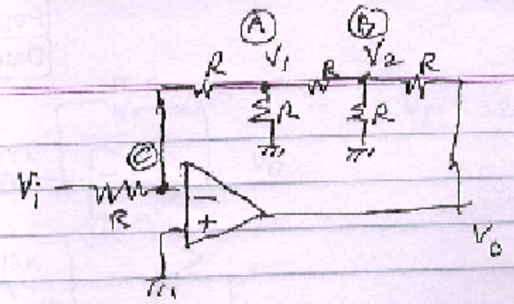
End-Sem Examination_Solutions

ECE 113 Basic Electronics

Maximum Marks: 60

Q1 (a). **[5 Marks]**

1 (a)



We have $\frac{V_i}{R} = -\frac{V_1}{R_1}$ or $V_1 = -V_i$

Writing node eqn. at (A), we get

$$\frac{V_1}{R} + \frac{V_1}{R} + \frac{V_1 - V_2}{R} = 0$$

$$\text{or } \frac{3V_1}{R} = \frac{V_2}{R} \Rightarrow V_2 = 3V_1 = -3V_i$$

At node (B), we have

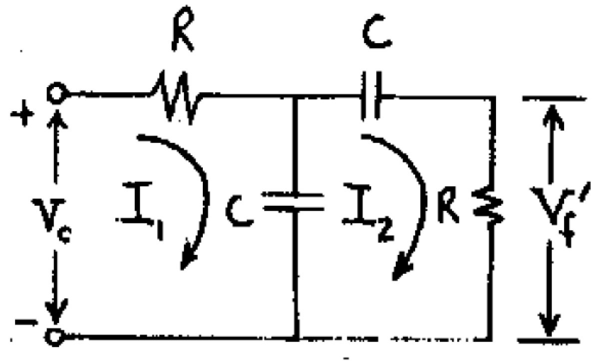
$$\frac{V_2 - V_1}{R} + \frac{V_2}{R} + \frac{V_2 - V_0}{R} = 0$$

$$-3V_i + V_i - 3V_i + 3V_i = \frac{V_0}{\cancel{R}}$$

$$\text{or, } V_0 = -8V_i \qquad \frac{V_0}{V_i} = -8$$

$$A_v = -8$$

Q1(b) **[5 Marks]**



(a) Let $X = \frac{1}{\omega C}$. Then

$$V_o = I_1(R - jX) - I_2(-jX)$$

$$0 = -I_1(-jX) + I_2(R - j2X)$$

$$I_1 = \left(\frac{R - j2X}{-jX}\right) I_2 = \left(2 + j\frac{R}{X}\right) I_2$$

so $$V_o = I_2\left[(R - jX)\left(2 + j\frac{R}{X}\right) + jX\right] = I_2\left[3R + j\left(\frac{R^2}{X} - X\right)\right]$$

$$\frac{V_f'}{V_o} = \frac{I_2 R}{V_o} = \frac{R}{3R + j\left(\frac{R^2}{X} - X\right)} = \frac{1}{3 + j\left(\frac{R}{X} - \frac{X}{R}\right)} = \frac{1}{3 + j\left(\omega RC - \frac{1}{\omega RC}\right)}$$

Q2 (a) **[5 Marks]**

2 (a)

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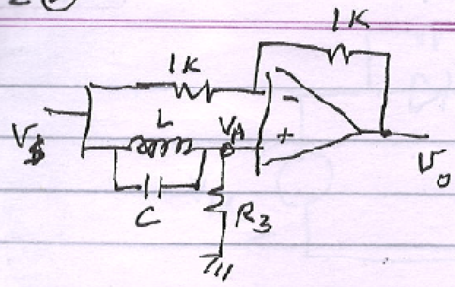
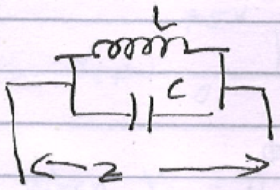




