Questions should be —
WRITTEN IN LEGIBLE HANDWRITING IN BLACK INK.
SIGNS, SKETCHES OR FIGURES IF ANY BE DRAWN IN NEAT BLACK INK,
so as to avoid mistakes in the printed question papers.

Duration ...03... Hours. Total Marks assigned to the paper ...80...

Q. No.		Marks

N.B. :

Q-1 (a)

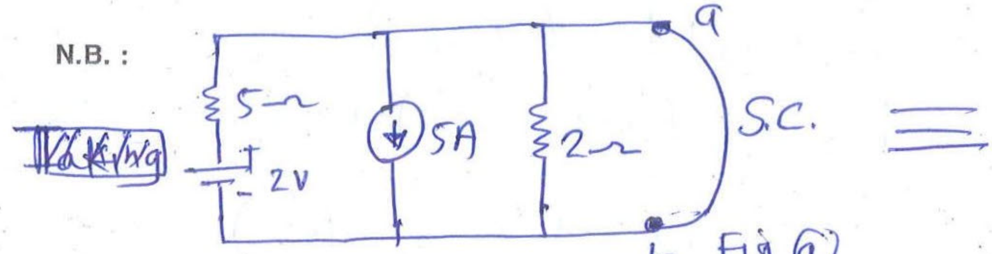


Fig (a)

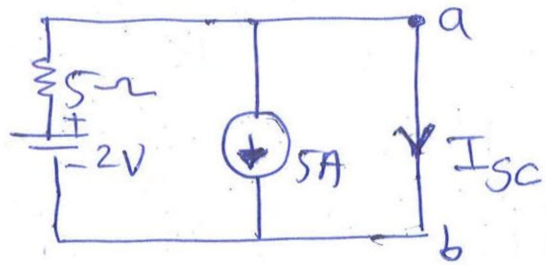


Fig (b)

Taking first 2 volt source in fig (b)

$2 = 5 \times I'_{SC}$ ∴ $I'_{SC} = \frac{2}{5} = 0.4$ Amp (2M)

Taking 5 A current source only in fig (b)

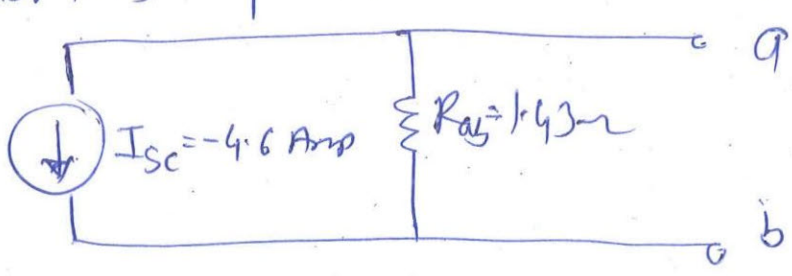
$I''_{SC} = -5$ Amp

∴ $I_{SC} = I'_{SC} + I''_{SC} = -4.6$ Amp (1M)

To find R_{ab}, the constant source are deactivated in fig (a)

∴ $R_{ab} = \frac{5 \times 2}{5+2} = 1.43\,\Omega$ (1M)

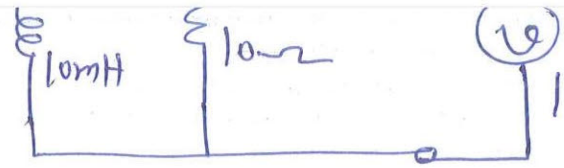
∴ Norton's eq. ckt is shown in fig. (C)



(1M)

Total = 5M

Q-1 (b)



$$I_R = \frac{V_m}{R} \sin(1000t + 36^\circ)$$
$$= 10 \sin(1000t + 36^\circ)$$
$$= 10 \cos(1000t - 54^\circ) \text{ Amp} \quad \text{--- (1)}$$

(1M)

$$I_L = \frac{V_m}{WL} \sin(1000t + 36^\circ - 90^\circ)$$
$[\because I_L$ lags v by $90^\circ]$

$$= 10 \sin(1000t - 54^\circ)$$
$$= 10 \cos(1000t - 144^\circ) \quad \text{--- (2)}$$

