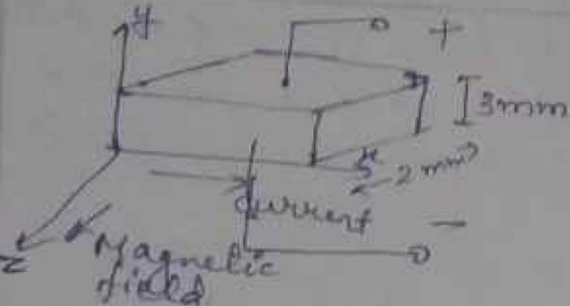
NAME:
ROLL NUMBER:
TEST NO: 14
SUBJECT:

1(a)(i)



force is applied on the electron moving inside the specimen. ~~This specimen~~ The majority carriers experience a force due to transverse magnetic field present.
This force is $f = q V_x \times B_z$
This force is acting in downward direction.

As a result majority carriers electrons accumulate on lower surface, to counterbalance this a force applied in upward direction so that charge carriers attain equillibrium.

$f_y = q V_x B_z$.
this f_y is due to hall voltage developed
$f_y = q \cdot E_y$
$q E_y = q V_x B_z \Rightarrow E_y = V_x B_z$

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Hall voltage $V_H = \frac{E_y}{d}$

Current density $J_x = n e V_x = \sigma E_x$

$$V_x = \frac{\sigma E_x}{ne} = \frac{n e \mu_n E_x}{ne} = \mu_n E_x.$$

$E_y = \mu E_x B_z$.

$$\boxed{V_H = \frac{\mu_n E_x B_z}{d}}$$

$$V_H = 3500 \times \frac{6}{10^{-2}} \times \frac{\cancel{0.3}\ 0.1}{\cancel{3} \times 10^{-31}} \times 10^{-4}$$

$V_H = 21\,KV$.

(ii) If p-type bar used force still acts in downward direction, as a result ~~positive~~ ~~stafa~~ lower surface becomes positive w.r.t top surface as a result polarity of Hall voltage reverses.

1(b) Initially assume both diodes to be off.

$V_{P1} = V_i$ $\quad V_{P2} = 75$

$V_{n1} = 25V$ $\quad V_{n2} = 25V$.

So D_2 can be assumed to be ON first.

As a result D_2 short circuit.

$$V_o(t) = \frac{25 \times 5 + 75 \times 5}{5+5} = 50V$$

when $V_i > 50V$, D1 becomes ON. and D_2 already ON so $V_o = V_i$

for $V_i < 50V$, D1 off & D2 ON so $V_o = 50V$.

Consider case when D_1 ON & D2 off. output cut off from input & $V_o = 75V$

We need to check if this happens.

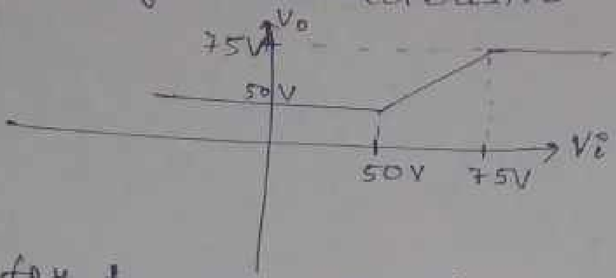
when D2 cut off. $V_{N2} = 75V$.

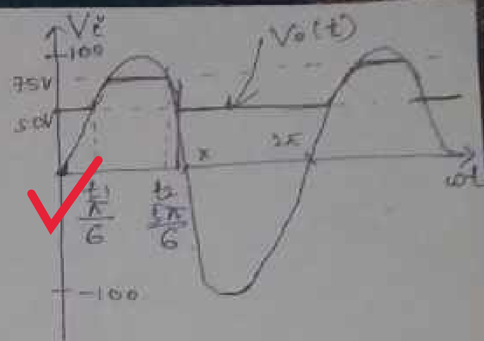
$V_{P2} = V_i$.

So when $V_i > 75V$, D2 cut off and $V_o = 75V$.

$$V_o = \begin{cases} 50 & V_i < 50 \\ V_i & 50 < V_i < 75 \\ 75 & V_i > 75 \end{cases}$$

Transfer characteristic





for t_1 $\quad 50 = 100\sin(\omega t_1)$

$\omega t_1 = \pi/6$

$\omega t_2 = \pi - \pi/6 = \frac{5\pi}{6}$

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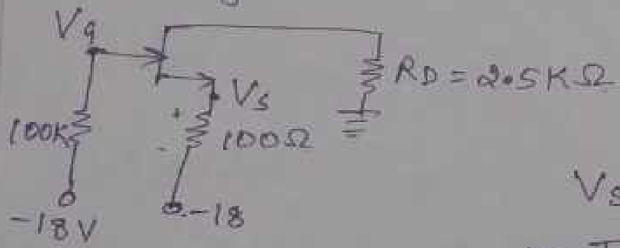
1 (c) For voltage gain we need g_m, for that DC analysis has to be done



$I_D = I_{DSS}\left(1 - \frac{|V_{GS}|}{|V_P|}\right)^2$

$V_G = -18V$

$V_S - I_D \times 100 + 18 = 0$

$100 I_D = V_S + 18$

$\Rightarrow V_{GS} = -100 I_D \Rightarrow I_D = \frac{-V_{GS}}{100}$

$$\frac{-V_{GS}}{100} = 8\times10^{-3}\left(1 - \frac{V_{GS}}{-3}\right)^2$$

$$-V_{GS} = 0.8\left(1 + \frac{V_{GS}^2}{9} + 2\frac{V_{GS}}{3}\right)$$

$$\frac{-9V_{GS}}{0.8} = 9 + V_{GS}^2 + 6V_{GS}.$$

$$V_{GS}^2 + 17.25 V_{GS} + 9 = 0$$

$V_{GS} = -0.66 \qquad V_{GS} = -13.56$

as $V_{GS} < V_P$ desired hence $V_{GS} = -0.66$

$$I_D = -\frac{(-0.66)}{100} = 6.6 mA.$$

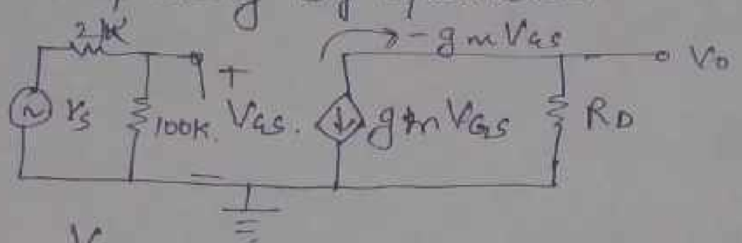
$$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{2 I_{DSS}}{|V_P|}\left(1 - \frac{V_{GS}}{V_P}\right) = 2 I_{DSS}\sqrt{\frac{I_D}{I_{SS}}}$$

$$g_m = \frac{2\sqrt{I_D I_{DSS}}}{V_P}$$

$$g_m = \frac{2}{|3|} \cdot \sqrt{6.6 \times 8} = 4.844 \ \text{mS}$$

Now for AC analysis.

