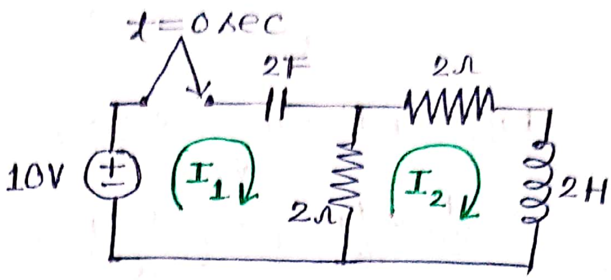
ASSIGNMEN-3 RUBRICS

SOL(1):



Step(I): at $t = 0^- \sec$ (steady state)

$I_1(0^-) = 0A$

$I_2(0^-) = 0A$

$V_c(0^-) = 0V$

Step(II): at $t = 0^+ \sec$ (Transient state)

$$I_1(0^+) = \left(\frac{10}{2}\right) = 5A \quad \text{— (a)}$$

$$I_2(0^+) = I_2(0^-) = 0A \quad \text{— (b)}$$

$$V_c(0^+) = V_c(0^-) = 0V \quad \text{— (c)}$$

(3×0.2 Points)

$$4I_2 + 2\frac{dI_2}{dt} - 2I_1 = 0 \quad \text{— (1)}$$

$$4(0) + 2\frac{dI_2(0^+)}{dt} - 2(5) = 0$$

$$\frac{dI_2(0^+)}{dt} = 5 \ (A/sec) \quad \text{— (d)}$$

— (1 Points)

Differentiating eq^n(1), w.r.t. time 't' —

$$4\frac{dI_2}{dt} + 2\frac{d^2I_2}{dt^2} - 2\frac{dI_1}{dt} = 0 \quad \text{— (2)}$$

$$-10 + \left(\frac{1}{2}\right)\int I_1\,dt + 2(I_1 - I_2) = 0 \quad \text{— (3)}$$

Differentiating eq^n(3), w.r.t. time 't' —

$$-0 + \left(\frac{1}{2}\right)I_1 + 2\left(\frac{dI_1}{dt} - \frac{dI_2}{dt}\right) = 0 \quad \text{— (4)}$$

$$\left(\frac{1}{2}\right)5 + 2\left(\frac{dI_1(0^+)}{dt} - 5\right) = 0$$

$$\frac{dI_1(0^+)}{dt} = 3.75 \ (A/sec) \quad \text{— (e)}$$

— (1 Points)

Put the value from eq^n(e) to eq^n(2) —

$$\frac{d^2 I_2(0^+)}{dt^2} = 2\times 3.75 - 4\times 5 = -6.25 \ A/sec^2 \quad \text{— (f)}$$

— (1 Points)

Differentiating eq^n(4) w.r.t. time 't' —

$$\left(\frac{1}{2}\right)\frac{dI_1}{dt} + 2\left[\frac{d^2 I_1}{dt^2} - \frac{d^2 I_2}{dt^2}\right] = 0$$

$$\frac{d^2 I_1(0^+)}{dt^2} = -7.18 \ A/sec^2 \quad \text{— (g)}$$ — (1 Points)

Step (III): at $t = \infty$ sec (at steady state)

$I_1(\infty) = 0 \ A$ —— (h)

$I_2(\infty) = 0 \ A$ —— (i)

(2×0.2 Points)

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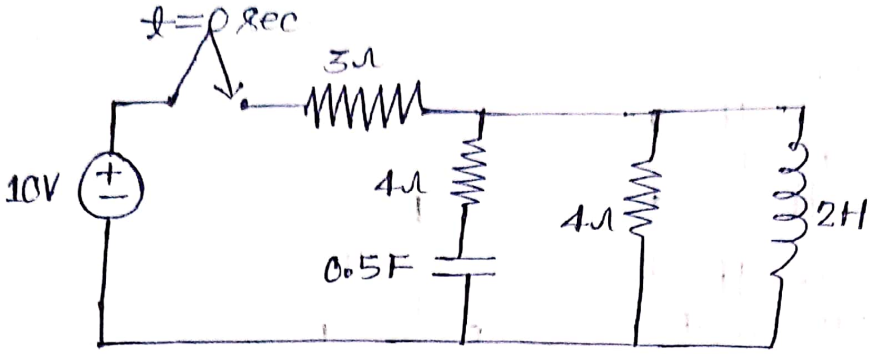
SOL(2) :-



