1000}}$$

$$\therefore m = \frac{8\sqrt{2}}{\pi} \times 10 = 36$$

$$\boxed{m = 36}$$

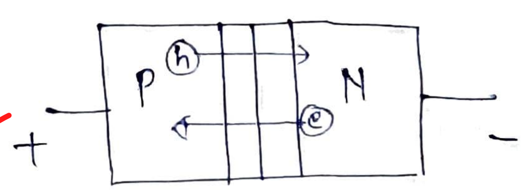
$\therefore$ R_s (multiplier Resistance) $= R_m(m-1) = 100(36-1) = 3.5\,K\Omega$

$$\boxed{R_s = 3.5\,K\Omega}$$

← Ans.

Ques-1(c)

Solution-



Consider a PN junction under Forward bias condition,

Emitter injection efficiency is defined as Ratio of electron current crossing the junction to total current, ie

$$\gamma = \frac{I_{NE}}{I_{NE} + I_{PE}} = \frac{1}{1 + \frac{I_{PE}}{I_{NE}}}$$

where, I_{PE} denotes hole current crossing the J_E from P to N side, which is diffusion current.

$$I_{PE} = -A \cdot e D_p \frac{d p_n(x)}{dx}$$

where, $P_n(x) = P_{n_0} + \Delta p\, e^{-x/L_p}$.

$$\frac{d P_n(x)}{dx} = 0 + \frac{\Delta p}{L_p} e^{-x/L_p}$$

at $x=0$ $\frac{d P_n(0)}{dx} = \frac{-\Delta p}{L_p}$

where $\Delta p = P_n(0)\, e^{V_D/V_T} = \frac{-n_i^2}{N_D} e^{V_D/V_T}$.

similarly, $\frac{d n_p(0)}{dx} = \frac{n_i^2}{N_A} e^{V_D/V_T}$.

$$\therefore \frac{I_{PE}}{I_{NE}} = \frac{\cancel{A e} D_p \cancel{n_i^2} \cancel{e^{V_D/V_T}} \times N_A}{\cancel{A e} D_n\, N_D \cdot \cancel{n_i^2} \cancel{e^{V_D/V_T}}} \times \frac{L_N}{L_p}$$

where L_N & L_p are diffusion length,

$$\therefore \frac{I_{PE}}{I_{NE}} = \frac{D_p N_A L_N}{D_n N_D L_p} = \frac{\mu_p}{\mu_n} \times \frac{N_A}{N_D} \times \sqrt{\frac{\tau_n}{\tau_p}} \times \sqrt{\frac{\mu_n}{\mu_p}}$$

$$\frac{I_{PE}}{I_{NE}} = \frac{N_A}{N_D} \times \sqrt{\frac{\tau_n}{\tau_p}} \times \sqrt{\frac{\mu_p}{\mu_n}}$$

$$\therefore \gamma = \frac{1}{1 + \frac{N_A}{N_D} \times \sqrt{\frac{\tau_n}{\tau_p}} \times \sqrt{\frac{\mu_p}{\mu_n}}} = \frac{1}{1 + \frac{N_A}{N_D} \sqrt{10} \times \frac{1}{\sqrt{2.4}}}$$

$$\gamma = \frac{1}{1 + \frac{N_A}{N_D} \times \sqrt{\frac{10}{2.4}}} = \frac{1}{\left(1 + 2.04 \frac{N_A}{N_D}\right)}$$

$$\boxed{\gamma = \frac{1}{1 + 2.04 \frac{N_A}{N_D}}}$$ ← Ans

Ques-4(a)(i)

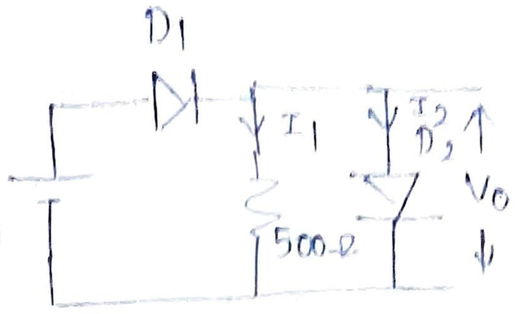
Solution- Given,

Identical Diodes D_1 & D_2

$\eta = 1 \quad V_\gamma = 0.6\ V, \quad V_T = 26\,mV$

$I_0 = 2\times10^{-13}\,A$ at $300K$

We have to Calculate V_{in} when V_0 600 mV



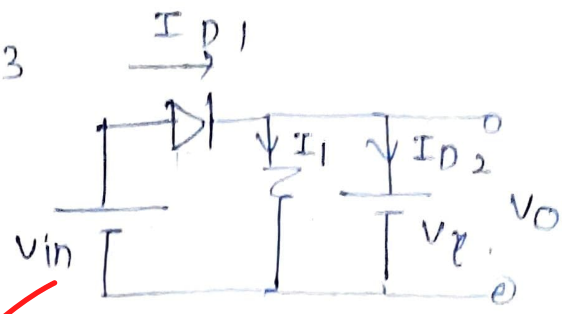
$$I_2 = I_S e^{V_{D2}/V_T}$$

$\because$ D_2 will Conduct as $V_0 = V_\gamma = 0.6$ Volt

$$\therefore I_2 = I_0 e^{V_{D2}/V_T}$$

$$I_2 = 2\times10^{-13}\, e^{0.6/26\times10^{-3}}$$

$$I_{D_2} = 2.105\,mA$$



$$I_1 = \frac{V_0}{500} = \frac{0.6}{500} = 1.2\,mA$$

$$\therefore I_{D_1} = I_1 + I_{D_2} = 1.2 + 2.105 = 3.305\,mA$$

$$\boxed{I_{D_1} = 3.305\,mA}$$

Now, $\boxed{V_{D_1} = V_{in} - 0.6}$

$$\therefore I_{D_1} = I_0 e^{V_{D1}/V_T}$$

$$3.3\times10^{-3} = 2\times10^{-13}\, e^{V_{D1}/26\times10^{-3}}$$

$$\therefore V_{D_1} = \frac{23.528\times26}{1000} = 0.612\ \text{Volt}$$

ie $V_{in} - 0.6 = 0.612$

$$\therefore \boxed{V_{in} = 1.212\,V}$$

Ans.

Qus-4(a)(ii)

Solution-

Given,

$f_o = 50\,Hz$.

$V_{rms} = 100\,V$.

Capacitor$(C) = 50\,\mu F$.

$I_{DC} = 50\,mA$.