Replacing by equivalent π model.



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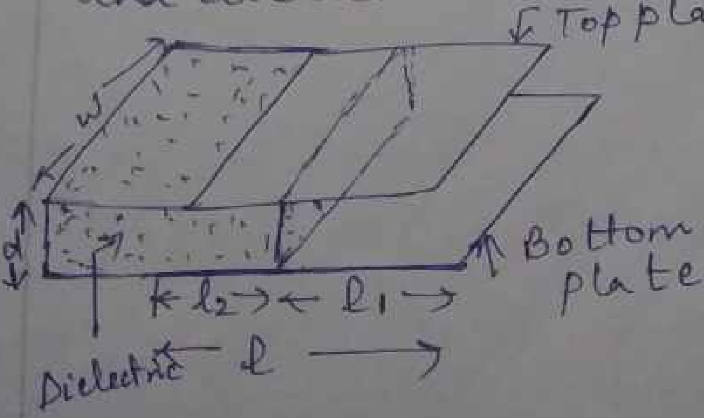
$$V_{GS} = \frac{V_s \times 100K}{100K + 2K} = \frac{V_s \times 100K}{102K} = 0.98 V_s$$

$$V_o = -g_m V_{GS} \cdot R_D = -g_m \times 0.98 V_s R_D$$

$$\frac{V_o}{V_s} = -g_m \times 0.98 \times R_D = -4.844 \times 0.98 \times 2.5$$

$$\boxed{\frac{V_o}{V_s} = -11.87}$$

1(d) For the measurement of displacement through capacitive transducer we can either change overlap area, plate separation and dielectric constant.



The plates of the capacitor are fixed. However a moving object having dielectric constant ε_r is moving into the plate. We are willing to measure displacement of object

(9)

At any intermediate stage, let l_2 length of object is inside the plates. Therefore upto l_2 length, the capacitor filled will dielectric having dielectric constant ε_r whereas for l_1 length we have air. Capacitance of combination can be found as

$$C = C_1 + C_2$$

$$C = \frac{\varepsilon_0 w l_1}{d} + \frac{\varepsilon_0 w l_2 \varepsilon_r}{d}$$

$$C = \frac{\varepsilon_0 w}{d}(l_1 + \varepsilon_r l_2)$$

As object moves into capacitor, the value of l_2 increases and capacitance C also increases. By measuring this capacitance, linear displacement can also be measured.

Let full length is l & penetration be x.

$$C = \frac{\varepsilon_0 w}{d}[(l-x) + \varepsilon_r x].$$

$$\frac{\partial C}{\partial x} = \frac{\varepsilon_0 w}{d}[(-1) + \varepsilon_r] = \frac{\varepsilon_0 w}{d}(\varepsilon_r - 1)$$

Hence can be used to measure linear displacements.

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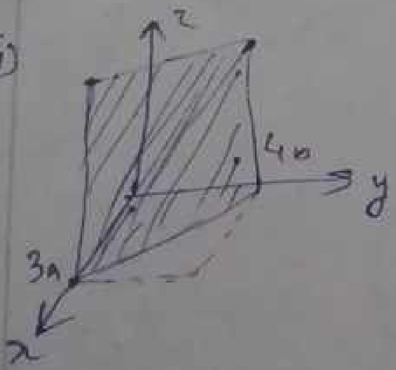
1(c)(i)



x	y	z	
3a	4b	∞	– Intercept
3	4	∞	— simple ratios
$\frac{1}{3}$	$\frac{1}{4}$	0	— Reciprocal.
4	3	0	— Ratios.

Miller indices $(4\ 3\ 0)$

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(ii) from Bragg's law we have

$n\lambda = 2d\sin\theta$

for 1st order reflection $n=1$

$1 \times 0.175 = 2d \times \sin 30$

$0.175 = 2 \times d \times \frac{1}{2} \Rightarrow d = 0.175$ mm

This d is interplanar separation between two planes having miller indices (h k l)

$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$; here a is interatomic separation & h k l are miller indices.

$0.175 = \frac{a}{\sqrt{1^2+1^2+1^2}} \Rightarrow a = 0.175 \times \sqrt{3}$ mm

$\boxed{a = 0.303 \text{ mm}}$

✓

4(a) Atomic polarisability is given as

$P = \alpha E. \Rightarrow \alpha = \frac{P}{E}$

here P is atomic dipole moment.

Let us first move towards finding electric field $\vec{E}$.

As from gauss law. $\oint D \cdot ds = Q_{enc}$

we are given the charge density

$Q = \int_V \rho(r)\, dV = \int_V \frac{q}{4\pi a^3} e^{-2r/a}\, dV$

$= \iiint \frac{q}{4\pi a^3} e^{-2r/a}\, r^2 \sin\theta\, d\theta\, d\phi\, dr$

$= \frac{q}{4\pi a^3} \int_0^r r^2 e^{-2r/a}\, dr \int_0^\pi \sin\theta\, d\theta \int_0^{2\pi} d\phi$

$= \frac{q}{4\pi a^3} \times 2\pi \times 2 \int_0^r r^2 e^{-2r/a}\, dr$

(4)

$$Q = \frac{q}{4\pi a^3} \times 4\pi \left[\frac{r^2 e^{-2r/a}}{-2/a} + \frac{a}{2} \int 2r\, e^{-2r/a}\, dr \right.$$

$$= \frac{q}{a^3}\left[\frac{-ar^2}{2} e^{-2r/a} + a\left[\frac{r\, e^{-2r/a}}{-2/a} + \frac{a}{2}\frac{e^{-2r/a}}{-2/a} \right]\right]\}$$

$$= \frac{q}{a^3}\left[\left[\frac{-a}{2} r^2 e^{-2r/a} + \frac{-a^2}{2} r\, e^{-2r/a} + \frac{-a^3}{4} e^{-2r/a}\right]_0^r\right.$$

$$= \frac{q}{a^3}\left[\frac{a^3}{4} - \frac{a}{4}(2r^2 - 2ar + a^2)\, e^{-2r/a}\right]$$