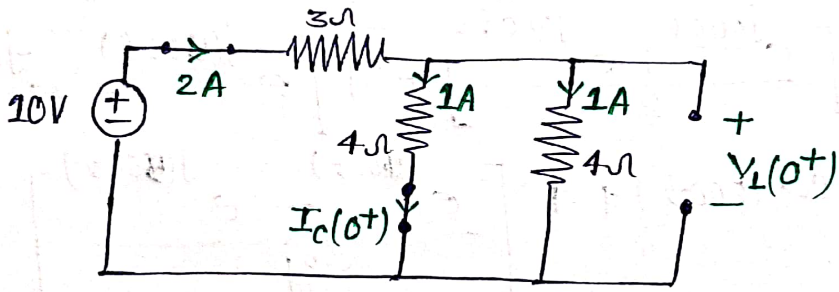
Step(I) : at $t = 0^-$ sec (at steady state)

$V_c(0^-) = 0\,V$

$I_L(0^-) = 0\,A$

Step(II) : at $t = 0^+$ sec (at Transient State)

Equivalent circuit at time $t = 0^+$ sec



$I_c(0^+) = 1\,A$ —— (a)

$I_c = C \cdot \frac{dV_c}{dt}$

$\frac{dV_c(0^+)}{dt} = \left(\frac{1}{0.5}\right) = 2\,(V/sec)$ —— (b)

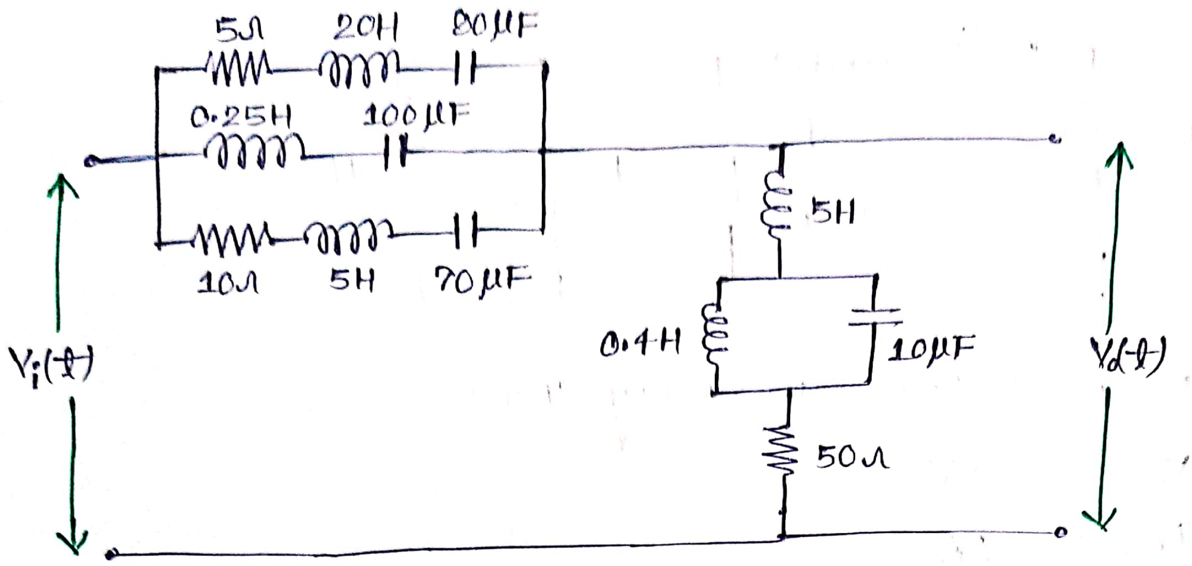
$V_L(0^+) = 1 \times 4 = 4\,V$ —— (c)

$V_L = L \cdot \frac{dI_L}{dt}$

$\frac{dI_L(0^+)}{dt} = \left(\frac{4}{2}\right) = 2\,(A/sec)$ —— (d)

(4 X 1.25 Points)