Ripple factor of Full wave Rectifier is given by,

$$r = \frac{V'_{rms}}{V_{avg}}$$

$$V'_{rms} = \frac{V_{mr}}{2\sqrt{3}}$$ where V_{mr} is peak to peak o/p Ripple

$$V_r = \frac{I_{DC}}{f_o C}$$

$$\frac{I_{DC} T_o}{2} = C V_r.$$

$$\therefore V_r = \frac{I_{DC}}{2 f_o C}.$$

$$\therefore \boxed{r = \frac{1}{4\sqrt{3} f_o C R_L}}$$

where $R_L = \frac{V_{DC}}{I_{DC}}$

$$V_{DC} = V_m - \frac{I_{DC}}{4 f_o C} = 100\sqrt{2} - \frac{50 \times 10^{-3}}{4 \times 50 \times 10^{-6} \times 50}$$

$$= 100\sqrt{2} - 5 = 136.42\ \text{Volt}$$

$$\therefore R_L = \frac{V_{DC}}{I_{DC}} = \frac{136.42}{50 \times 10^{-3}} = 2.728\,K\Omega$$

Now, ripple factor,

$$r = \frac{1}{4\sqrt{3} f_o C R_L} = \frac{10^6}{4\sqrt{3} \times 50 \times 50 \times 2.728 \times 10^3}$$

$$\boxed{r = 0.0212}$$ or 2.12%

Ques - 4 (b)

Solution- accuracy of voltmeter $= \pm 1\%$ of FSD

ie $\frac{\delta V}{V} \times 100 = 1$

$\therefore \frac{\delta V}{V} = \frac{1}{100}$

Since, voltmeter reads 100V on its 150 V Range.

ie $V_{FSD} = 150V$

$\therefore \frac{\delta V}{150} = \frac{1}{100}$

$\therefore \delta V = \frac{150}{100} = 1.5$

$\therefore$ Limiting error in measuring 100 V.

$\frac{\delta V}{V_m} = \frac{1.5}{100} = 0.015$

Similarly accuracy of ammeter $= \pm 1\%$ FSD

i.e $\frac{\delta I}{I} = \frac{1}{100}$

$\therefore \delta I = \frac{100}{100} = 1mA$.

Since, ammeter reads 50 mA on its 100 mA Range

Limiting error in measuring 50 mA.

$\frac{\delta I}{I_m} = \frac{1}{50} = 0.02$

Calculation of Power, $P = VI$.

Take log on both sides

$\log P = \log V + \log I$

Differentiating,

$\frac{1}{P} dP = \frac{dV}{V} + \frac{dI}{I}$.

or $\boxed{\frac{\delta P}{P} = \frac{\delta V}{V} + \frac{\delta I}{I}}$

∴ limiting error in Power Calculation,

$$\frac{\delta P}{P} = \frac{\delta V}{V} + \frac{\delta I}{I} = 0.015 + 0.02$$

$$\therefore \boxed{\frac{\delta P}{P} = 0.035}$$ ~~Abso~~ Relative limiting error.

$\therefore \delta P = 0.035 \times P$

where $P = VI = \frac{100 \times 50}{1000} = 5$ watt

$\therefore P = P_0 \pm \delta P$

$P = (5 \pm 0.175)$ watt

% Relative limitting error $= \frac{\delta P}{P} \times 100 = 3.5\%$

Ans:

Ques-4 (c)

$N_D = 10^{19} /cm^3$

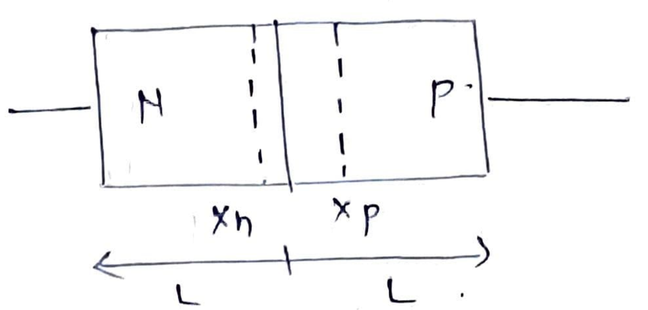
$N_A = 10^{16} /cm^3$

$\tau_n = \tau_p = 10^{-6}$ sec

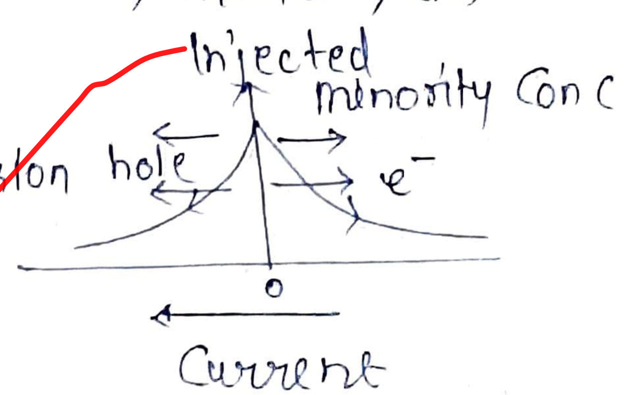
$L_n = L_p = 500 \mu m$

$L >> x_n, x_p$.

$T = 300K$, $\mu_n = 1248\ cm^2/V \cdot s$, $n_i = 10^{10} / cm^3$



Current density at $x=0$ is sum of hole & e^- diffusion current densities



$$p_n(x) = p_{n_0} + \Delta p\, e^{-x/L_p}$$

$$\frac{d\, p_n(x)}{dx}\bigg|_{(x=0)} = 0 + \left(\frac{-\Delta p}{L_p}\right) = -\frac{n_i^2}{L_p \times N_D} e^{V_D/V_T}$$

∴ forward current density

$$J_F = q n_i^2 \left[\frac{D_P}{L_P N_D} + \frac{D_N}{L_n N_A}\right]\left(e^{V_D/V_T} - 1\right)$$

$$L_p = \sqrt{D_p \tau_p} = \sqrt{\mu_p V_T \tau_p} =$$

$$L_n = \sqrt{D_n \tau_n} = \sqrt{\mu_n V_T \tau_n} = \sqrt{1248 \times 0.026 \times 10^{-6}}$$

$$= 5.696 \times 10^{-3}\,\text{cm}$$

$$\therefore 1.5 \times 10^{-6} = 1.6 \times 10^{-19} \times 10^{20} \left(e^{V_D/0.026}\right)\left[\frac{1248 \times 0.026}{5.696 \times 10^{-3} \times 10^{16}}\right]$$

neglecting $\frac{D_P}{L_P N_A}$ term as $N_A >> N_D$

$$1.5 \times 10^{-6} = 1.6 \times 10^{-19} \times 10^{20} \times 5.6966 \times 10^{-13}\, e^{V_D/0.026}$$

$$\therefore e^{V_D/V_T} = \frac{1.5 \times 10^{-6}}{16 \times 5.69663 \times 10^{-13}} = 164571.006$$

Take natural log, on both sides

$$\frac{V_D}{V_T} = 12.01 \text{ volt}$$

$$\therefore \boxed{V_D = 0.3123\,\text{mV}}$$

(ii)

$$J = J_0\, e^{V_D/V_T}.$$

$$J = K e^{-E_g/KT} \cdot e^{V_D/V_T}.$$

Take log on both sides

$$\log J = \log K - \frac{E_g}{KT} + \frac{V_D}{V_T} = \log K - \frac{E_g}{KT} + \frac{K' V_D}{T}.$$

Differentiating w.r.t T

$$\frac{1}{J} \times \frac{dJ}{dT} = 0 + \frac{E_g}{KT^2} - \frac{11600\, V_D}{T^2}$$

Given, J is constant

i.e $\frac{\partial J}{J} = 0$.

i.e $\frac{E_g}{KT^2} = \frac{11600 V_D}{T^2}$

$\therefore V_D = \frac{E_g}{11600 \times K} = \frac{1.12 \times \cancel{1.6 \times 10^{-19}}}{11600 \times 8.6 \times 10^{-5}}$

$\therefore V_D = 1.12$ volt/°K * Ans

8

Section-B

Qus. 5 (a)
Solution›

Given,

No. of e^-/sec carried in a Picture Tube $= 10^{15}$ e^-/sec.