$$Z = \frac{j\omega L \times \frac{1}{j\omega C}}{j\omega L + 1/j\omega C} = \frac{j\omega C L}{1 - \omega^2 LC}$$

$$V_A = \frac{R_3}{R_3 + Z} \cdot V_s$$

$$= \frac{R_3 \quad V_s}{R_3 + \frac{j\omega LC}{1-\omega^2 LC}} = \frac{R_3(1-\omega^2 LC)\, V_s}{R_3(1-\omega^2 LC) + j\omega LC}$$

$$\frac{V_0}{\cancel{V_s}} = -V_s + 2V_A$$

$$= -V_s + \frac{2R_3(1-\omega^2 LC)\, V_s}{R_3(1-\omega^2 LC) + j\omega LC}$$

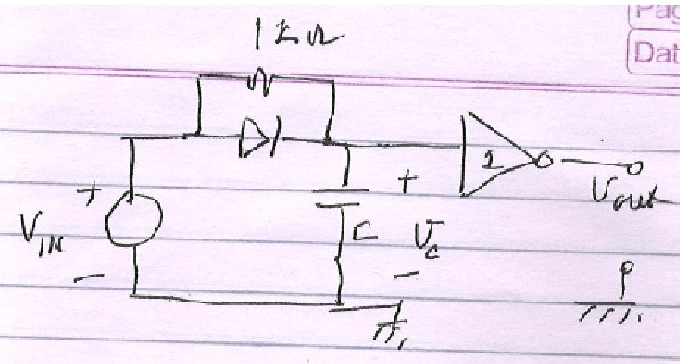
$$= V_s \left[\frac{-R_3(1-\omega^2 L) - j\omega LC + 2R_3(1-\omega^2 LC)}{R_3(1-\omega^2 LC) + j\omega LC} \right]$$

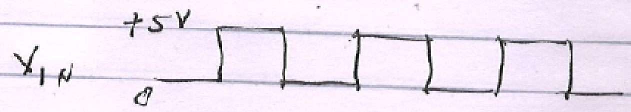
$$= V_s \left[\frac{R_3(1-\omega^2 LC) - j\omega LC}{R_3(1-\omega^2 LC) + j\omega LC} \right]$$

$$\frac{V_0}{V_s} = \frac{R_3(1-\omega^2 LC) - j\omega LC}{R_3(1-\omega^2 LC) + j\omega LC}$$

Q.2 (b) **[5 Marks]**

2 (b)





100 KHZ Square Wave

(a) When $V_{in} = 0$ for first pulse, Diode is not conducting.
and output $V_c = 0$ V
This gives $V_{out} = 0$ V

(b) When $V_{in} = 5$ V, the diode conducts and capacitor charges to +5 V and $V_{out} = +5$ V

(c) When $V_{in} = 0$, the capacitor C discharges through resistance of 1K and the

$$V_c(t) = 5e^{-t/RC} \text{ V}$$

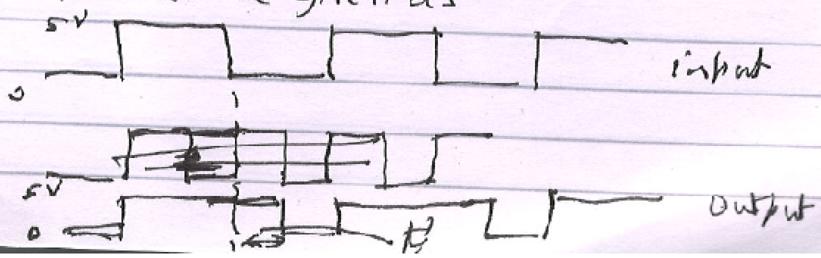
Where $RC = 1K \times 2\times10^{-9} = 2\times10^{-6}$ sec.

Period of square wave $= \frac{1}{100\times10^3} = 10\ \mu$Sec.