SOL(3):



where $V_i(t) = e^{-j200t} + 2e^{-j(500t-\pi/2)} + e^{j200t} - 2e^{j(500t+\pi/2)}$

$$= \left(e^{j200t} + e^{-j200t}\right) + 2j\,e^{-j(500t)} - 2j\,e^{j(500t)}$$

$$= 2\left[\frac{e^{j200t} + e^{-j200t}}{2}\right] + 2j\left[e^{-j(500t)} - e^{j(500t)}\right]$$

$$= 2\cos(200t) + 4\left[\frac{e^{j(500t)} - e^{-j(500t)}}{2j}\right]$$

$$= 2\cos(200t) + 4\sin(500t)$$

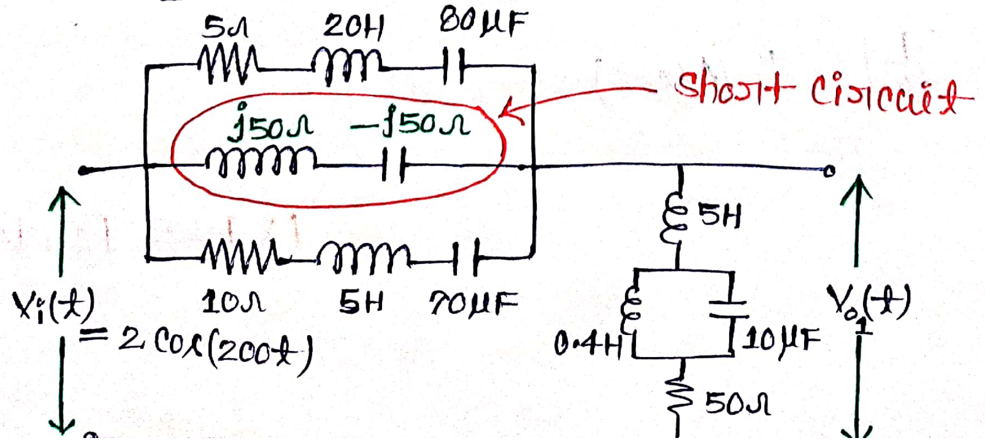
As different frequencies are operating, using superposition theorem, we get –

for $\omega = 200$ rad/sec

$$X_L = \omega L = (200)(0.25) = 50\Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{(200)(100\times 10^{-6})} = 50\Omega$$

$\because X_L = X_C$



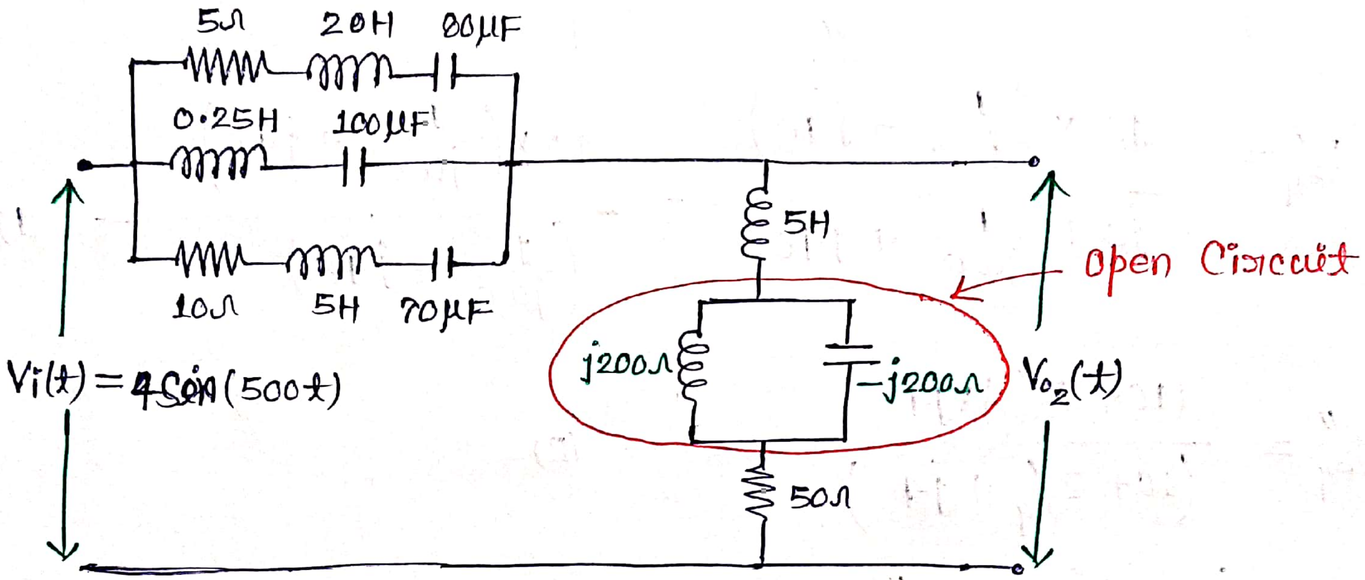
$\therefore V_{o_1}(t) = V_i(t) = 2\cos(200t)$ —— (1) — (2 Points)