$$Q = \frac{q}{\cdot}\left[1 - \frac{e^{-2r/a}}{a^2}(2r^2 - 2ar + a^2)\right]$$

$$e^{-2r/a} = 1 - \frac{2r}{a} + \frac{1}{2}\left(\frac{2r}{a}\right)^2 - \frac{1}{6}\left(\frac{2r}{a}\right)^3$$

$$Q = q\left\{1 - \left(1 - \frac{2r}{a} + \frac{1}{2}\left(\frac{2r}{a}\right)^2 - \frac{1}{6}\left(\frac{2r}{a}\right)^3 \cdots\right)\left(2\left(\frac{r}{a}\right)^2 - 2\left(\frac{r}{a}\right) + 1\right)\right\}$$

$$\oint D \cdot ds = Q \Rightarrow D \cdot 4\pi r^2 = Q$$

$$D = \frac{Q}{4\pi r^2}$$

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$$D = \varepsilon E \Rightarrow E = \frac{Q}{4\pi\varepsilon r^2}$$

$$E = \frac{q}{4\pi\varepsilon r^2}\left[1 - \left(1 - \left(\frac{2r}{a}\right) + \frac{1}{2}\left(\frac{2r}{a}\right)^2 - \frac{1}{6}\left(\frac{2r}{a}\right)^3 \cdots\right)\left(2\left(\frac{r}{a}\right)^2 - 2\left(\frac{r}{a}\right) + 1\right)\right]$$

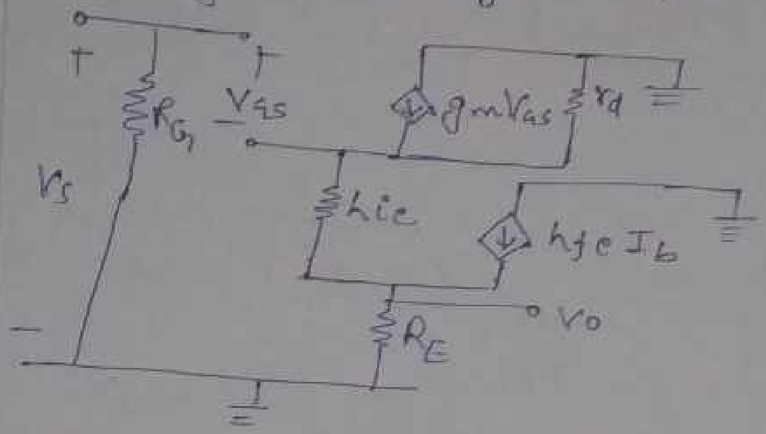
$$= \frac{q}{4\pi\varepsilon r^2} \cdot \frac{4}{3}\left(\frac{r}{a}\right)^3 \quad \text{[neglecting higher terms as } r \gg a]$$

$$= \frac{q}{4\pi\varepsilon} \cdot \frac{4}{3}\frac{r}{a^3} = \frac{qr}{3\pi\varepsilon a^3}$$

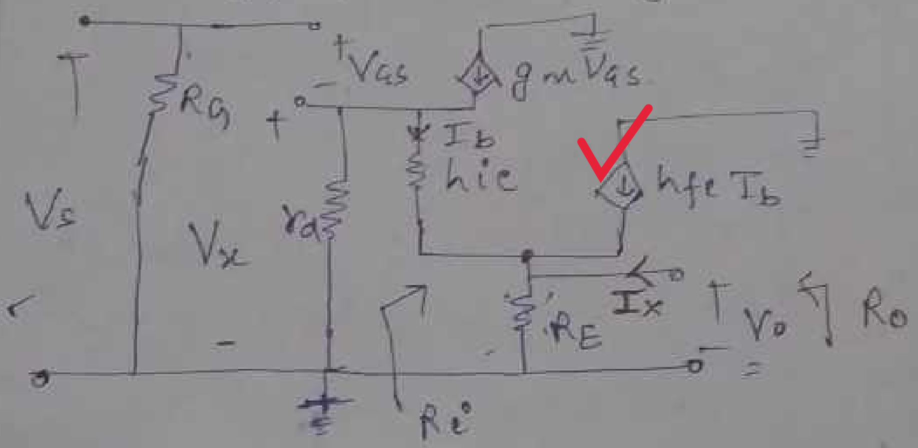
$qr = p$ = atomic polarisation

$$E = \frac{p}{3\pi\varepsilon a^3} \Rightarrow \boxed{\frac{p}{E} = 3\pi\varepsilon a^3 = \alpha.}$$

4(b) Drawing small signal equivalent circuit (5)



Simplifying the arrangement.



$V_i = h_{ie} I_b + R_E (1 + h_{fe}) I_b$

$R_i = \frac{V_i}{I_b} = h_{ie} + (1 + h_{fe}) R_E$ — (1)

$g_m V_{GS}$ divided b/w r_d & R_i as they appear in parallel.

$V_S = V_{GS} + V_x = V_{GS} + g_m V_{GS} (r_d \| R_i)$ — (2)

$V_o = I_b (1 + h_{fe}) R_E$ — (3)

$I_b = g_m V_{GS} \cdot \frac{r_d}{r_d + R_i}$ — (4)

(4) in (3) $V_o = g_m V_{GS} \frac{r_d}{r_d + R_i} (1 + h_{fe}) R_E$ — (5)

from (2)

$$V_s = V_{gs} + g_m V_{gs} \frac{r_d R_i}{r_d + R_i}$$

$$V_s = \frac{V_{gs}(r_d + R_i) + g_m V_{gs} r_d R_i}{r_d + R_i} \quad \text{—— (6)}$$

(5) $\div$ (6)

$$\frac{V_o}{V_s} = \frac{g_m V_{gs} \frac{r_d}{r_d + R_i} (1 + h_{fe}) R_E}{\frac{V_{gs}(r_d + R_i) + g_m V_{gs} r_d R_i}{r_d + R_i}}$$

$$\frac{V_o}{V_s} = \frac{g_m r_d (1 + h_{fe}) R_E}{(r_d + R_i) + g_m r_d R_i}$$

$$= \frac{g_m r_d (1 + h_{fe}) R_E}{r_d + h_{ie} + (1 + h_{fe}) R_E + g_m r_d (h_{ie} + (1+h_{fe}) R_E)}$$

$g_m = \frac{\mu}{r_d}$ (as μ and r_d given in question).

$$\boxed{\frac{V_o}{V_s} = \frac{\mu (1 + h_{fe}) R_E}{r_d + h_{ie} + (1 + h_{fe}) R_E + \mu (h_{ie} + (1 + h_{fe}) R_E)}}$$

This is required voltage gain.