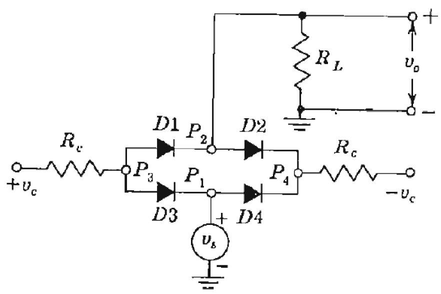
~~When t' When $V_c(t)$ = 0.5~~

$V_c(t)$ discharges to 2.5 V at
$t' = \log 2$ sec.

Waveform will be given as



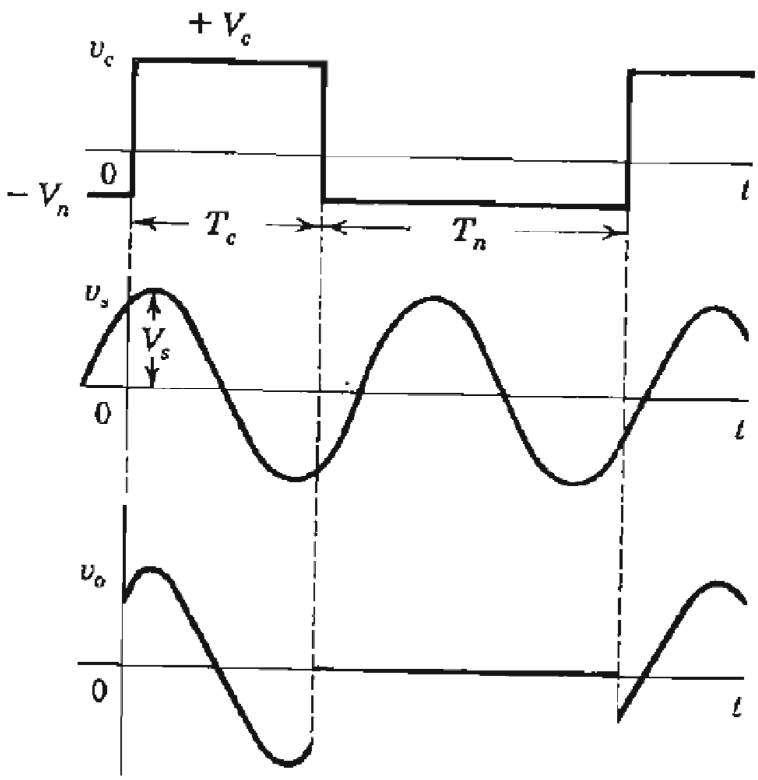
Q3 (a) **[5 Marks]**



In this figure all four diodes will be conducting as long as the control signal is positive (v_c- ($-v_c$) is positive and greater than zero Volt. Under this condition Point P_1 and P_3 will be at the same potential and output will follow the input voltage.

The diodes will be reverse biased when control signal is zero. The point P_3 will be at ground potential.

Thus the output waveform will be as shown in following figure.



Q3(b) **[5 Marks]**

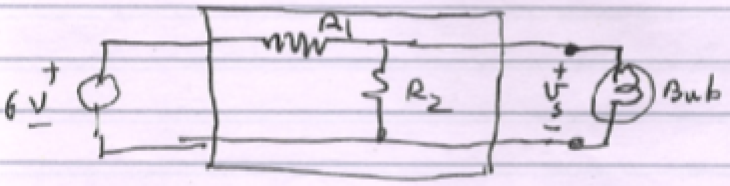
Q. 3 b

The required ~~network~~ network is a ~~z~~ simple resistance divider such that (a) when the light is ON, the ~~current~~ bulb voltage is 1.5 V and it draws 0.5 Amp of currents.

So, the resistance of bulb $= \frac{1.5V}{0.5A} = 3\ \Omega = R_B$

(b) When the Bulb is off, the voltage is 2V.

The network will be following.