for $\omega = 500$ rad/sec

$X_L = 500 \times 0.4 = 200\,\Omega$

$X_c = \left(\dfrac{1}{500 \times 10 \times 10^{-6}}\right) = 200\,\Omega$

$\because X_L = X_c$



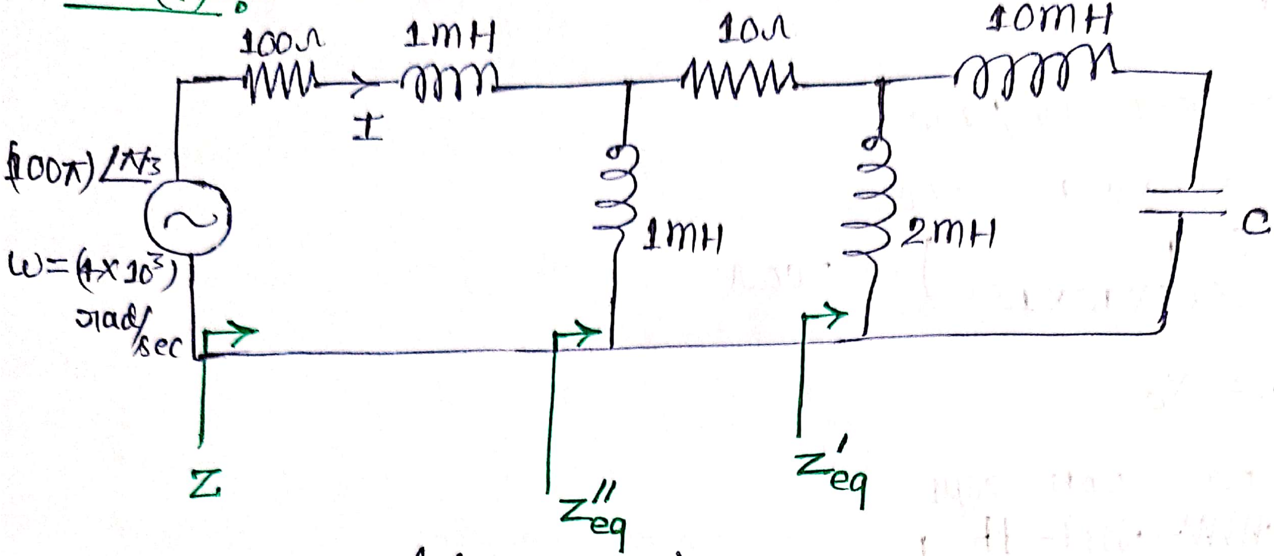
$\therefore V_{o_2}(t) = V_i(t) = 4\sin(500t)$ —— (2) — (2 Points)

By eq^n(1) & eq^n(2) — [By Superposition Theorem]

$V_o(t) = V_{o_1}(t) + V_{o_2}(t)$

$V_o(t) = 2\cos(200t) + 4\sin(500t)$ — (1 Points)

Sol (4) :



$$Z'_{eq} = \frac{j8 \times \left(\frac{1}{j\omega C} + j40\right)}{j8 + \frac{1}{j\omega C} + j40} = \frac{j8 \times \left(\frac{1}{j\omega C} + j40\right)}{\left(\frac{1}{j\omega C} + j48\right)} \quad \text{—— (1)}$$

$$Z''_{eq} = \frac{(10 + Z'_{eq}) \times j4}{(10 + Z'_{eq} + j4)} \quad \text{—— (2)}$$

$$Z = (100 + j4 + Z''_{eq}) \quad \text{—— (3)}$$

$\because$ $I = 0$ (Given)

$\therefore$ Z should be infinite (∞).