(1M)

From eqn (1) and (2), RMS value of Current are

$$I_R = 10 \angle -54^\circ$$
$$I_L = 10 \angle -144^\circ$$

(1M)

$\therefore$ Net RMS Current, $I = I_R + I_L$

$$\therefore I = 10 \angle -54^\circ + 10 \angle -144^\circ$$
$$= 10(\cos 54 - j \sin 54) + 10[\cos(-144) + j \sin(-144)]$$

22-j13.97

=14.14∠-99°

$$= 5.88 - j8.1 - 8.1 - j5.88$$

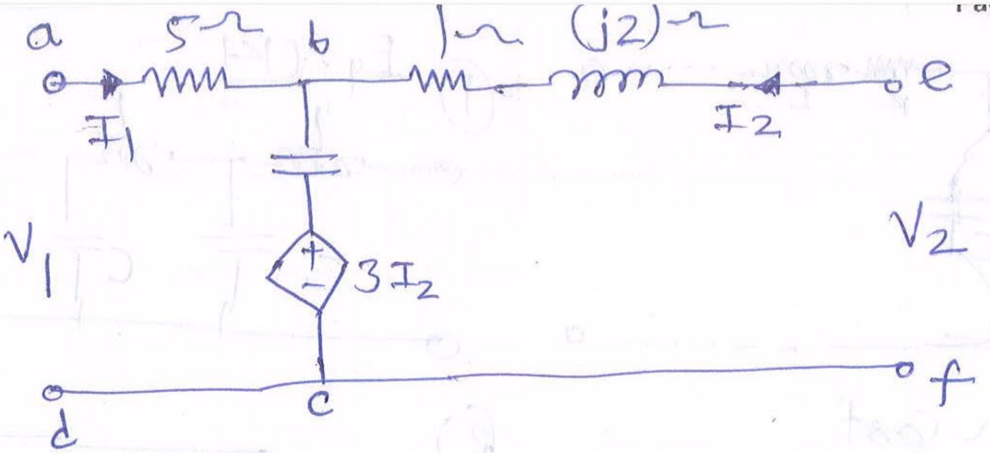
$I =$

(2M)

Total=5M

Q. No. Marks

Q-1 (c)



Applying KVL to loop abcd in above fig.

$$V_1 = 5I_1 - j5I_1 + 3I_2 + (-j5I_2)$$

$$V_1 = (5-j5)I_1 + (3-j5)I_2 \quad \text{--- (1)}$$ 2M

Apply KVL to loop bcfe,

$$I_2(1+j2-j5) + I_1(-j5) + 3I_2 - V_2 = 0$$

$$\therefore V_2 = (-j5)I_1 + (4-j3)I_2 \quad \text{--- (2)}$$ 2M

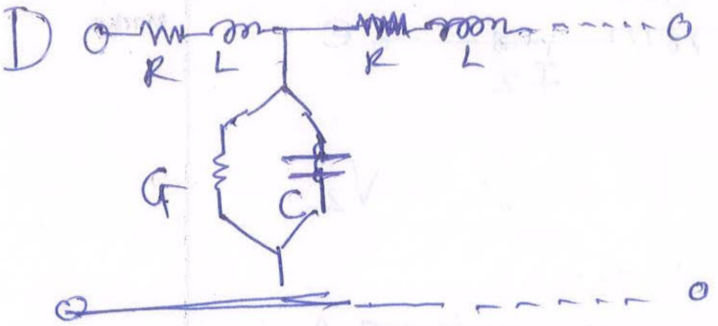
Writing eqn (1) and (2) in matrix

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 5-j5 & 3-j5 \\ -j5 & 4-j3 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\therefore [Z]_{matrix} = \begin{bmatrix} 5-j5 & 3-j5 \\ -j5 & 4-j3 \end{bmatrix}$$ 1M

Total=5M

1)



2) Propagation Const

$$\gamma = \sqrt{ZY} = \sqrt{(R+j\omega L)(G+j\omega C)}$$

Attenuation Constant

3) $\gamma = \alpha + j\beta$

$\therefore \alpha \neq 0$

4) Characteristic Imped

$$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{R+j\omega L}{G+j\omega C}}$$