Open circuit voltage $V_s = 2V$

When load i.e. Bulb is ON, $V_s = 1.5V$

Thus $\frac{R_2}{R_1+R_2} \times 6V = 2V$ — (1)

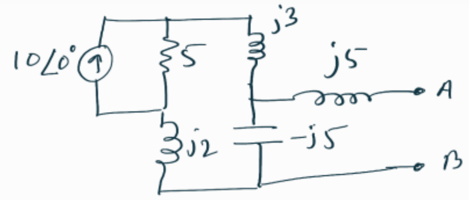
and $\frac{R_2 \| R_B}{R_1 + (R_2 \| R_B)} \times 6V = 1.5V$ — (2)

Solving ~~the~~ for R_1 & R_2 from eqn (1) & (2), we obtain $R_1 = 3\ \Omega$

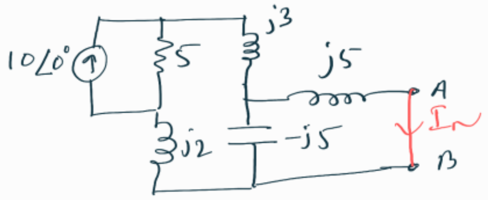
$R_2 = 1.5\ \Omega$

Q.4(a) **[5 Marks]**

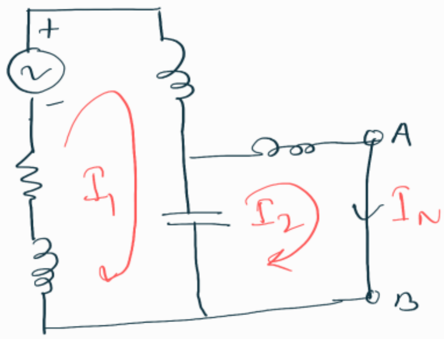
4(a)



For I_N



By source transformation,



writing KVLs in matrix form.

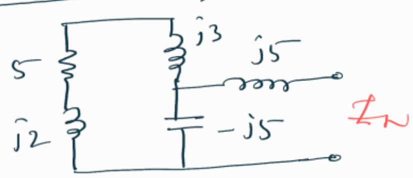
$$\begin{bmatrix} 5 & j5 \\ j5 & 0 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 50\angle 0^\circ \\ 0 \end{bmatrix}$$

By Cramer's rule,

$$I_2 = \frac{\begin{vmatrix} 5 & 50\angle 0^\circ \\ j5 & 0 \end{vmatrix}}{\begin{vmatrix} 5 & j5 \\ j5 & 0 \end{vmatrix}} = 10\angle -90^\circ$$