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For output resistance, V_s removed

~~from eqn (2)~~ $\cancel{V_{gs} + g_m V_{gs}(r_d \| R_i) = 0}$

$\cancel{g_m (r_d \| R_i) = -1}$

~~KCL at emitter junction~~

$\cancel{\frac{V_o}{R_E} = I_x + (1 + h_{fe}) I_b}$.

$$V_{gs} + V_x = 0$$

$$V_x = I_b h_{ie} + V_o \quad \text{—— (7)}$$

$$\cancel{V_o = [(1+h_{fe})I_b + I_x]R_E} \quad (8)$$

$$V_x = I_b h_{ie} + \{(1+h_{fe})I_b + I_x\}R_E$$

At source terminal KCL eqn.

$$g_m V_{GS} = I_b + \frac{V_x}{r_d}$$

$$g_m(-V_x) = I_b + \frac{V_x}{r_d}$$

$$I_b = -V_x\left(g_m + \frac{1}{r_d}\right) \quad (9)$$

eqn (9) in (7)

$$V_x = -V_x h_{ie}\left(g_m + \frac{1}{r_d}\right) + V_o$$

$$V_x\left[1 + h_{ie}\left(\frac{1}{g_m} \| r_d\right)\right] = V_o$$

$$I_x = (1+h_{fe}) I_b$$

$$I_x = (1+h_{fe})\left(g_m + \frac{1}{r_d}\right)(-V_x)$$

$$I_x = (1+h_{fe})\left(g_m + \frac{1}{r_d}\right)\frac{V_o}{1 + h_{ie}(1/g_m \| r_d)}$$

$$\frac{V_o}{I_x} = R_o' = \frac{1 + h_{ie}\left(\frac{1}{g_m} \| r_d\right)}{(1+h_{fe})\left(\frac{1}{g_m} \| r_d\right)}$$

$$\boxed{R_o = \frac{1 + h_{ie}\left(\frac{1}{g_m} \| r_d\right)}{(1+h_{fe})\left(\frac{1}{g_m} \| r_d\right)} \| R_E} \simeq \frac{h_{ie}}{1+h_{fe}} \| R_E$$

4(c) for linearly graded junction charge density given as $\rho_v = \{ g x e \quad -\frac{w}{2} \le x \le \frac{w}{2}$

as this is charge consisting region, so we apply Poisson relation.

$$\nabla^2 V = -\frac{\rho_v}{\varepsilon} = \frac{-g x e}{\varepsilon}$$

Integrating both sides

$$\nabla V = -g\frac{x^2 e}{2\varepsilon} + C$$

This is equation of Electric field
as $E = -\nabla V = 0$ at $x = -w/2$

$$0 = -\frac{qe\left(-\frac{w}{2}\right)^2}{2\varepsilon} + C_1 \Rightarrow C_1 = \frac{qew^2}{8\varepsilon}$$

$$\frac{dV}{dx} = -\frac{qex^2}{2\varepsilon} + \frac{qew^2}{8\varepsilon}$$

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Integrating both sides.

$$V = -\frac{qex^3}{6\varepsilon} + \frac{qew^2x}{8\varepsilon} + C_2$$

at $x = 0$; $V = 0 \Rightarrow C_2 = 0$

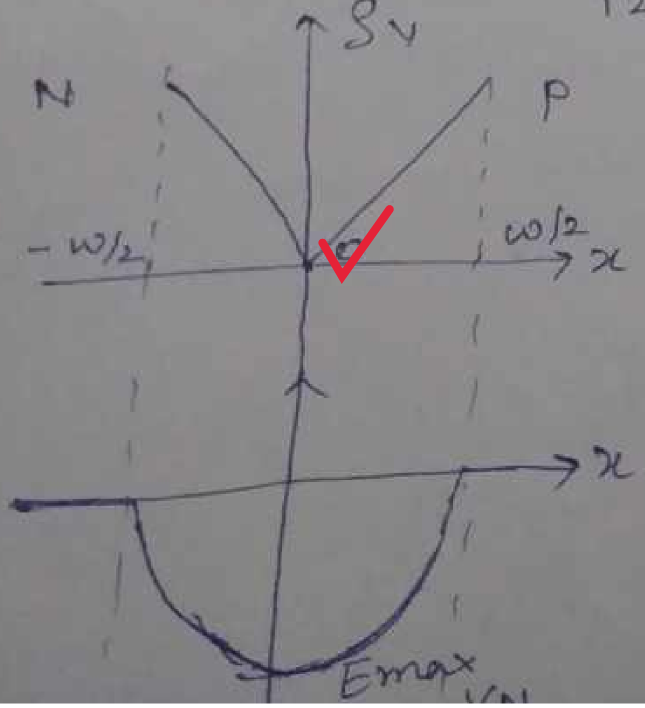
$$V = -\frac{qex^3}{6\varepsilon} + \frac{qew^2x}{8\varepsilon}$$

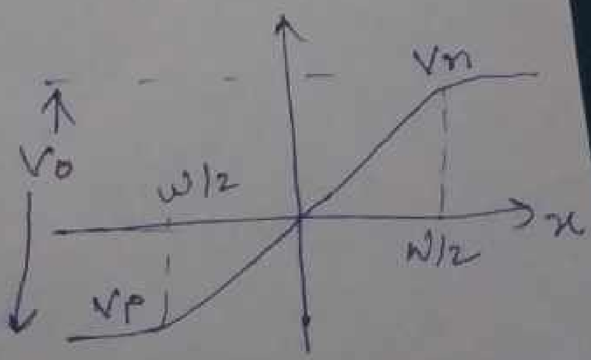
at $x = -w/2$ $V = V_p$.

$$V_p = -\frac{qe\left(-\frac{w}{2}\right)^3}{6\varepsilon} + \frac{qew^2\left(-\frac{w}{2}\right)}{8\varepsilon} = -\frac{qew^3}{24\varepsilon}$$

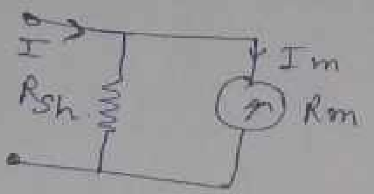
at ~~ω~~ $x = w/2$ $V = V_n \Rightarrow V_n = \frac{qew^3}{24\varepsilon}$

$$V_o = V_n - V_p = \frac{qew^3}{12\varepsilon}$$





4(d) $R_m = 20\,\Omega$; $I_m = 1\,mA$

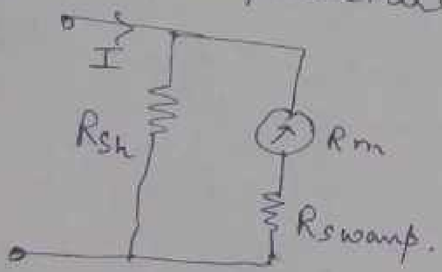


$$\frac{I}{I_m} = m = \frac{100}{1} = 100$$

$$R_{sh} = \frac{R_m}{m-1}$$

$$R_{sh} = \frac{20}{100-1} = 0.202\,\Omega$$

Now $75\,\Omega$ resistance connected in series for temperature compensation



$$R_{sh\,new} = \frac{R_m + R_{swamp}}{m-1}$$

$$= \frac{20+75}{100-1} = 0.9596\,\Omega$$

for $20°C$ rise in temp.