$\therefore$ Current $I = \dfrac{Ne}{t}$

ie $I = 10^{15} \times 1.6 \times 10^{-19}$

$I = 1.6 \times 10^{-4}$ Amp.

Let Voltage Required be V_0 such that to accelerate beam to achieve Power of 5 Watt

therefore, $V_0 I = P$

$V_0 I = 5$

$\therefore V_0 = \dfrac{5}{1.6 \times 10^{-4}} = \dfrac{50}{1.6}$ K volt.

$\boxed{V_0 = 31.25 \text{ KV}}$ - Ans.

Qus 5 (c)
Solution -

Given,

Series-shunt feedback.

open loop gain $= 10^5$.

Close loop gain $= 50$.

Input Resistance of Ampr without feed back $R_i = 20\,K\Omega$

O/P Resistance of ampr without feed back $= 40\,K\Omega$.

We have to calculate Input & output Resistance of amplifier with feed back.

for Series-shunt feedbak. since f/B N/w is Connected in shunt with load (Voltage sampling)

& f/B N/w is Connected in series with signal source

ie Voltage mixing.

$$\therefore \boxed{R_{if} = R_i(1+A\beta)}$$

& $$\boxed{R_{of} = \frac{R_o}{(1+A\beta)}}$$

for feedback amplifier,

$$A_{CL} = \frac{A}{1+A\beta}.$$

$$\therefore (1+A\beta) = \frac{A}{A_{CL}} = \frac{10^5}{50} = \frac{100}{50} \times 10^3 = 2000$$

$$\boxed{1+A\beta = 2000}$$

$$\therefore R_{if} = 20K\Omega \times 2000$$

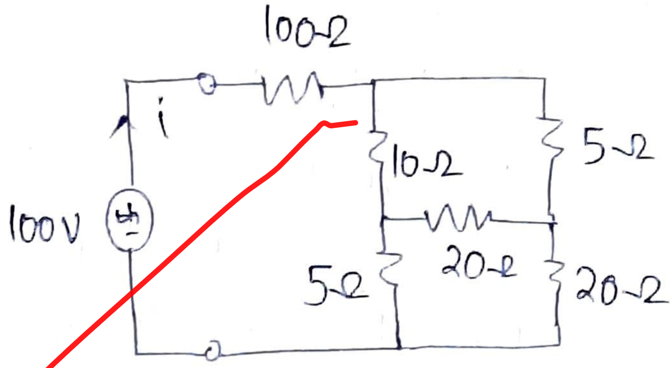
$$\boxed{R_{if} = 40 M\Omega.}$$ Ans

& $$R_{of} = \frac{40 \times 1000}{2000} = 20\Omega$$

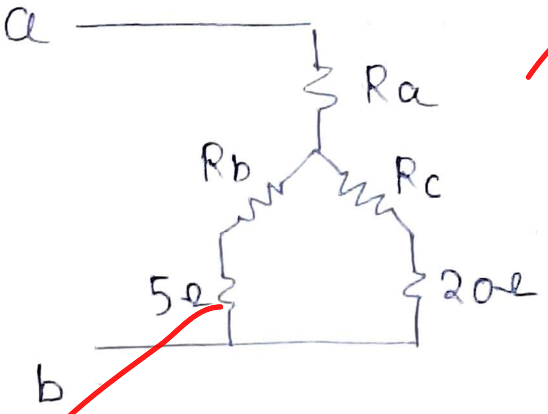
$$\boxed{R_{of} = 20\Omega}$$ Ans.

Qus. 5(b) Given Network

Solution-



from Star-delta Transformation, we have



where

$$R_a = \frac{10\times5}{10+20+5} = \frac{50}{35}\,\Omega$$

$$R_b = \frac{10\times20}{10+20+5} = \frac{200}{35}\,\Omega$$

& $$R_c = \frac{20\times5}{35} = \frac{100}{35}$$

$$R_{eq} = [(R_b+5) \parallel (R_c+20)] + R_a$$

$$R_b+5 = \frac{200}{35}+5 = \frac{375}{35}\,\Omega = 10.714\,\Omega$$

$$(R_c+20) = \frac{100}{35}+20 = \frac{800}{35}\,\Omega = 22.857\,\Omega.$$

$$\therefore (R_b+5) \parallel (R_c+20) = \frac{1}{\left(\frac{35}{375}+\frac{35}{800}\right)} = 7.295\,\Omega.$$

$$\therefore R_{ab} = \frac{50}{35} + 7.295 = 8.723\,\Omega$$

$$\boxed{R_{ab} = 8.723\,\Omega} \leftarrow \text{Ans}$$

$$\text{Current } (i) = \frac{V_{ab}}{R_{ab}} = \frac{100}{8.723} = 11.46 \text{ Amp}$$

$$\boxed{i = 11.46 \text{ amp}} \leftarrow \text{Ans}$$

Ques-5(e) Given,

$E_2 I_2 = E_1 I_1 = 50\,KVA$.