$\therefore I_N = I_2 = \underline{10\angle -90^\circ \text{ A}}$

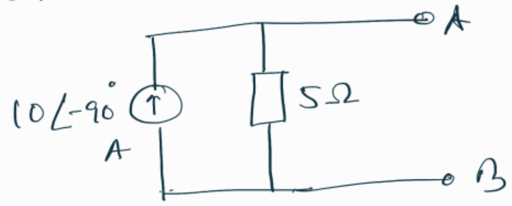
Calculation of Z_N



$$\therefore Z_N = j5 + \frac{(5+j5)(-j5)}{5+j5-j5}$$

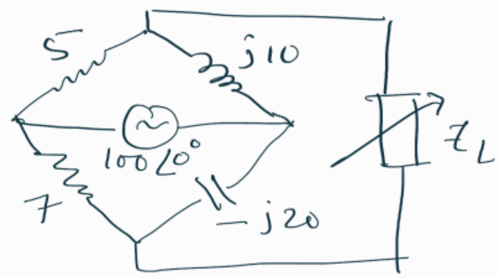
$$= \underline{5\,\Omega}$$

So, The Norton's equivalent network is

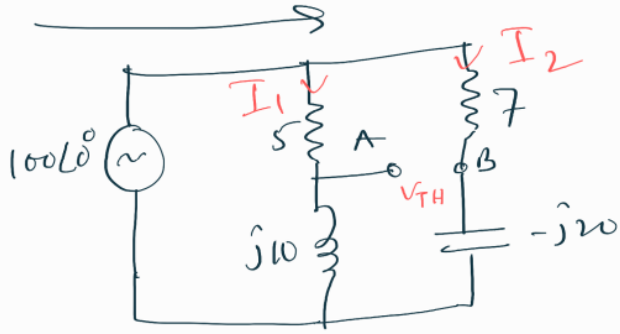


Q.4(b) **[5 Marks]**

4(b)



Calculation of V_{TH}



$$I_1 = \frac{100\angle 0^\circ}{5+j10} = 8.94\angle -63.43^\circ\,A$$

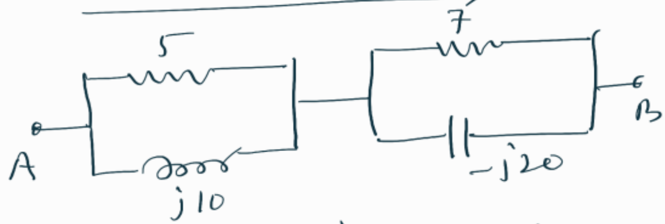
$$I_2 = \frac{100\angle 0^\circ}{7-j20} = 4.72\angle 70.7^\circ\,A$$

So, $V_{TH} = V_A - V_B$

$$= (8.94\angle -63.43^\circ)(j10) - (4.72\angle 70.7^\circ)(-j20)$$

$$= 71.76\angle 97.3 \text{ V}$$

Calculation of Z_{TH}



$$\therefore Z_{TH} = \frac{5(j10)}{5+j10} + \frac{7(-j20)}{7-j20}$$

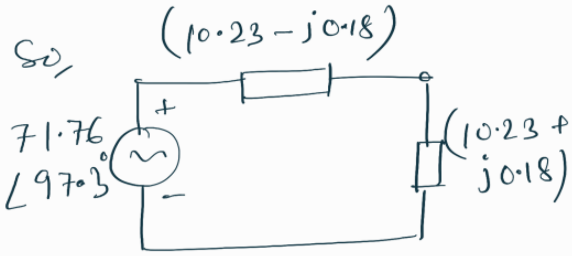
$$\Rightarrow \frac{50\angle 90^\circ}{11.18\angle 63.43^\circ} + \frac{140\angle -90^\circ}{21.19\angle -70.7^\circ}$$

$$\Rightarrow (10.23 - j0.18)\ \Omega$$

For maximum power transfer, the load impedance should be complex conjugate of the source impedance.

$$\therefore Z_L = (10.23 + j0.18)\ \Omega$$

So,

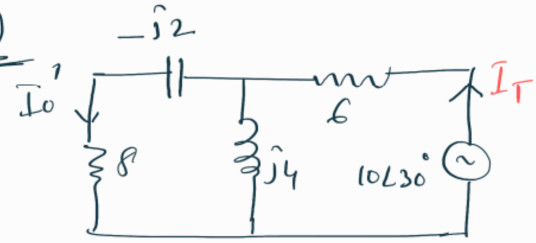


$$P_{max} = \frac{|V_{TH}|^2}{4R_L} = \frac{|71.76|^2}{4 \times 10.23}$$

$$= 125.84 \text{ W}$$

Q5(a) **[4 Marks]**

5 (a)



So, when $10\angle 30^\circ$ V is acting alone,

$$Z_T = 6 + \frac{j4(8-j2)}{j4+8-j2}$$

$$= 8.64\angle 24.12^\circ\ \Omega$$

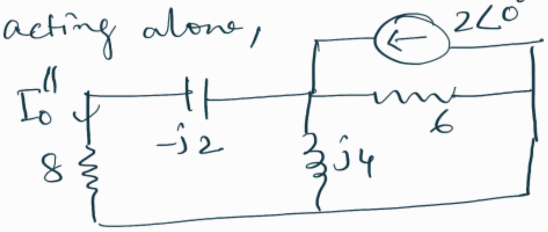
$$I_T = \frac{10\angle 30^\circ}{8.64\angle 24.12^\circ} = 1.16\angle 5.88^\circ \text{ A}$$