$$R_m' = R_m(1+\alpha T) = 20(1+0.005\times 20) = 22\,\Omega$$

$$R_{swamp}' = 75(1+0.0002\times 20) = 75.3\,\Omega$$

$$R_{meter\ arm} = 22 + 75.3 = 97.3\,\Omega$$

$$R_{shunt} = 0.9596(1+0.0002\times 20)$$
$$= 0.9634\,\Omega$$

$$I_m = I \times \frac{R_{sh}}{R_{sh} + R_{meter\,arm}}$$

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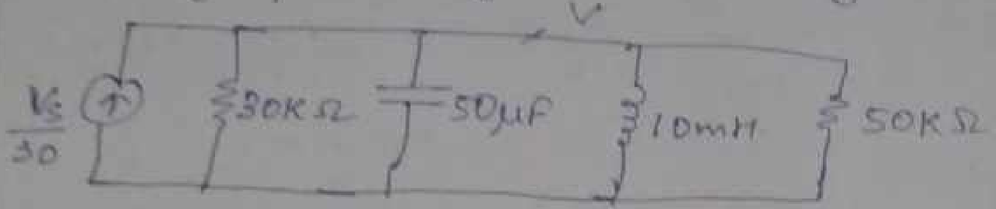
$$I_m = I \times \frac{0.9634}{0.9634 + 97.3} = 0.9804\,mA$$

Error due to temperature rise

$$= MV - TV = 0.9804 - 1$$
$$= -0.0196\,mA$$

$$\%\ error = \frac{-0.0196}{1} \times 100 = -1.96\,\%$$

5(a) Changing voltage source by current source



~~At resonance~~ $\frac{V_s}{30} = \frac{V}{30} + \frac{V}{50} + \frac{V}{j\omega L} + \frac{V}{1/j\omega C}$

$\frac{V_s}{30} = V\left(\frac{1}{30} + \frac{1}{50}\right) + \frac{V}{j\omega L} + j\omega C V$

at resonance all current flows through resistor & L & C form OC.

$\frac{1}{j\omega_0 L} + j\omega_0 C = 0 \Rightarrow 1 + j^2\omega_0^2 LC = 0$

$\omega_0^2 LC = 1 \Rightarrow \boxed{\omega_0 = \frac{1}{\sqrt{LC}}} \Rightarrow$

This is required resonant frequency.

Quality factor $Q = \frac{1}{\omega_0 C R}$

3

$R = 30 // 50 = 18.75 K\Omega$

$\omega_0 = \frac{1}{\sqrt{10\times10^{-3} \times 50\times10^{-6}}}$

$\boxed{\omega_0 = 1.414 \text{ Krad/sec}}$

$Q = \frac{1}{1.414\times10^{3} \times 50\times10^{-6} \times 18.75\times10^{3}}$

$Q = 7.5436\times10^{-4}$

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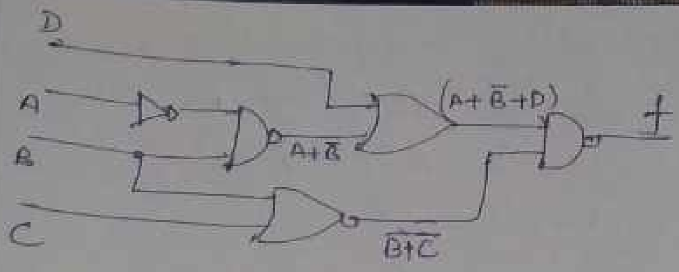
5(b) (i)



$$f = \overline{(A+\bar{B}+D)\cdot\overline{B+C}}$$
$$= \overline{A+\bar{B}+D} + (B+C)$$
$$= \bar{A}B\bar{D} + B + C$$
$$= B(\bar{A}\bar{D}+1) + C = B+C$$

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(ii)

$$F(P, Q, R) = P(P'+Q)(P'+Q+R')$$
$$= (PP' + PQ)(P'+Q+R')$$
$$= PQP' + PQ + PQR'$$
$$= PQ + PQR' = PQ(1+R') = PQ.$$

F: P \ QR	00	01	11	10
0	0	0	0	0
1	0	0	1	1

$$F = (P+Q+R)(P+Q+\bar{R})(P+\bar{Q}+\bar{R})(P+\bar{Q}+R)$$
$$(\bar{P}+Q+R)(\bar{P}+Q+\bar{R}).$$

$$f = \Pi M(0, 1, 2, 3, 4, 5)$$

5(c) Let two variables are A & B. Boolean with n variables number of Boolean expressions are 2^{2^n}

here $n = 2$

hence number of Boolean expressions

$$= 2^{2^2} = 2^4 = 16$$

Let us write these expression

1. $Y = AB$
2. $Y = A + B$
3. $Y = \bar{A} B$
4. $Y = A\bar{B}$
5. $Y = \bar{A} + B$
6. $Y = A + \bar{B}$
7. $Y = \bar{A} + \bar{B}$
8. $Y = \bar{A}\bar{B}$
9. $Y = AB + \bar{A}\bar{B}$
10. $Y = A\bar{B} + \bar{A}B$
11. $Y = 0$
12. $Y = \bar{A}$
13. $Y = \bar{B}$
14. $Y = A$
15. $Y = B$
16. $Y = 1$

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5(d) Output mechanical power $= VI\cos\phi$

$7.46 = 500 \times I \times 0.9 \Rightarrow \boxed{I_a = 16.577\,A}$

Copper loss $= I_a^2 R_a = (16.577)^2 \times 0.8 = 219.86\,W$

Total losses $= 1500 + 219.86$
$= 1719.86\,W.$

Commercial efficiency

$$\eta = \frac{O/P}{O/P + \text{losses}}$$

$$\eta = \frac{7460}{7460 + 1719.86} = 81.265\%$$

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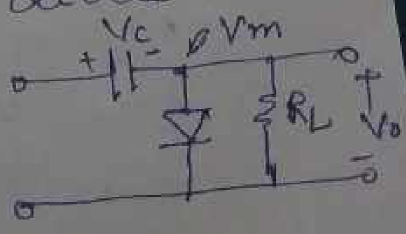
5(e) $R_L C$ large means charging & discharging times can be neglected.