$Z_0 =$ Complex

5) Input impedance

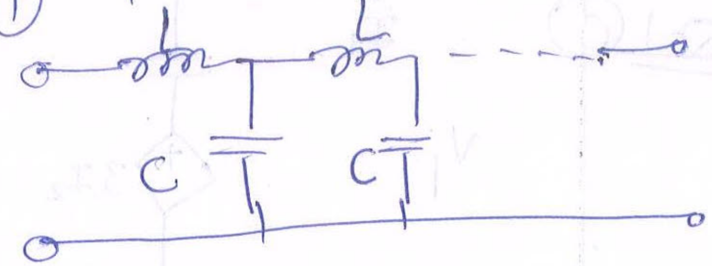
$$Z_{in} = Z_0 \frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_0 \tan \beta l}$$

where,

$Z_0 =$ Complex form

$\gamma = \alpha + j\beta, \ \alpha \neq 0$

1) Eq. Ckt



2)

$$\gamma = \sqrt{j\omega L \times j\omega C}$$

$$\gamma = j\omega\sqrt{LC} = \alpha + j\beta$$

$\therefore$ ~~$\beta = \lambda\omega\sqrt{LC}$~~

3) $\gamma = \alpha + j\beta$

$\therefore \alpha = 0, \ \beta = \omega\sqrt{LC}$

4)

$$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{j\omega L}{j\omega C}} = \sqrt{\frac{L}{C}}$$

$Z_0 =$ real

5)

$$Z_{in} = Z_0 \frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_0 \tan \beta l}$$

where $Z_0 =$ real form

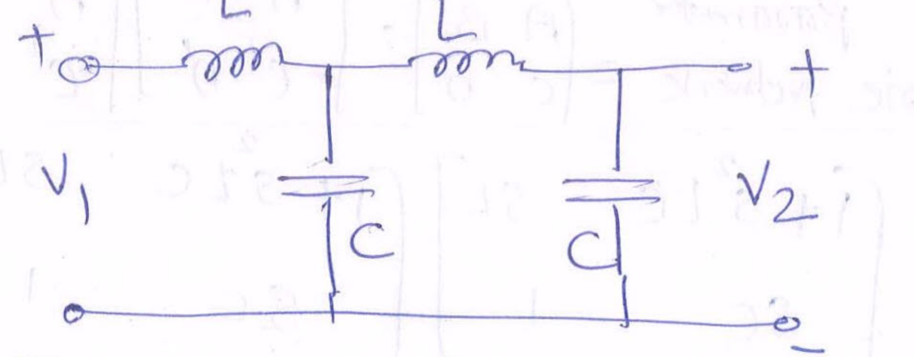
$\alpha = 0$

$\therefore \gamma = j\beta$

1 Mark for each point $\therefore$ Total = 5M

Q. No. Marks

Q-2 (a)



Writing in S domain and splitting —

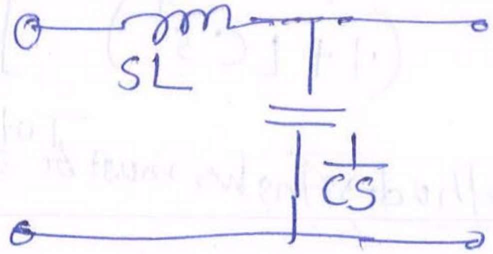


Fig (a)

+

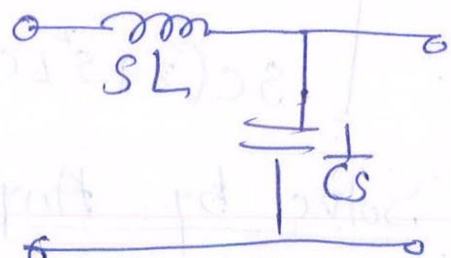
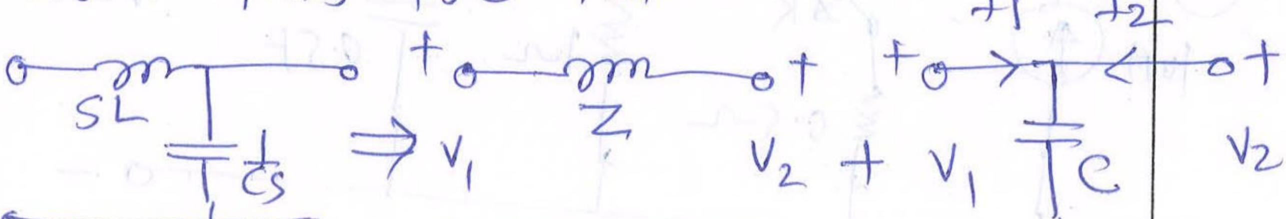