Hence $Z''_{eq} = \infty$ (By eq^n(3))

$\therefore$ $10 + Z'_{eq} + j4 = 0$ (By eq^n(2))

$$-(10 + j4) = \frac{j8 \times \left(\frac{1}{j\omega C} + j40\right)}{\left(\frac{1}{j\omega C} + j48\right)}$$

$$-(10 + j4)\left(\frac{1}{j\omega C} + j48\right) = \frac{8}{\omega C} - 320$$

After solving — $C = 5.21\,\mu F$ (Imaginary Part)

AND

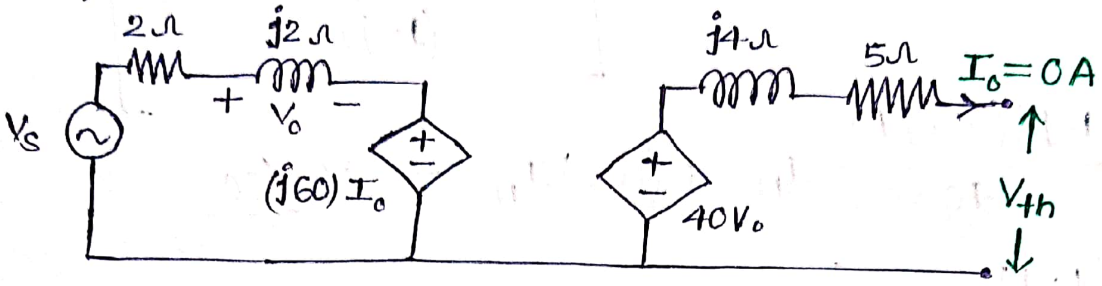
$C = 5.86\,\mu F$ (Real Part)

(5 Points)

NOTE: In Practical, complex value of 'C' is not possible.

SOL(5) :-

Step(I): To find the V_{th} —



$\because I_o = 0$

$\therefore (j60)I_o = 0$ (Short Circuit)

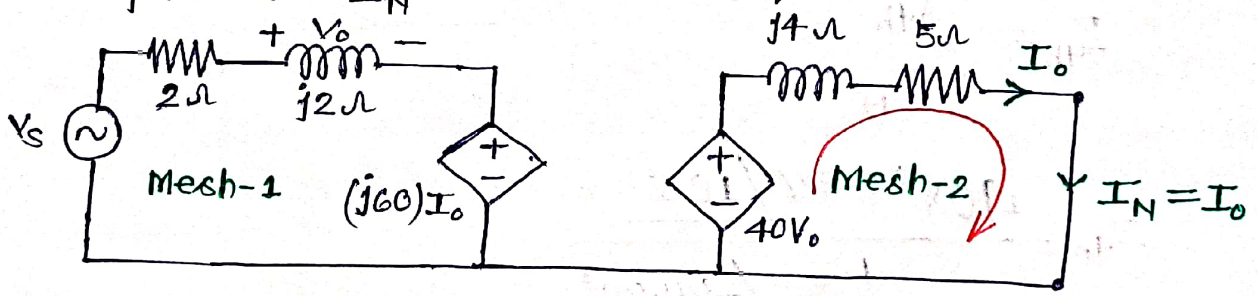
$V_s = 80\angle 60^\circ$ (Given)

$$\therefore V_o = \left(\frac{j2}{2+j2}\right)(80\angle 60^\circ)$$

$$= \left(\frac{1\angle 90^\circ}{\sqrt{2}\angle 45^\circ}\right)(80\angle 60^\circ) = 56.57\angle 105^\circ \text{ Volt}$$

$$\therefore V_{th} = 40V_o = (2262.8)\angle 105^\circ \text{ Volt}$$ —(2 Points)