$V_{in} > V_r$, Diode forward biased and capacitor charges through diode D upto voltage $V_{in} - V_r$

i.e $V_C = V_{in} - V_r = 5 - 0.8$
$= 4.2V$

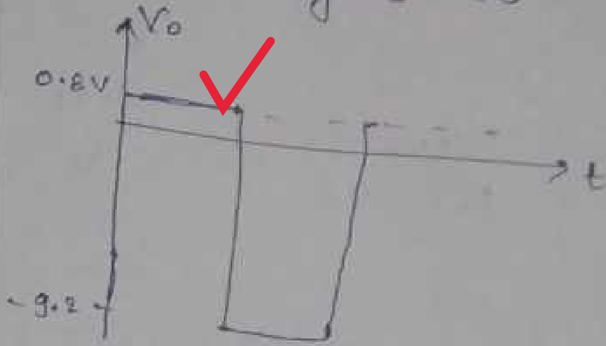


$V_o = V_{in} - V_c$

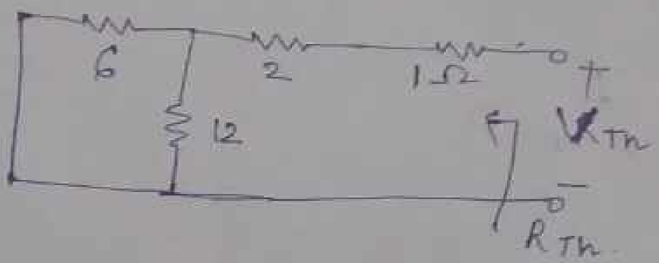
for +ve cycle $V_o = 5 - 4.2 = 0.8$ V.

for -ve cycle $V_o = -5 - 4.2 = -9.2$ V

8



5(f) For maximum power transfer $R_L = R_{Th}$ here R_{Th} is thevenin's equivalent resistance for this we deactive source.



Open circuit current source and short circuit voltage source.

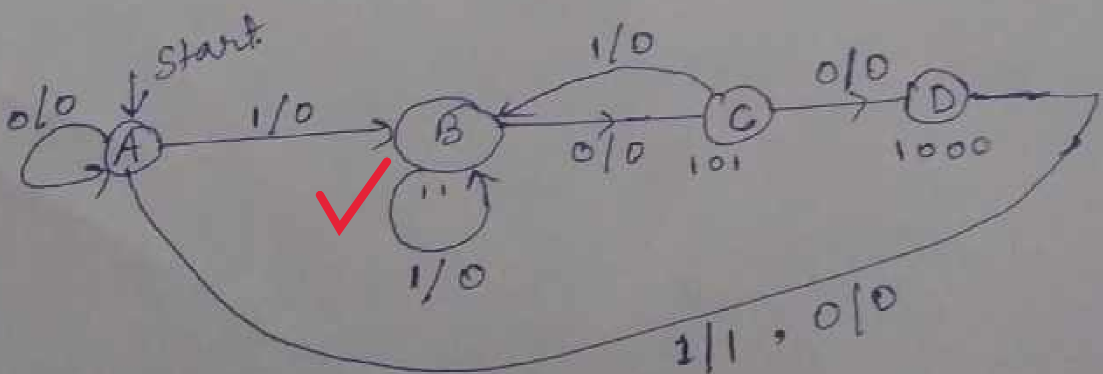
$R_{Th} = 1 + 2 + 12 \| 6$

$= 1 + 2 + 4 = 7\Omega$

5

$\boxed{R_L = 7\Omega}$ for maximum power transfer

6(a)

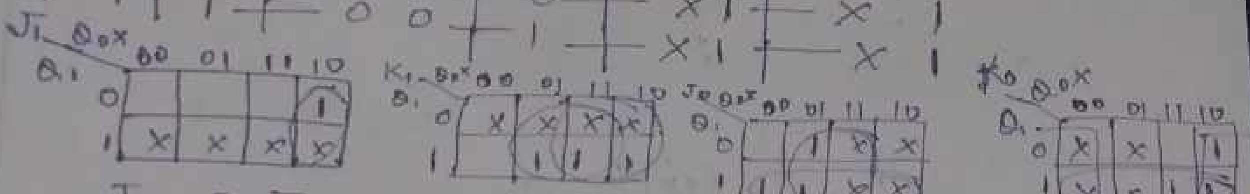


(10)

A : 00
B : 01
C : 10
D : 11

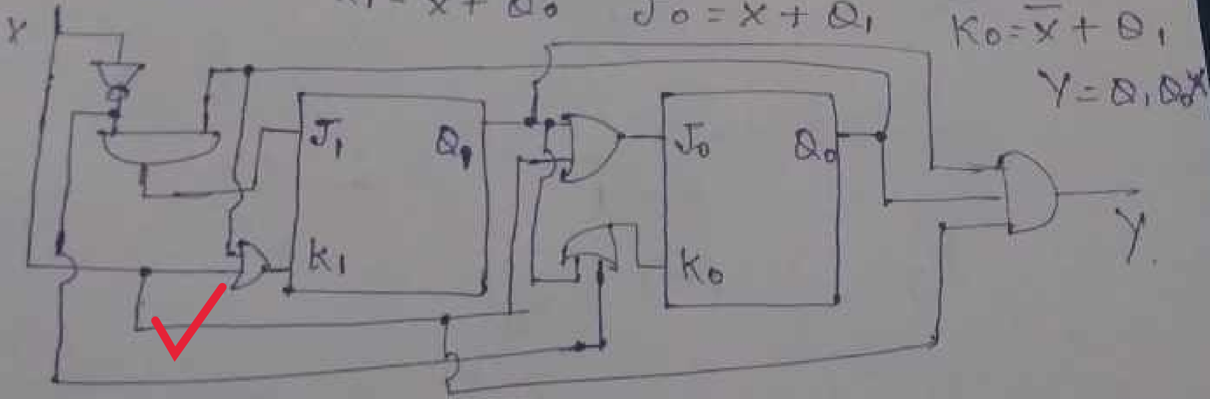
Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

PS		X	NS		Y				
Q_1	Q_0	X	Q_1^+	Q_0^+	Y	J_1	K_1	J_0	K_0
0	0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	0	X	1	X
0	1	0	1	0	0	1	X	X	1
0	1	1	0	1	0	0	X	X	0
1	0	0	1	1	0	X	0	1	X
1	0	1	0	1	0	X	1	1	X
1	1	0	0	0	0	X	1	X	1
1	1	1	0	0	1	X	1	X	1



$J_1 = Q_0\overline{X}$ $K_1 = X + Q_0$ $J_0 = X + Q_1$ $K_0 = \overline{X} + Q_1$

$Y = Q_1 Q_0 X$



$J_1 = Q_0\overline{X}$ $K_1 = X + Q_0$ $J_0 = X + Q_1$ $K_0 = \overline{X} + Q_1$

$Y = Q_1 Q_0 X$.