$E_1/E_2 = 2000/200$

$f = 50\,Hz$ Transformer

Iron loss $(W_I) = 400\,W$

Primary winding Resistance $= 0.6\,\Omega\ (R_1)$

Secondary winding Resistance $= 0.006\,\Omega\ (R_2)$

Total equivalent Resistance w.r.t 2^{0}ry side

$$R_{o_2} = R_2 + R_1'$$

$$R_{o_2} = R_2 + \left(\frac{I_1}{I_2}\right)^2 R_1 = R_2 + \left(\frac{N_2}{N_1}\right)^2 R_1$$

$$\frac{N_2}{N_1} = \frac{200}{2000} = \frac{E_2}{E_1} = \frac{1}{10}$$

$$\therefore R_{o_2} = 0.006 + \frac{0.6}{100} = 0.012\,\Omega$$

$$\boxed{R_{o_2} = 0.012\,\Omega}$$

$$I_2 = \frac{50\times10^3}{200} = 250\text{ amp.}$$

$$\therefore \text{Total FL Cu loss} = I_2^2 R_{o_2} = 250^2 \times 0.012$$

$$\boxed{W_{FL\,cu} = 750\text{ watt}}$$

Transformer efficiency,

$$\boxed{\eta\,\% = \frac{x\,E_2 I_2 \cos\theta_2}{\left(x\,E_2 I_2 \cos\theta_2 + x^2 W_{FL\,cu} + W_I\right)} \times 100\,\%}$$

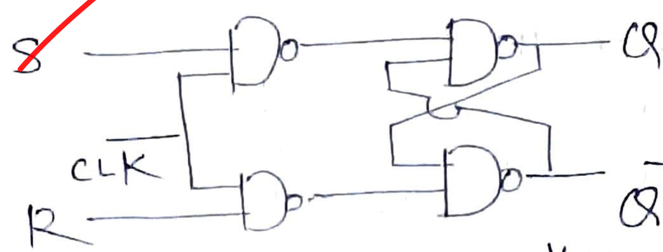
$$\eta\,\% = \frac{0.5\times50\times10^3\times0.8}{0.5\times50\times10^3\times0.8 + 0.5^2\times750+400} = \frac{20,000\times100}{20587.5}$$

$$\boxed{\eta\,\% = 97.146\,\%} \leftarrow \text{Ans}$$

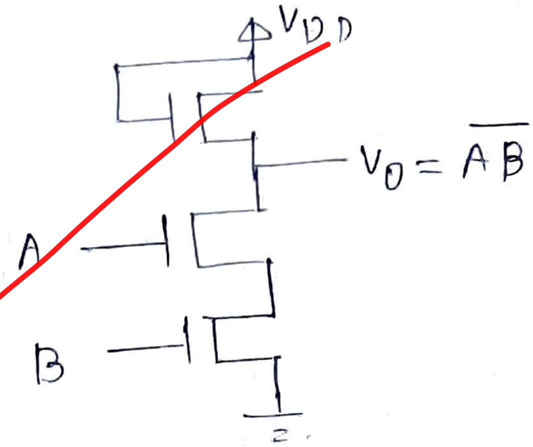
Ques-5(d)

Solution- Design of SR-flip-flop using NMOS-

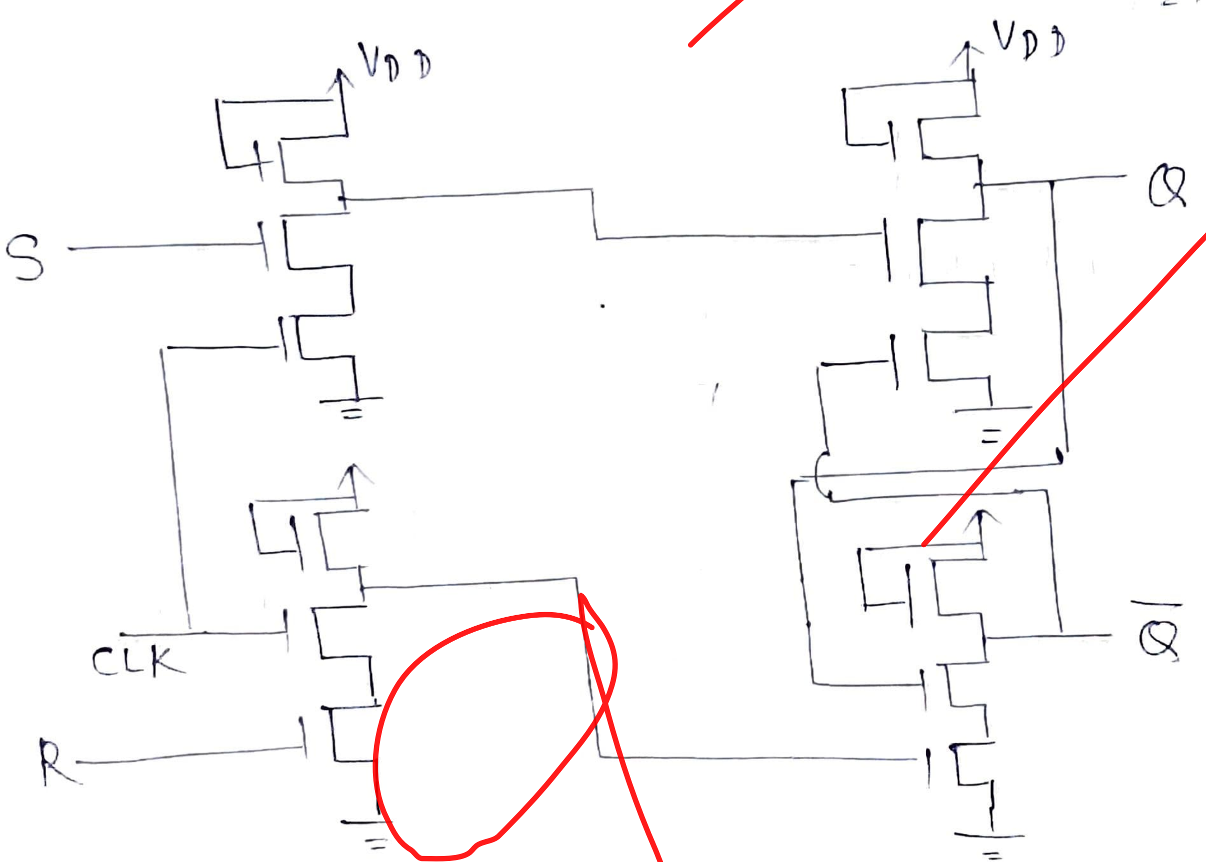
Gate Level Designing- (SR f/f)
using NAND Latch-



Implementation of NAND Gate using NMOS-



Therefore Implementing SR-f/f using NMOS →



→ Ans.

Ques-6 (d)

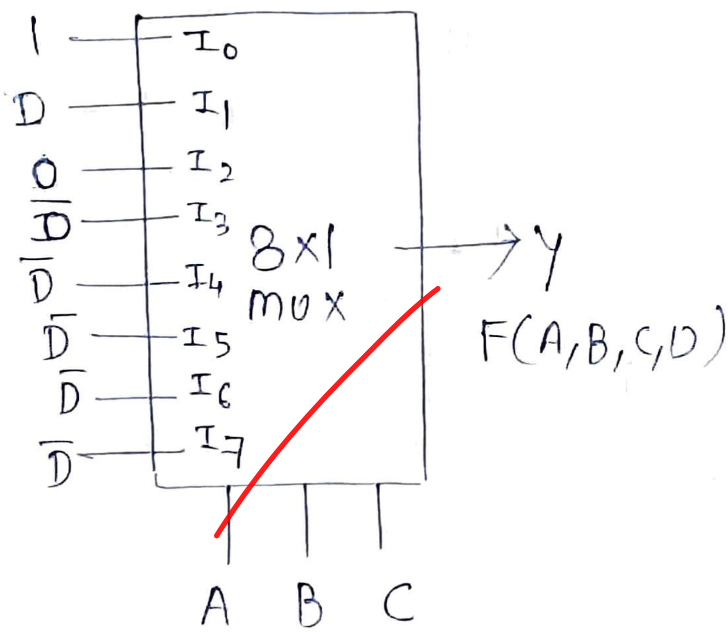
Solution- $F(A,B,C,D) = \Sigma m(0,1,3,6,8,10,12,14)$