Step(II): To find the I_N —



In Mesh-2 —

$$-40V_o + (5+j4)I_N = 0 \quad \text{—— (1)}$$

In Mesh-1 —

$$\frac{V_s - (j60)I_N}{(2+j2)} = \frac{V_o}{j2}$$

$$V_s - (j60)I_N = -j(1+j)V_o = (1-j)V_o$$

$$V_o = \frac{80\angle 60^\circ - (j60)I_N}{(1-j)} \quad \text{—— (2)}$$

By eq^n (1) & (2) —

$$(5+j4)I_N = 40\left[\frac{80\angle 60^\circ - (j60)I_N}{(1-j)}\right]$$

$$\frac{(1-j)(5+j4)}{40} I_N + (j60)I_N = 80\angle 60^\circ$$

$$\left[\frac{(9-j)}{40} + j60\right] I_N = 80\angle 60^\circ$$

$$(0.23 + j59.98) I_N = 80\angle 60^\circ$$

$$\left[59.98\angle 89.78^\circ\right] I_N = 80\angle 60^\circ$$

$$I_N = 1.33\angle -29.78^\circ \text{ A}$$ — (2 Points)

Step (III): To find R_{th}/Z_{th}

$$Z_{th} = \frac{V_{th}}{I_N}$$

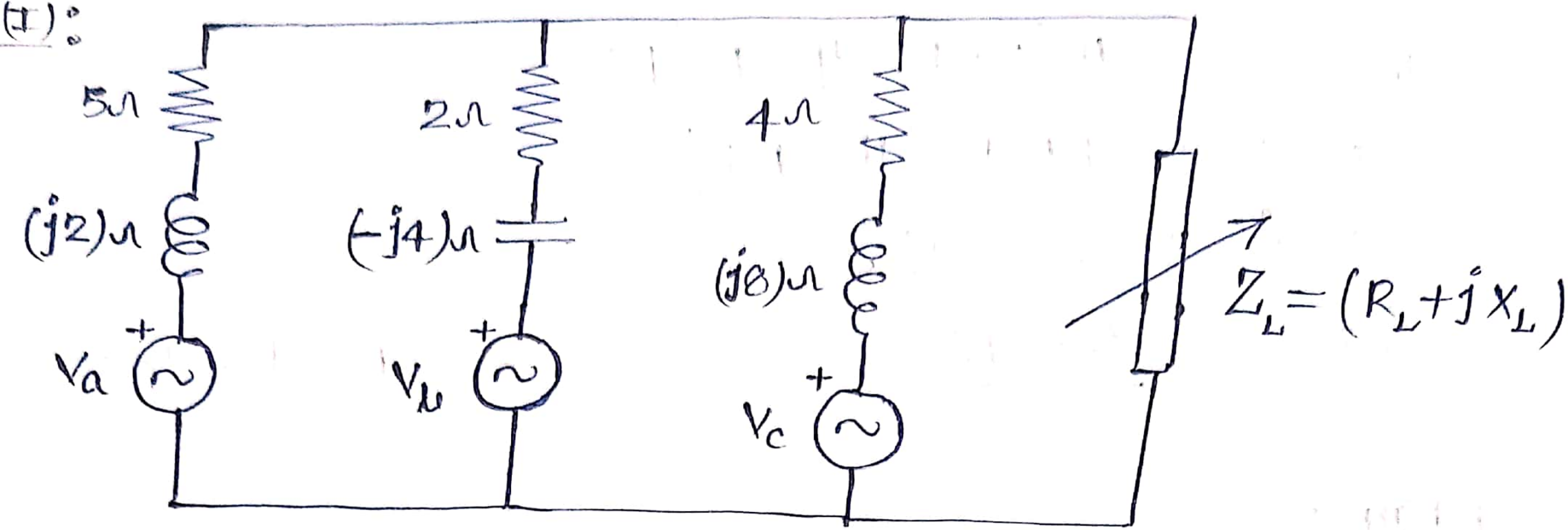
$$Z_{th} = \frac{40 \times 56.57\angle 105^\circ}{1.33\angle -29.78^\circ}$$

$$Z_{th} = 40 \times (42.53)\angle 134.78^\circ \ \Omega$$

$$Z_{th} = (1701.35)\angle 134.78^\circ \ \Omega$$ — (1 Points)

SOL (6) :