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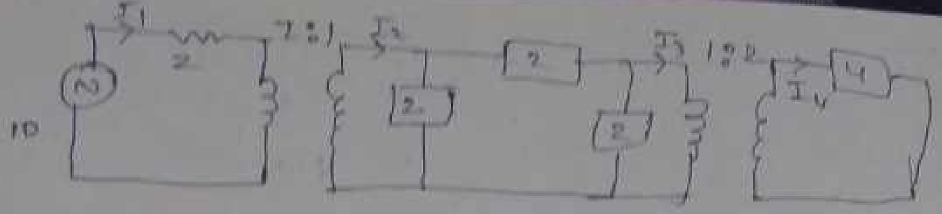
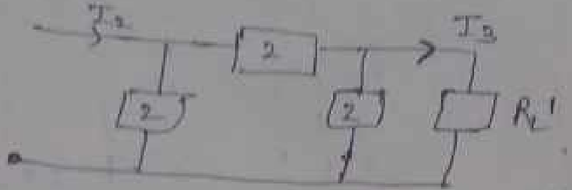
Q b) (i)



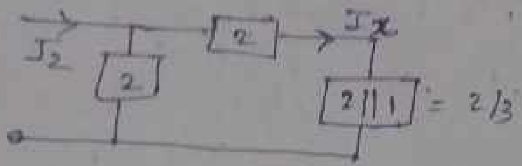
$I_1 = \frac{10}{2} = 5A$

$\frac{I_1}{I_2} = \frac{1}{2} \Rightarrow I_2 = 5\times2 = 10\Omega$

for finding I_3 we move 4Ω of load into its branch.



$R_L' = \frac{4}{(2)^2} = 1\Omega$



$I_x = \frac{I_2 \times 2}{2 + \frac{2}{3} + 2} = \frac{I_2 \times 2}{\frac{14}{3}}$

$I_x = \frac{6}{14} I_2 = \frac{3}{7} I_2$

$I_3 = \frac{I_x \times 2}{2+1} = \frac{3}{7} \cancel{I_2} \times \frac{2}{3} = \frac{2 I_2}{7}$

$I_3 = \frac{2}{7}(10) = \frac{20}{7}$

4

$I_4 = \frac{I_3}{2} = \frac{20}{7} \times \frac{1}{2} = \frac{10}{7} = 1.428 A$

Power delivered $P_L = I_4^2 R_L$

$P_L = \left(\frac{10}{7}\right)^2 \times 4 = 8.16$ Watts

~~(ii) $V_T' = V_i + I_1 \times 1K \Rightarrow V_T$~~

6(b)(ii) $V_2 = -2000 I_2$ —— 1

$V_1 = 100 I_1 + 0.0025 V_2$

$V_1 = 100 I_1 + 0.0025 \times 2000 I_2 = 100 I_1 + 5 I_2$ —— 2

4

$I_2 = 20 I_1 + 10^{-3} V_2$ —— 3

$I_2 = 20 I_1 + 10^{-3} \times 2 \times 10^{3} (-I_2)$ [1 in 3]

$3 I_2 = 20 I_1 \Rightarrow I_1 = \frac{3}{20} I_2$ —— 4

4 in 2

$V_1 = \cancel{100}^{5} \left(\frac{3}{\cancel{20}} I_2\right) + 5 I_2 = 20 I_2$ —— 5

1 ÷ 5

$$\frac{V_2}{V_1} = \frac{-2000 I_2}{20 I_2} = -100 \Rightarrow \boxed{\frac{V_2}{V_1} = -100}$$

6(c)(i) ~~Torque~~ Power delivered $= 3 I_2^2 \cdot \frac{R_2}{s}$ —— 1

$$I_2 = \frac{E_2}{\sqrt{\left(\frac{R_2}{s}\right)^2 + \left(X_2\right)^2}} = \frac{s E_2}{\sqrt{(R_2)^2 + (sX_2)^2}}$$ —— 2

2 in 1

$$P_g = \frac{3 s^2 E_2^2}{(sX_2)^2 + (R_2)^2} \times \frac{R_2}{\cancel{s}}$$

$$P_g = \frac{3 s E_2^2 R_2}{(sX_2)^2 + (R_2)^2}$$

Torque generated $T = \frac{P}{\omega}$.

$$T = \frac{3}{\frac{2\pi N_s}{60}} \cdot \frac{s E_2^2 R_2}{(sX_2)^2 + (R_2)^2}$$

$$T = \frac{3E_2^2}{\frac{2\pi N_s}{60}} \cdot \frac{R_2}{(\sqrt{s}X_2)^2 + \left(\frac{R_2}{\sqrt{s}}\right)^2}$$

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$$T = \frac{K R_2}{\left(\frac{R_2}{\sqrt{s}}\right)^2 + 2R_2X_2 - 2R_2X_2 + (\sqrt{s}X_2)^2}$$

$$T = \frac{K R_2}{\left(\frac{R_2}{\sqrt{s}} - \sqrt{s}X_2\right)^2 + 2R_2X_2}$$

for maximum torque. $\frac{R_2}{\sqrt{s}} - \sqrt{s}X_2 = 0$

$$\boxed{R_2 = sX_2}$$

This is condition for maximum torque

$$T_{max} = \frac{K \cancel{R_2}}{2\cancel{R_2}X_2} = \frac{K}{2X_2}$$

$$T_{max} = \frac{3E_2^2}{\frac{2\pi N_s}{60} 2X_2} = \frac{3}{\frac{2\pi N_s}{60}} \frac{E_2^2}{2X_2}$$

(ii) $T_{max} = 110\ Nm$

$N_{Tmax} = 1360$ rpm.

$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500$ rpm

$s_{max} = \frac{N_s - N}{N_s} = \frac{1500 - 1360}{1500} = 0.093$

$R_2 = 0.25$ (star connected).