Implementing $F(A,B,C,D)$ using 8-to-1 multiplexer needs 3 selection lines. Let A, B, C be the selection lines,

A	B	C	D	Y
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I
$\bar{D}$	0	2	4	6	8	10	12	1
D	1	3	5	7	9	11	13	1
	1	D	0	$\bar{D}$	$\bar{D}$	$\bar{D}$	$\bar{D}$	$\bar{D}$

Implementation using mux-

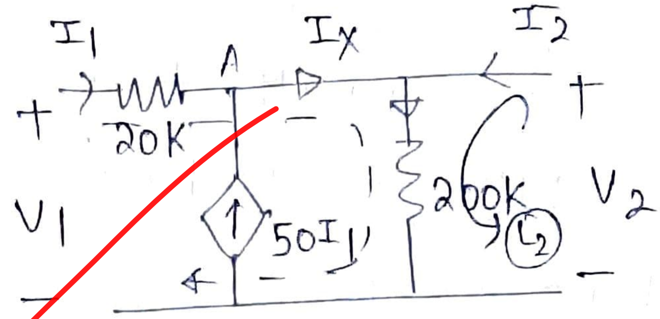


Ans-

Ques-6 (b)

Solution →

h-parameter equations,



$$\boxed{\begin{aligned} V_1 &= h_{11}I_1 + h_{12}V_2 \\ I_2 &= h_{21}I_1 + h_{22}V_2 \end{aligned}}$$

apply KCL at Node A.

$$I_1 + 50I_1 = I_x \qquad\qquad I_{200K} = I_x + I_2$$

$$\therefore\ I_x = 51I_1$$

apply KVL in Loop shown

$$V_1 = 20\times10^3 I_1 + 200\times10^3(51I_1 + I_2)$$

$$V_1 = 20\times10^3 I_1 + 10{,}200\times10^3 I_1 + 200\times10^3 I_2$$

$$V_1 = 10{,}220\times10^3 I_1 + 200\times10^3 I_2 \quad \text{—— (1)}$$

& KVL in outer Loop (2)

$$V_2 = 200\times10^3(51I_1 + I_2)$$

$$V_2 = 10{,}200\times10^3 I_1 + 200\times10^3 I_2 \quad \text{—— (2)}$$

from (2)

$$200\times10^3 I_2 = -10{,}200\times10^3 I_1 + V_2$$

$$\therefore\ I_2 = -51I_1 + (0.005\times10^{-3})V_2 \quad \text{—— (3)}$$

Put I_2 in eqn (1).

$$V_1 = 10{,}220\times10^3 I_1 + 200\times10^3(-51I_1 + 0.005\times10^{-3})V_2$$

$$V_1 = (10{,}220 - 10200)\times10^3\ I_1 + V_2$$

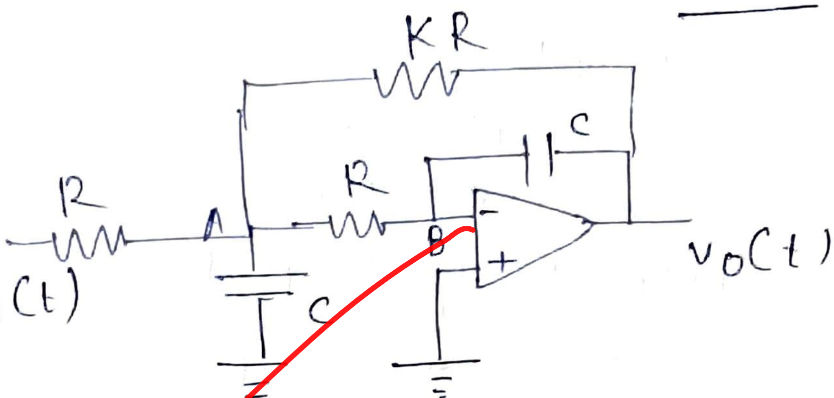
$$V_1 = 20\times10^3 I_1 + V_2 \quad \text{—— (4)}$$

from eq^n (3) & (4)
Comparing with standard h-parameter equation, we have

$$\begin{bmatrix} h_{11} = 20\times10^{3}\,\Omega & h_{12} = 1 \\ h_{21} = -51 & h_{22} = 0.005\times10^{-3}\,\mho \end{bmatrix}$$

← Ans.

Ques-6(a)
Solution:-



from virtual Ground Concept

$$\boxed{V_B = 0}$$

apply KCL at B

$$\frac{V_B - V_A}{R} = \frac{V_B - V_o(s)}{(1/cs)}$$

$$\boxed{\therefore V_A = RCs\,V_o(s)} \quad \text{— (1)}$$

apply KCL at Node A,

$$\frac{V_A}{R} + \frac{V_A - V_s}{R} + \frac{V_A}{(1/cs)} + \frac{V_A - V_o}{KR} = 0$$

$$\frac{2V_A}{R} + V_A(cs) + \frac{V_A}{KR} - \frac{V_o}{KR} = \frac{V_s}{R} \quad \text{— (2)}$$

Put $\boxed{V_A = RCs\,V_o(s)}$ in eq^n (2)

$$\frac{2\cancel{R}Cs\,V_o(s)}{\cancel{R}} + RC^2s^2\,V_o(s) + \frac{\cancel{R}Cs\,V_o(s)}{K\cancel{R}} - \frac{V_o}{KR} = \frac{V_s}{R}$$

$$V_o(s)\left[2sC + R(Cs)^2 + \frac{Cs}{K} - \frac{1}{KR}\right] = \frac{V_s}{R}$$

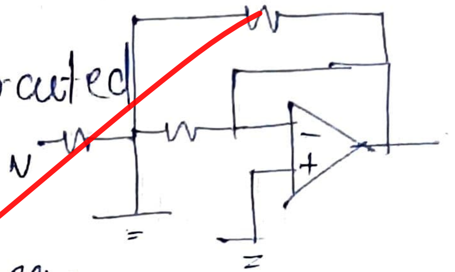
$$V_o(s)\left[\frac{(2KRC)s + K(RC)^2 s^2 + (RCs) - 1}{KR}\right] = \frac{V_s}{R}$$

$$\boxed{\frac{V_o(s)}{V_i(s)} = \frac{K}{s^2(KR^2C^2) + s(RC - 2KRC) - 1}}$$

when frequency is high

i.e $\omega \to \infty$

$\frac{1}{sC} = \frac{1}{j\omega C}$ will be shortcircuted

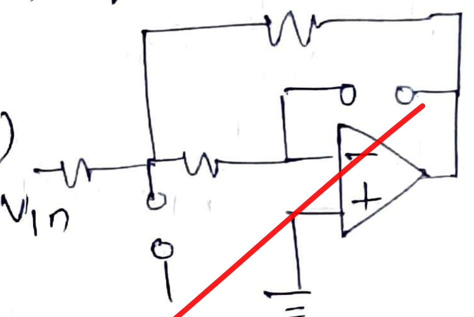


$\therefore$ ckt will have o/p zero.

ie they are blocking High freq.

when freq is Low

then $\frac{1}{sC} \to \infty$ ie (o.c)



then ckt will act as.