Fig (b)

Again Spitting fig (a) into —



Series Z Shunt C

Transmission parameters of Series Z $\begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$ 2M

Transmission Para. of Shunt C $\begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix}$

$$\begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & LS \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ CS & 1 \end{bmatrix} = \begin{bmatrix} 1+S^2LC & SL \\ SC & 1 \end{bmatrix}$$

6M

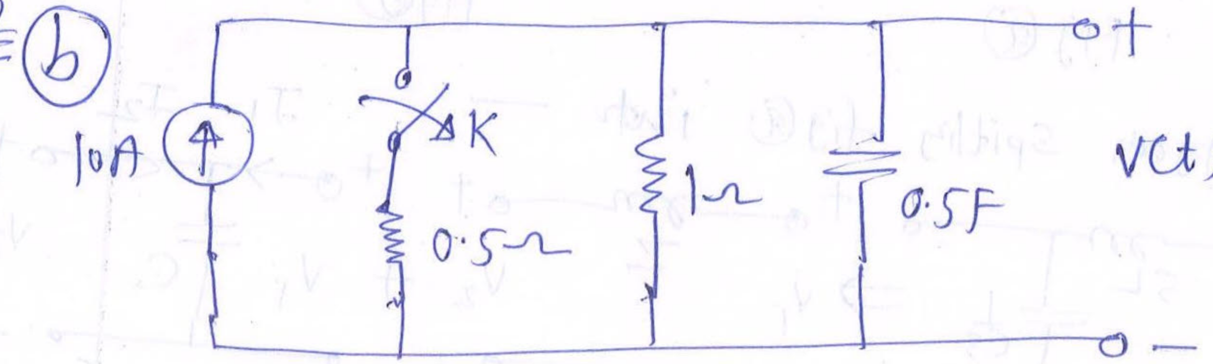
$\therefore$ ABCD parameter of entire network $= \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix}$

$$= \begin{bmatrix} 1+s^2LC & SL \\ SC & 1 \end{bmatrix} \begin{bmatrix} 1+s^2LC & SL \\ SC & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1+3LCs^2+L^2C^2s^4 & SL(2+s^2LC) \\ SC(2+s^2LC) & (1+LCs^2) \end{bmatrix}$$ (2M)

OR Solve by Any method → Answer must be same. Total = 10M

Q2 (b)



At $t=0^-$, N/w is shown in fig (a) below

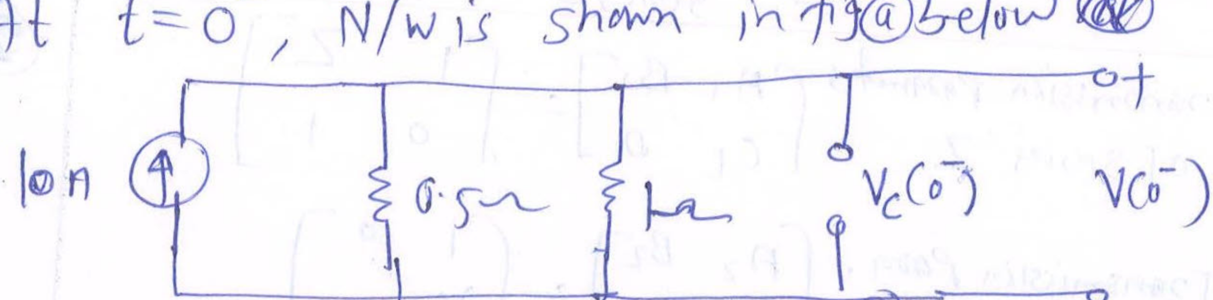


fig (a)