$X_2 = \frac{R_2}{s} = \frac{0.25}{0.093} = 2.688\ \Omega$

$T = \frac{P_g}{\omega} \Rightarrow P_g = T\omega = T \cdot \frac{2\pi N_s}{60}$

$P_g = 110 \times \frac{2\pi \times 1500}{60} = 17.2787\ kW.$

$P_g = 3 I_{2ph}^2 \frac{R_2}{s}$

$17.2787 = 3 I_{2ph}^2 \times \frac{0.25}{0.093} \Rightarrow I_{2ph} = 46.287\ A$

Now required $T_{st} = \frac{1}{2} T_{FL} \Rightarrow T_{st} = \frac{110}{2}$

$T_{st} = 55\ Nm$

$\cancel{\frac{T_{st}}{T_{FL}} = \frac{2}{S_s}}$ $S_T = 1 \leftarrow$ slip at starting

$E_2 = I_2 \sqrt{\left(\frac{R_2}{s}\right)^2 + (X_2)^2}$

$= 46.287 \sqrt{\frac{0.25}{0.093} + (2.688)^2}$

$E_{2ph} = 175.95\ V.$

for case 2. $P_g = 8.63935\ kW$

$P_g = 3 I_{2ph}'^2 \frac{R_2}{s}$

$8.63935 = 3 I_{2ph}'^2 \times (0.25 + R_{ext})$

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$I_2'ph = \frac{E_2}{\sqrt{(R_2 + R_{ext})^2 + (2.688)^2}}$

$8.63935 \times 10^3 = \frac{3(175.95)^2}{(0.25 + R_{ext})^2 + (2.688)^2} (0.25 + R_{ext})$

$(0.25 + R_{ext})^2 + (2.688)^2 = 10.75(0.25 + R_{ext})$

$0.0625 + R_{ext}^2 + 0.5 R_{ext} + 2.688^2 = 2.6875 + 10.75 R_{ext}$

$R_{ext}^2 - 10.25 R_{ext} + 4.6 = 0$

$R_{ext} = 0.47\Omega,\ 9.7796\Omega$

$R_{ext} = 0.47\Omega$

10

7(a) Voltage across capacitor given as

$V = \frac{1}{C}\int i\,dt = \frac{I}{Cf_0}$

$V_{co} = \frac{10^{-3}}{20\times10^{-6}\times 4\times10^{3}} = 0.0125\,V$

This is the voltage that can be sampled in one instant or can be called as resolution.

when $V_A > V_{co}$ then counter enabled and starts to count until $V_A < V_{co}$. when it is cleared

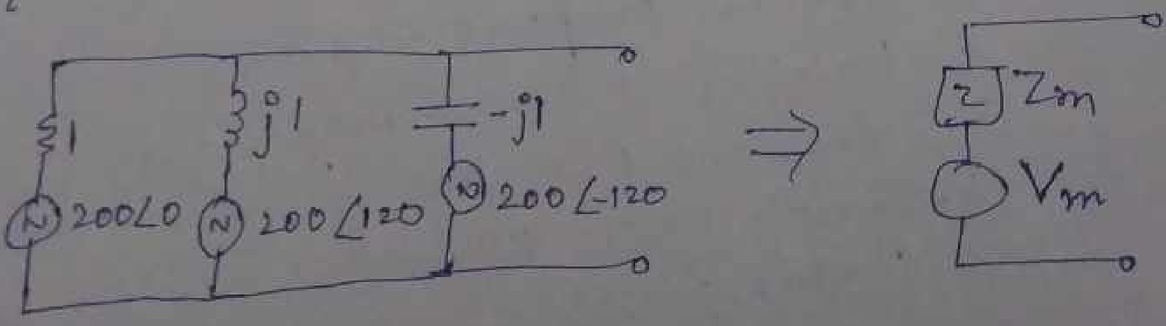
No of steps $= \frac{2}{0.0125} = 160$

So counter counts from 0 to 159 in 160 clock pulses.

when it stops it has $(159)_{10} = (10011111)_2$

Q_7	Q_6	Q_5	Q_4	Q_3	Q_2	Q_1	Q_0
1	0	0	1	1	1	1	1

7(b) From millman theorem when a network consists of parallel voltage sources then it is can be replaced by equivalent ~~voltage & current sour~~ source & equivalent resistance.



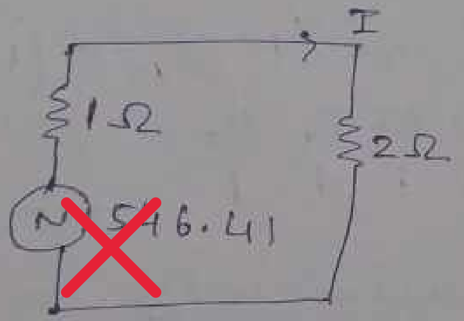
$$V_m = \cancel{\frac{200}{\phi}} \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$V_m = \frac{\frac{200}{1} + \frac{200\angle 120}{1\angle 90} + \frac{200\angle -120}{1\angle -90}}{\frac{1}{1} + \frac{1}{j} + \frac{1}{-j}}$$

4

$$= \frac{200 + 200\angle 30 + 200\angle -30}{1 - \cancel{j} + \cancel{j}} = 546.41\angle 0$$

$$R_m = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{1} + \cancel{\frac{1}{j}} + \cancel{\frac{1}{-j}}} = 1$$



$$I = \frac{546.41}{2+1}$$

$$I = 182.1367 \text{ A}$$

7(c) Intel 8086 contains the following registers –

1. General purpose register
2. Pointer & Index registers
3. Segment Register.
4. Instruction pointer
5. Status flags.

AH	AL	General purpose register
BH	BL	
CH	CL	
DH	DL	
SP		Pointer
BP		
SI		Index registers
DI		
CS		Segment registers
DS		
SS		
ES		
IP		
Flags		

Acc – AX
Base – BX
Counter – CX
Data – DX
Stack pointer – SP
Base pointer – BP
Source Index – SI
Destination index – DI
Code segment – CS
Data segment – DS
Stack segment – SS
Extra segment – ES
Instruction Pointer – IP
Status Register – flags

General Purpose register: 16 bit registers further classified as two 8 bit 12

Pointer & Index Register: SP holds address of top of stack. BP, SS, DI are used in memory address computation.

Segment Registers: Code segment of memory holds instruction codes of a program. Data, variables constants in data segment. Stack segment holds content of subroutine. Extra segment holds destination address of some data.

Instruction Pointer (IP): Holds address of next instuction to be executed. Its content automatically incremented while program execution

7(c) Resistance drop of 10%

$\cos\phi = 0.5$

$\sin\phi = 0.866$

$\frac{\% R}{R} = 10\%$

Impedance drop 20%

$\frac{\% X}{X} = 20\%$

3

Voltage regulation

$$VR = \frac{I R_{eq} \cos\phi + I X_{eq} \sin\phi}{V} \times 100.$$

$\frac{R_{eq}}{V/I} = 10\%$ $\frac{X_{eq}}{V/I} = 20\%$

$VR = 10 \times 0.5 + 20 \times 0.866$

$\boxed{VR = 22.32\%}$