By current-division rule,

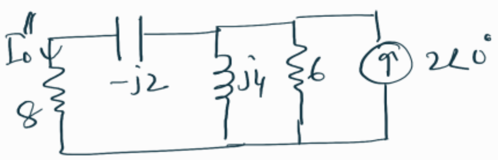
$$I_o' = 1.16\angle 5.88 \times \frac{j4}{8-j2+j4}$$

$$= 0.56\angle 81.84^\circ \text{ A}$$

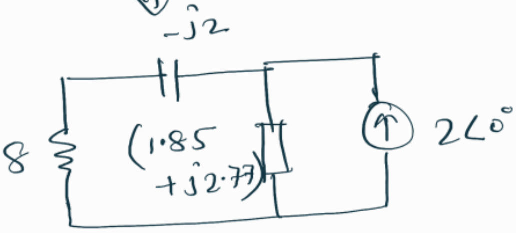
When the $2\angle 0^\circ$ A source is acting alone,



The network can be redrawn as,



$\Downarrow$



By current division,

$$I_o'' = 2\angle 0^\circ \times \frac{1.85 + j2.77}{1.85 + j2.77 + 8 - j2}$$

$$= 0.67\angle 51.83^\circ \text{ A}$$

So, by superposition theorem,

$$I_o = I_o' + I_o''$$

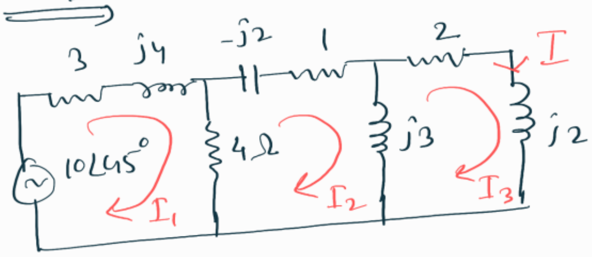
$$= 0.56\angle 81.84^\circ + 0.67\angle 51.83^\circ$$

$$= 1.19\angle 65.46^\circ \text{ A}$$

Q5(b) **[3+3=6 Marks]**

5(b)

Case I



KVL for Mesh I,

$$10\angle 45^\circ - (3+j4)I_1 - 4(I_1 - I_2) = 0$$

$$\Rightarrow (7+j4)I_1 - 4I_2 = 10\angle 45^\circ \quad \text{(I)}$$

KVL for Mesh II

$$-4(I_2 - I_1) - (1-j2)I_2 - j3(I_2 - I_3) = 0$$

$$\Rightarrow -4I_1 + (5+j)I_2 - jI_3 = 0 \quad \text{(II)}$$

KVL for Mesh III

$$-j3(I_3 - I_2) - 2I_3 - j2I_3 = 0$$

$$\Rightarrow -j3I_2 + (2+j5)I_3 = 0 \quad \text{(III)}$$

we can write (I), (II), (III) as,

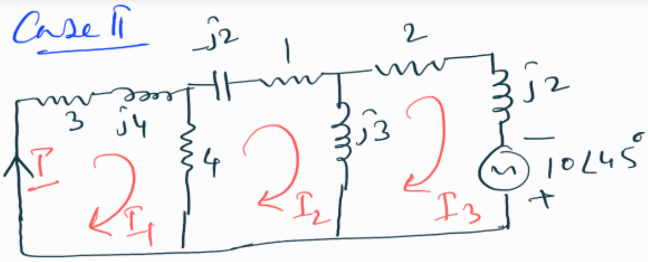
$$\begin{bmatrix} 7+j4 & -4 & 0 \\ -4 & 5+j & -j3 \\ 0 & -j3 & 2+j5 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 10\angle 45^\circ \\ 0 \\ 0 \end{bmatrix}$$