At $t=0^-$, the network attains steady state condition and hence capacitor C acts as O/C

$\therefore V_c(0^-) = 0$ (2M)

Writing the KCL at $t=0^-$ for above fig (a)

$$\frac{V(0^-)}{1} + \frac{V(0^-)}{0.5} = 10$$

$$\therefore V(0^-) = 3.33 \text{ volt}$$

Q. No. | Marks

Since the voltage across Capacitor Cannot Change instantaneously

$$V_c(0^+) = V(0^+) = 3.33 \text{ volt}$$ (2M)

For $t>0$, the network is shown in fig (b), below

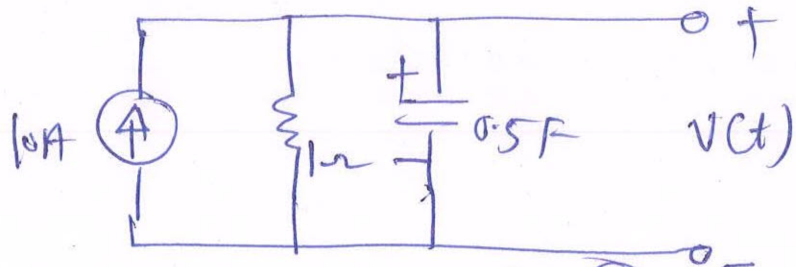


Fig (b)

Writing KCL for $t>0$

$$0.5 \frac{dV}{dt} + V = 10$$

$$\therefore \frac{dV}{dt} + 2V = 20 \quad \text{—— (1)}$$ (3M)

Comparing with differential eqn $\frac{dV}{dt} + PV = Q$

$$P = 2 \quad Q = 20$$

The solution of eqn (1) is given by -

$$V(t) = e^{-Pt}\int Q e^{Pt} + K e^{-Pt}$$

$$= e^{-2t}\int 20 e^{-2t} + K e^{-2t}$$

$$V(t) = \frac{20}{2} + K e^{-2t} = 10 + K e^{-2t}$$

At $t=0$, $V(0) = 3.33$ volt

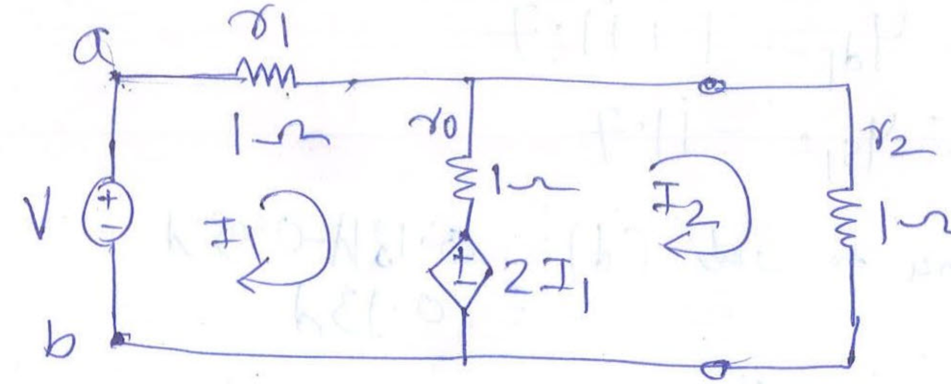
$$\therefore 3.33 = 10 + K \quad \therefore K = 6.67$$

$$\therefore \boxed{V(t) = 10 + 6.67 e^{-2t}}$$ (3M)

Total = 10M

Q. No. Q-3 (a)

Marks



* Left terminal a-b be O/C of above fig. This leads to $I_1 = 0$, also, depedent voltage Source $2I_1 = 0 \therefore I_2 = 0 \therefore V_{ab} = V_{oc} = 0$
* Now apply dc voltage Source V_{dc} across ab such that I/p current be I_1 at terminal a.