Step (I) :



where, $V_a = 100\angle 60^\circ$ V

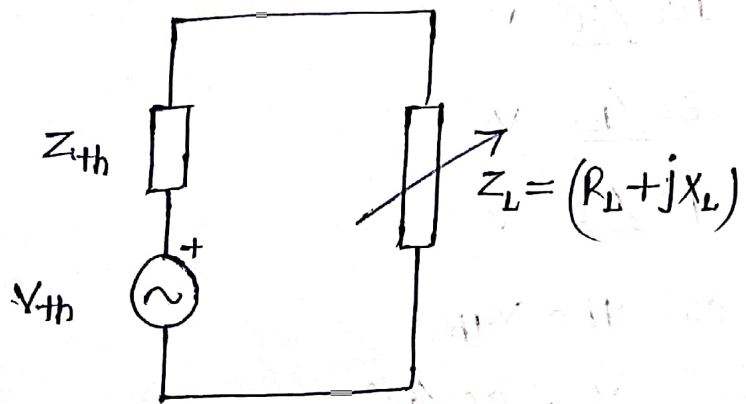
$V_b = 80\angle 40^\circ$ V

$V_c = 40\angle 20^\circ$ V

Step(II): To find Z_{th}

$$Z_{th} = (5+j2) \parallel (2-j4) \parallel (4+j8)$$
$$= (2.98 - j1.43) \parallel (4+j8)$$
$$= (3.07 - j0.29)\ \Omega$$
$$= 3.08 \angle -5.40^\circ\ \Omega$$ — (1.5 Points)

Step(III):

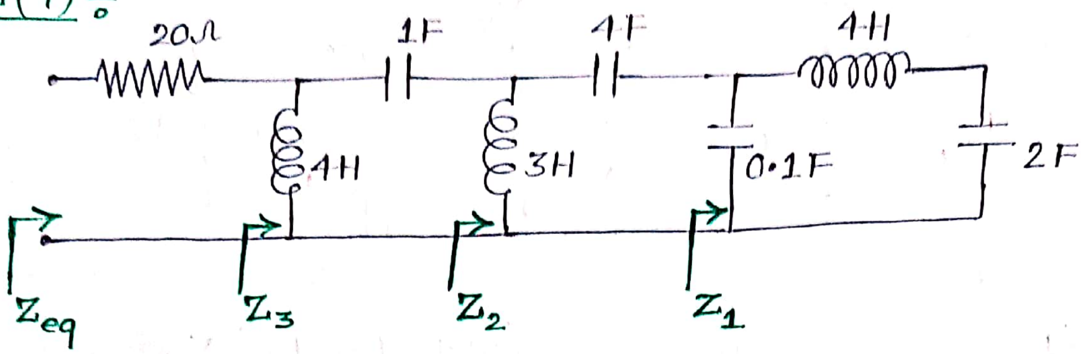


For maximum power transfer in the load impedance –

$$Z_L = Z_{th}^{*}$$ (R_L & X_L both are variable)

$$\therefore Z_L = (3.07 + j0.29)\ \Omega$$
$$= 3.08 \angle 5.40^\circ\ \Omega$$ — (1 Points)

Sol (7) :-



$$Z_1 = \left(-\frac{10j}{\omega}\right) \parallel \left[j\left(4\omega - \frac{1}{2\omega}\right)\right]$$

$$Z_1 = \frac{(-10j)(8\omega^2 - 1)}{\omega(8\omega^2 - 21)}$$ — (1 Point)

$$Z_2 = (j3\omega) \parallel \left[\left(\frac{-j}{4\omega}\right) + Z_1\right]$$

$$Z_2 = \frac{j3\omega(-328\omega^2 + 61)}{(96\omega^4 - 580\omega^2 + 61)}$$ — (1 Point)

$$Z_3 = (j4\omega) \parallel \left[\frac{-j}{\omega} + Z_2\right]$$

$$Z_3 = \frac{j4\omega\left[-1080\omega^4 + 763\omega^2 - 61\right]}{\left[-1080\omega^4 + 763\omega^2 - 61\right] + 4\omega^2\left[96\omega^4 - 580\omega^2 + 61\right]}$$ — (1 Point)