So, by Cramer's rule

$$I_3 = \frac{\begin{vmatrix} 7+j4 & -4 & 10\angle 45^\circ \\ -4 & 5+j & 0 \\ 0 & -j3 & 0 \end{vmatrix}}{\begin{vmatrix} 7+j4 & -4 & 0 \\ -4 & 5+j & -j3 \\ 0 & -j3 & 2+j5 \end{vmatrix}} = 0.704\angle 30.72^\circ A$$

$= I$

Case II



KVL for Mesh I,

$$-(3+j4)I_1 - 4(I_1 - I_2) = 0$$

$$\Rightarrow (7+j4)I_1 - 4I_2 = 0 \quad \text{--- (I)}$$

KVL for Mesh II,

$$-4(I_2 - I_1) - (1-j2)I_2 - j3(I_2 - I_3) = 0$$

$$\Rightarrow -4I_1 + (5+j)I_2 - j3 I_3 = 0 \quad \text{--- (II)}$$

KVL for Mesh III,

$$-j3(I_3 - I_2) - 2I_3 - j2I_3 + 10\angle 45^\circ = 0$$

$$-j3I_2 + (2+j5)I_3 = 10\angle 45^\circ \quad \text{--- (III)}$$

writing eqns (I), (II), (III) in matrix form,

$$\begin{bmatrix} 7+j4 & -4 & 0 \\ -4 & 5+j & -j3 \\ 0 & -j3 & 2+j5 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 10\angle 45^\circ \end{bmatrix}$$

So, by Cramer's rule,

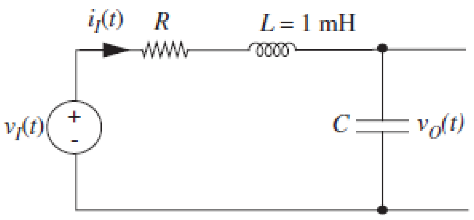
$$I_1 = \frac{\begin{vmatrix} 0 & -4 & 0 \\ 0 & 5+j & -j3 \\ 10\angle 45^\circ & -j3 & 2+j5 \end{vmatrix}}{\begin{vmatrix} 7+j4 & -4 & 0 \\ -4 & 5+j & -j3 \\ 0 & -j3 & 2+j5 \end{vmatrix}}$$

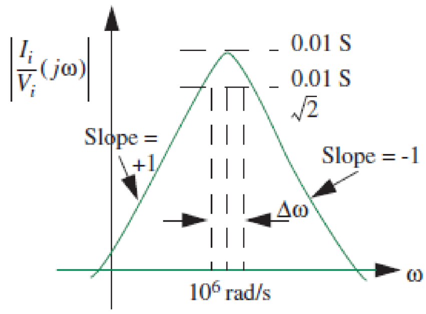
$$= 0.704\angle 30.72^\circ \text{ A} \equiv I$$

So, I is same in both the cases.

→ Reciprocity is verified.

Q.6(a) **[1+1+1+2=5 Marks]**





$$\omega_0 = \frac{1}{\sqrt{LC}}$$

a)

$$\omega_0 = 10^6$$

$$C = 10^{-9}F$$

b) at resonance:

$$R = \left\|\frac{V_i}{I_i}\right\| = 100\Omega$$

c)

$$Q = \frac{\omega_0 L}{R} = 10$$

$$Q = \frac{\omega_0}{\Delta\omega} = 10$$

$$\Delta\omega = 100,000\frac{rad}{s}$$

(d) We have the following equation:

$$\frac{1}{L}v_I'(t) = i'' + \frac{R}{L}i' + \frac{1}{LC}i$$

$$s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$$

$$s = -\frac{R}{2L} \pm j\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}} = -5000 \pm j\underbrace{(998,749)}_{\omega}$$