Inverting amplifier.

So They allow lower frequency.

$\therefore$ ckt will be passing Lower freq. & blocking Higher freq.

Hence, it acts as Low Pass filter.

(ii) $R = 10\,k\Omega$,

$C = 1\,\mu F$

$V_s(t) = 10\,\delta(t)$

$K = 1$

We have to find $V_o(t)$.

$$V_i(s) = L[V_i(t)]$$
$$= L[10\,\delta(t)] = 10 .$$

$$V_o(s) = \frac{10 \times 1}{s^2(1\times 10^{-4}) + s \times 10^{-2}(1-2) - 1}$$

$$V_o(s) = \frac{10}{s^2 \times 10^{-4} - s \times 10^{-2} - 1}$$

$$V_o(s) = \frac{10^5}{(s^2 - 100s - 10^4)} = \frac{10^5}{(s-161.8)(s+61.8)} .$$

$$\frac{10^5}{(s-161.8)(s+61.8)} = \frac{A}{(s-161.8)} + \frac{B}{(s+61.8)}$$

$$A = \frac{10^5}{161.8+61.8} = 447.227 .$$

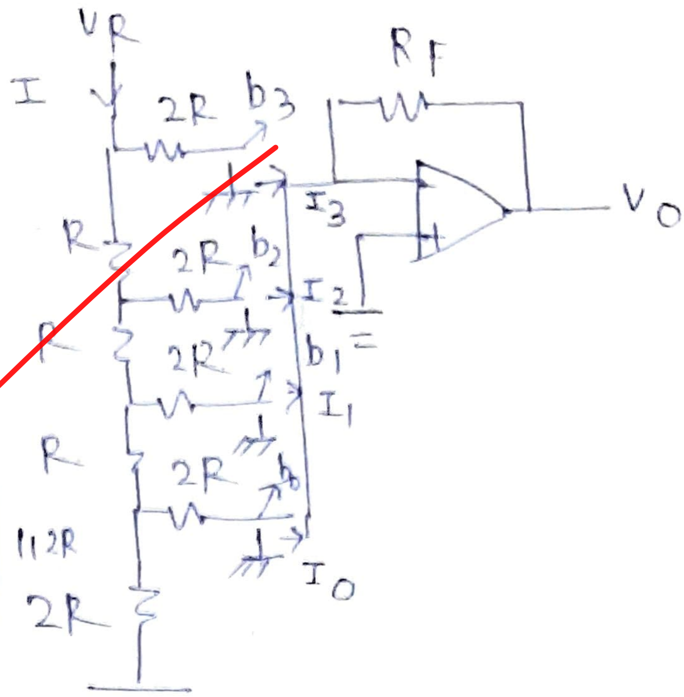
$$B = \frac{10^5}{-(61.8+161.8)} = -447.227$$

$$\therefore\ V_o(t) = 447.227\left[e^{161.8t} - e^{-61.8t}\right]u(t)$$

Ans.

Ques-7(b)

4 bit Inverted R-2R ladder type Digital to analog Converter →



Total Current

$$I = \frac{V_R}{R_{eq}}$$

$$R_{eq} \left[\left[\left[(2R \| 2R) + R\right] \| 2R\right] + R\right] \| 2R$$

ie $R_{eq} = R$

$$\therefore I = \frac{V_R}{R}$$

$$I_3 = \frac{I}{2} \times b_3 \quad I_2 = \frac{I}{4} b_2 \quad I_1 = \frac{I}{8} b_1 \;\&\; I_0 = \frac{I}{16} b_0$$

$$\therefore \quad I_F = I_0 + I_1 + I_2 + I_3$$

$$I_F = \frac{V_R}{2R} b_3 + \frac{V_R}{4R} b_2 + \frac{V_R}{8R} b_1 + \frac{V_R}{16R} b_0$$

$$I_F = \frac{V_R}{16R}\left[8b_3 + 4b_2 + 2b_1 + b_0\right]$$

$$I_f = \frac{V_r}{2^n R} \times \sum_{i=0}^{n} 2^i b_i$$

$$\boxed{\therefore V_0 = -I_F \cdot R_F = \frac{-V_R}{2^n R} \cdot R_f \cdot \sum_i 2^i b_i}$$ ← Proved

Given, $V_o = 10V$

for Digital input $(1000)_2$

& $V_R = -5$ volt

i.e $10 = \frac{5}{2^4 R} R_f \times 8$

$10 = \frac{5}{16} \times 8 \times \frac{R_f}{R}$

$\therefore \frac{R_f}{R} = 4$

$\therefore \boxed{R_f = 4R}$

Put $R = 5K\Omega$
then $R_f = 20K\Omega$

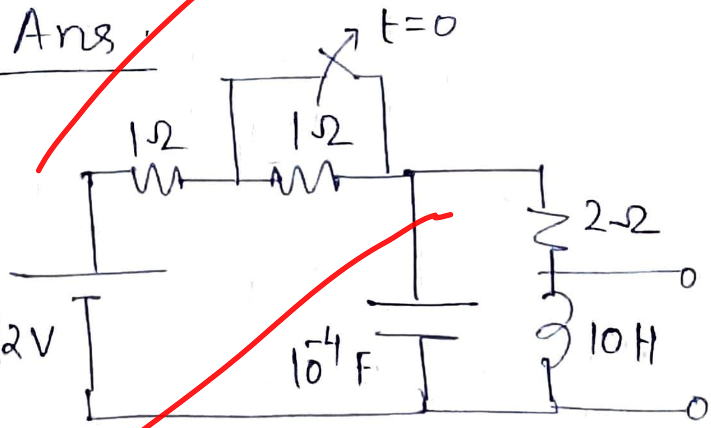
for the designed ckt,
analog o/p voltage for digital input (1100)