$$Z_{eq} = 20 + Z_3$$

for resonance frequency of the circuit —

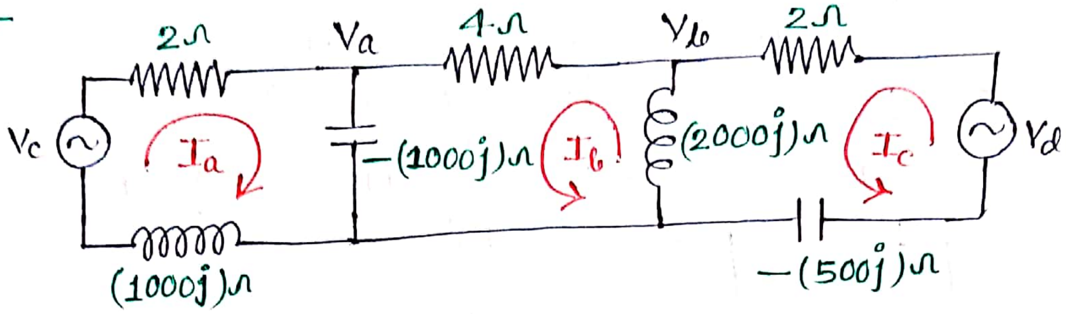
$$Img(Z_{eq}) = 0$$ — (1 Point)

$$4\omega(-1080\omega^4 + 763\omega^2 - 61) = 0$$

$$\omega = 0,\ 0.78,\ 0.3 \text{ rad/sec}$$

$$f = 0\text{ Hz},\ 0.12\text{ Hz},\ 0.05\text{ Hz}$$ — (1 Point)

SOL(B):-



$V_c = 40\sin(1000t + 60^\circ) = 40\angle 60^\circ = (20 + 34.64j)$ Volt

$V_d = 60\sin(1000t - 40^\circ) = 60\angle -40^\circ = (45.96 - 38.57j)$ Volt

(a) Using Nodal analysis—

$$\frac{V_a - V_c}{(2 + 1000j)} + \frac{V_a}{(-1000j)} + \frac{V_a - V_b}{4} = 0$$

$$0.25V_a - 0.25V_b = (0.03 - 0.02j) \quad \text{--- (1)}$$

$$\frac{V_b - V_a}{4} + \frac{V_b - V_d}{(2 - 500j)} + \frac{V_b}{(2000j)} = 0$$

$$-0.25V_a + (0.25 + 1.5\times10^{-3}j)V_b = (0.08 + 0.09j) \quad \text{--- (2)}$$

By eqn (1) & (2), we get —

$\therefore V_a = (46.8 - 73.4j)$ Volt
$= 87.05\angle(-57.48^\circ)$ Volt
$= 87.05\sin(1000t - 57.48^\circ)$ Volt
(3×0.5 Points)

$\therefore V_b = (46.67 - 73.33j)$ Volt
$= 86.92\angle(-57.53^\circ)$ Volt
$= 86.92\sin(1000t - 57.53^\circ)$ Volt
(3×0.5 Points)

(b) Using Mesh Analysis—

$$-(20 + 34.64j) + (2 + 1000j)I_a + (-1000j)(I_a + I_b) = 0 \quad \text{--- (3)}$$

$$(-1000j)(I_b + I_a) + 4I_b + (2000j)(I_b - I_c) = 0 \quad \text{--- (4)}$$

$$-(45.96 - 38.57j) + (2 - 500j)I_c + (2000j)(I_c - I_b) = 0 \quad \text{--- (5)}$$

By solving eqn (3), (4) & (5), we get—

$\therefore I_a = (0.1 + 0.03j)\,A = 0.1\angle 16.7^\circ = 0.1\sin(1000t - 16.7^\circ)\,A$

— (3×0.5 Points)

$$\therefore I_L = (-0.03 + 0.02j)\,A$$
$$= 0.04 \angle 151.7^\circ \; A$$
$$= 0.04 \sin(1000t + 151.7^\circ)\; A$$

(3×0.5 Points)

$$\therefore I_c = (-0.07 + 0.j)\,A$$
$$= 0.07 \angle 180^\circ \; A$$
$$= 0.07 \sin(1000t + 180^\circ)\, A$$

(3×0.5 Points)