$$i = A^{st+B}$$

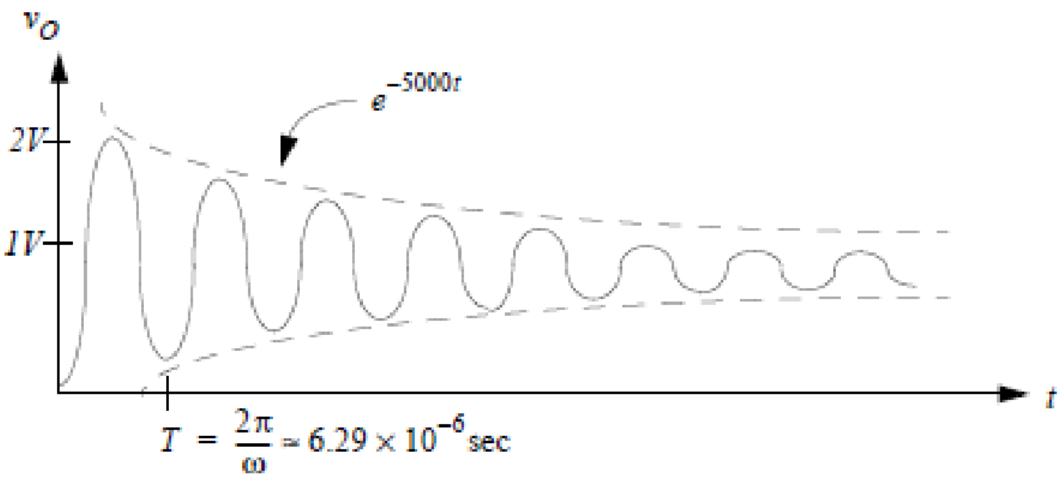
$$v_O = \frac{\int idt}{C} = \frac{A}{Cs}e^{st+B} + D = 1 - e^{-5000t}[A\sin(\omega t) + B\cos(\omega t)]$$

$$v_O(0) = 0 \Rightarrow B = 1$$

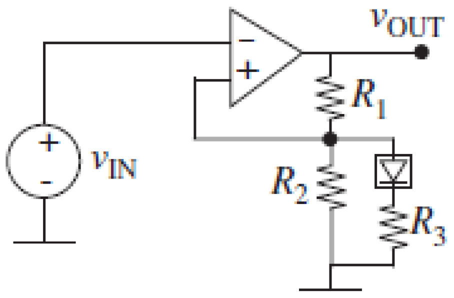
$$v_O'(0) = 0 \Rightarrow 5000B - A\omega = 0 \Rightarrow A = 0.005$$

$$v_O(t) = 1 - e^{-5000t}[0.005\sin(998,749t) + \cos(998,749t)]$$

Following is the output plot:



Q6(b) **[5 Marks]**



The op amp has a positive feedback. This is a inverting Schmitt trigger circuit.

When the input v_{In} is greater than zero, the output will v_{OUT} will be negative supply voltage $-V_{CC}$. Thus the diode will be reverse biased.

The potential at the junction of R1 and R2 will be $-\frac{R_2}{R_2+R_1}V_{CC}$. The output will switch to positive when v_{IN} is less that $-\frac{R_2}{R_2+R_1}V_{CC}$.. At this point the output will switch to + V_{CC}. and the diode starts conducting.

Thus the voltage at the junction of R1 and R2 will be equal to $\frac{\frac{R_2R_3}{R_2+R_3}}{R_1+\frac{R_2R_3}{R_2+R_3}}V_{CC}$.

LTL = $-\frac{R_2}{R_2+R_1}V_{CC}$.

UTL = $\frac{\frac{R_2R_3}{R_2+R_3}}{R_1+\frac{R_2R_3}{R_2+R_3}}V_{CC}$