$V_o = \frac{5}{2^4} \times 4 \, [8+4+0+0]$

$V_o = \frac{5}{16} \times 4 \times 12$

$\boxed{V_o = 15\text{ V}}$ ← Ans

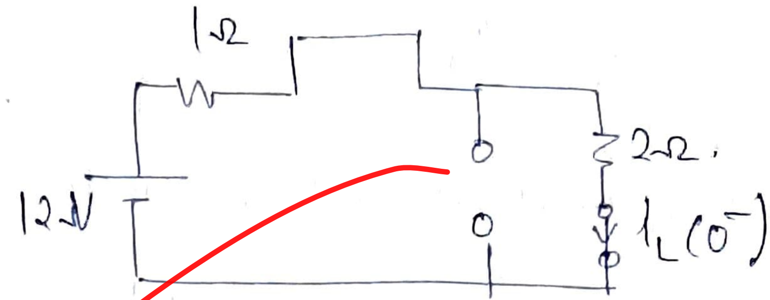
Ques-7(c) Given ckt,



ckt was in steady state when swich was closed

∴ eq. ckt diagram under steady state at $t=0^-$ just before opening switch,

$i_L(0^-) = \frac{12}{1+2} = 4$ amp



Cap. will be open

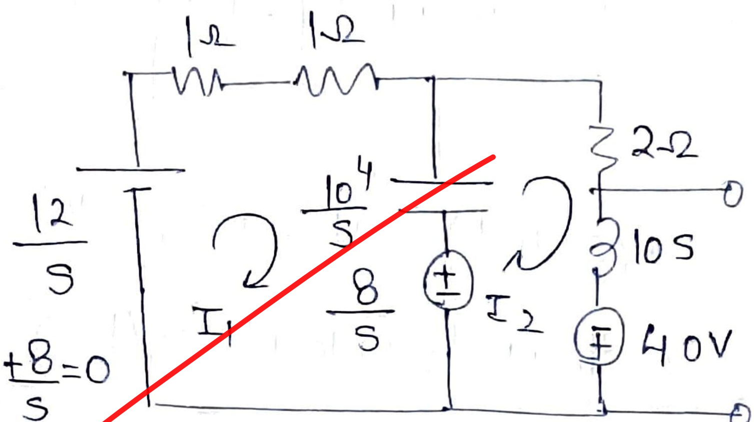
& Inductor will be short in steady state condition

$V_C(0^-) = 8$ volt.

for $t>0$, Transforming ckt in S-domain,

$V_c(0^+) = V_c(0^-) = 8V$

$i_L(0^+) = i_L(0^-) = 4A$



Using mesh analysis,

KVL in mesh ①

$$-\frac{12}{s} + 2I_1(s) + \frac{10^4}{s}\left[I_1(s) - I_2(s)\right] + \frac{8}{s} = 0$$

i.e. $$\left(2 + \frac{10^4}{s}\right) I_1(s) - \frac{10^4}{s} I_2(s) = \frac{4}{s} \quad — ①$$

KVL in mesh ②

$$I_2(s)\left[2 + 10s + \frac{10^4}{s}\right] - \frac{10^4}{s} I_1(s) - 40 - \frac{8}{s} = 0$$

$$I_2(s)\left[2 + 10s + \frac{10^4}{s}\right] - \frac{10^4}{s} I_1(s) = 40 + \frac{8}{s} \quad — ②$$

from ① $$\frac{10^4}{s} I_2(s) = \left(2 + \frac{10^4}{s}\right) I_1(s) - \frac{4}{s}$$

$$\therefore I_2(s) = \frac{\left(2 + \frac{10^4}{s}\right) I_1(s) - \frac{4}{s}}{\left(\frac{10^4}{s}\right)}$$

substitute $I_2(s)$ in eqn ②

$$\cancel{\left(2+10s+\frac{10^4}{s}\right)\left(2+\frac{10^4}{s}\right)I}$$

from eq^n (1) get $I_1(s)$ in terms of $I_2(s)$ & Put in eq^n (2)

$$I_1(s) = \frac{\frac{4}{s}+\frac{10^4}{s}I_2(s)}{\left(2+\frac{10^4}{s}\right)}$$

substitute in eq^n (2)

$$I_2(s)\left[2+10s+\frac{10^4}{s}\right]-\frac{10^4}{s}\left[\frac{\frac{4}{s}+\frac{10^4}{s}I_2(s)}{\left(2+\frac{10^4}{s}\right)}\right]=\left(40+\frac{8}{s}\right)$$

$$I_2(s)\left(2+\frac{10^4}{s}\right)\left(2+10s+\frac{10^4}{s}\right)-\frac{10^4}{s}\left(\frac{4}{s}\right)-\frac{10^4}{s}\cdot\frac{10^4}{s}I_2(s)=\left(40+\frac{8}{s}\right)\left(2+\frac{10^4}{s}\right)$$

$$I_2(s)\left[\left(2+\frac{10^4}{s}\right)\left(2+10s+\frac{10^4}{s}\right)-\left(\frac{10^4}{s}\right)^2\right]=\left(40+\frac{8}{s}\right)\left(2+\frac{10^4}{s}\right)+\frac{4}{s}\times\frac{10^4}{s}$$

$$I_2(s)\left[\left(2+\frac{10^4}{s}\right)^2+\left(2+\frac{10^4}{s}\right)10s-\left(\frac{10^4}{s}\right)^2\right]=80+\frac{40\times10^4}{s}+\frac{16}{s}+\frac{8\times10^4}{s^2}+\frac{4\times10^4}{s^2}$$

$$I_2(s)\left[4+\cancel{\left(\frac{10^4}{s}\right)^2}+\frac{4\times10^4}{s}+20s+10^5-\cancel{\left(\frac{10^4}{s}\right)^2}\right]=80+\frac{16}{s}+\frac{40\times10^4}{s}+\frac{12\times10^4}{s^2}.$$

$$I_2(s)\left[\frac{4s+4\times10^4+20s^2+10^5s}{s}\right]=\left[\frac{80s^2+16s+40\times10^4s+12\times10^4}{s^2}\right]$$

$$\therefore I_2(s)=\frac{80s^2+(16+40\times10^4)s+12\times10^4}{s\left[20s^2+(4+10^5)s+4\times10^4\right]}$$

$$V_L(s)=(10s)I_2(s)-40$$

ie, $$V_L(s)=10\times\left[\frac{80s^2+(16+40\times10^4)s+12\times10^4}{20s^2+(4+10^5)s+4\times10^4}\right]-40$$

$$V_L(s)=\frac{80s^2+(16+40\times10^4)s+12\times10^4}{2s^2+(0.4+10^4)s+0.4\times10^4}-40$$

$$V_L(s) = \frac{80s^2 + (16+40\times10^4)s + 12\times10^4 - 80s^2 + (16+40\times10^4)s + 6\times10^4}{2s^2 + (0.4+10^4)s + 0.4\times10^4}$$

$$V_L(s) = \frac{-4\times10^4}{2s^2 + 10^4 s + 0.4\times10^4} = \frac{-2\times10^4}{s^2 + 5000s + 2000}$$

$$V_L(s) = \frac{-2\times10^4}{(s+0.4)(s+4999.6)} = \frac{A}{s+0.4} + \frac{B}{s+4999.6}$$

$$\therefore A = \frac{-2\times10^4}{(-0.4+4999.6)} = -4.00064$$

$$B = \frac{-2\times10^4}{(-4999.6+0.4)} = 4.00064$$

$$\boxed{\therefore V_L(t) = 4.00064\left[e^{-4999.6t} - e^{-0.4t}\right]u(t)}$$

← Ans.

Ques-7(a)

Solution-

Given!

15 KVA, 2400/240, 60Hz Transformer

circuit Parameter

$R_1 = 2.5\Omega$ $X_1 = 7\Omega$ $R_c = 32K\Omega$

$R_2 = 0.025\Omega$ $X_2 = 0.07\Omega$ $X_m = 11.5K\Omega$

If T/F is supplying a 10KW, 0.8pf lagging at Rated voltage.

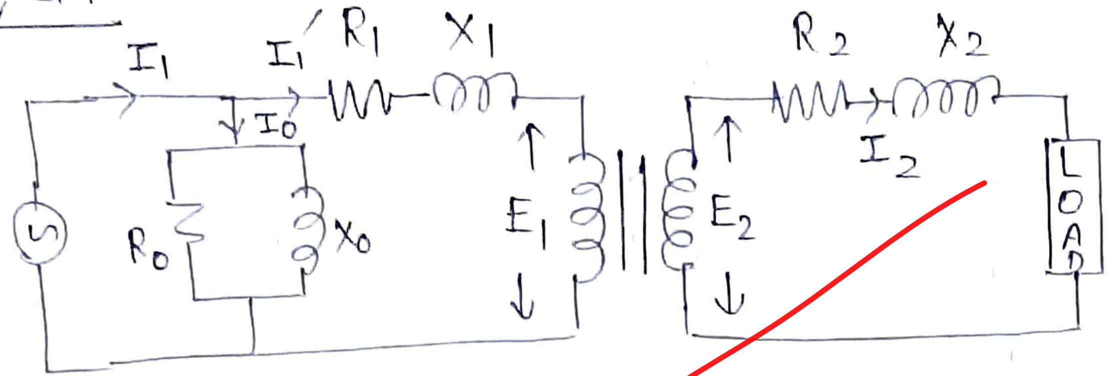
We have to draw eq. ckt referred to H.V side

$$\frac{E_1}{E_2} = \frac{N_1}{N_2} = \frac{2400}{240} = 10 = \frac{I_2}{I_1}$$

$$I_2 = \frac{E_2 I_2}{E_2} = \frac{15\text{ KVA}}{2400} = 62.5\text{ Amp}$$

$$\therefore I_1 = 6.25\text{ A}$$

eq. ckt -



Transforming Resistance from 2° ry to Primary sides,

$$I_1^2 R_2' = I_2^2 R_2$$

$$\therefore R_2' = \left(\frac{I_2}{I_1}\right)^2 R_2 = 10^2 \times 0.025$$

$$R_2' = 2.5\,\Omega$$

∴ Total eq Resistance Referred to Primary (HV)

$$R_{o_1} = R_1 + R_2' = 2.5 + 2.5 = 5\,\Omega.$$

Transforming Reactance from 2° ry to 1° ry side

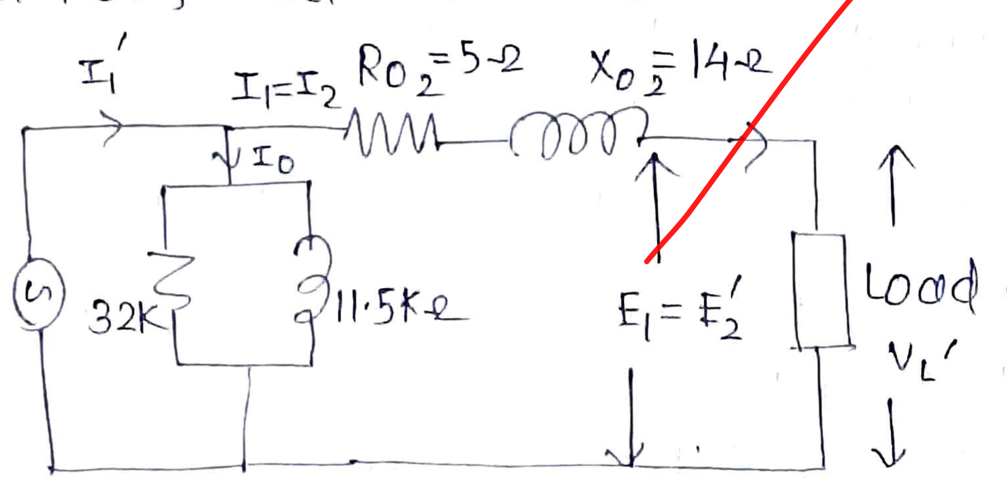
$$I_1^2 X_2' = I_2^2 X_2$$

$$\therefore X_2' = \left(\frac{I_2}{I_1}\right)^2 X_2 = 10^2 \times 0.07 = 7\,\Omega.$$

∴ Total eq. Reactance referred to Primary (HV)

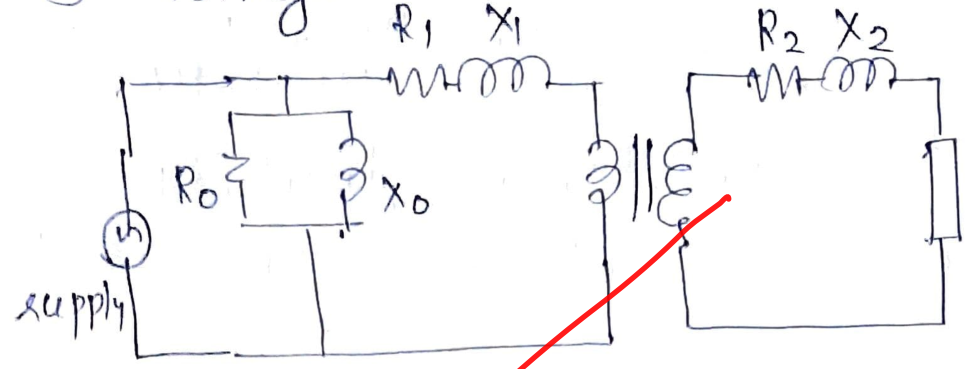
$$X_{o_2} = X_1 + X_2' = 7 + 7 = 14\,\Omega$$

eq. ckt referred to HV Side.



(ii) Input Current -

T/F is supplying 10KW, 0.8pf lag load at Rated Voltage.



$\because I_1 = I_2'$

$\therefore I_2' = \dfrac{E_2' I_2'}{E_2'} = \dfrac{10 \times 10^3}{2400} = 4.167$ Amp.

$\therefore$ Input current $I_1 = 4.167$ amp.