Applying KVL at the left loop (I_1) under this condition.

$$V_{dc} = I_1 r_1 + I_1 r_0 - I_2 r_0 + 2I_1$$

$$V_{dc} = r_1 I_1 + r_0(I_1 - I_2) + 2I_1$$

Applying KVL to the outer loop — ①

$$V_{dc} = r_1 I_1 + r_2 I_2$$

Put $r_0 = r_1 = r_2 = 1$ in eqn ①

$$V_{dc} = 4I_1 - I_2 \quad — ②$$

$$V_{dc} = I_1 + I_2 \Rightarrow I_2 = V_{dc} - I_1 \quad — ③$$

Put eqn ③ in eqn ②

$$V_{dc} = 4I_1 - V_{dc} + I_1$$

$$\therefore 2V_{dc} = 5I_1$$

$$\therefore \frac{V_{dc}}{I_1} = \frac{5}{2} = 2.5$$

Thus internal resistance across a-b is 2.5Ω

The given circuit is thus Thevenised to give

$R = 2.5\Omega$ $V_{oc} = 0$ volt Total-10M

(b) $y_{d_1} = 1 + j1.7$

$\therefore y_{s_1} = -j1.7$

$\therefore$ Distance to stub $(d) = 0.18\lambda - 0.05\lambda$
$= 0.13\lambda$

$y_{s_1} = -j1.7$

$\therefore$ Stub length $= (l) = 0.085\lambda$ (From S/C end of Smith chart i.e. right most end)

$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{100 \times 10^6} = \frac{3 \times 10 \times 10^7}{10^8} = 3m$

$d = 0.13 \times 3m =$

$l = 0.085 \times 3m =$

Total = 10 M

Q. No. Marks

Q-4 (a) $Z_{LC}(s) = \dfrac{s(s^2+4)(s^2+6)}{(s^2+1)(s^2+5)}$

$Z_{LC}(s) = \dfrac{s^5+10s^3+24s}{s^4+6s^2+5}$

Continued fraction expansion is shown below

$s^4+6s^2+5 \,)\, s^5+10s^3+24s \,(\, s$

$-\; s^5+6s^3+5s$

$4s^3+19s \,)\, s^4+6s^2+5 \,(\, s/4$

$s^4+\frac{19}{4}s^2$

$\frac{5}{4}s^2+5 \,)\, 4s^3+19s \,(\, \frac{16}{5}s$

$4s^3+16s$

$3s$

$3s \,)\, \frac{5}{4}s^2+5 \,(\, \frac{5}{12}s$

$\frac{5}{4}s^2$

$5 \,)\, 3s \,(\, \frac{3s}{5}$

$3s$

$\times$

$Z_{LC}(s) \to \infty$ with $s \to \infty$; also $Z_{LC}(s) \to 0$ with $s \to 0$

Thus for the function $Z_{LC}(s)$, having $n > m$, the first element is L_1 and the last element is also an inductor

$$Z_{LC}(s) = s + \cfrac{1}{\frac{s}{4} + \cfrac{1}{\frac{16s}{5} + \cfrac{1}{\frac{5s}{12} + \cfrac{1}{\frac{3s}{15}}}}}$$

Thus $L_1 = 1H$, $Z_1(s) = 1\cdot s \; (= L_1 s)$

$C_2 = \frac{1}{4}F \quad Y_2(s) = s/4$

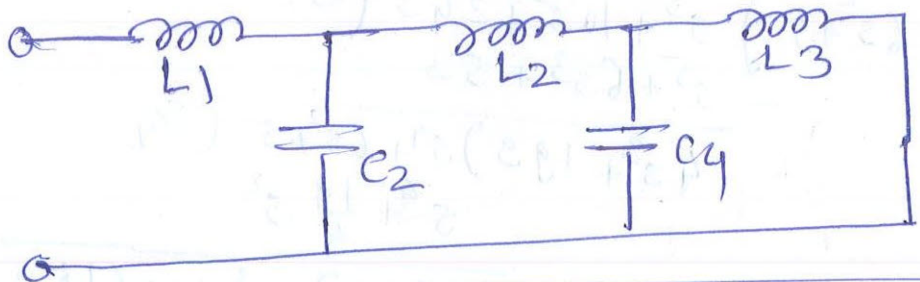
giving $Z_2(s) = \frac{4}{s} = \frac{1}{s/4} \left(= \frac{1}{Cs} \right)$

$C_4 = \frac{5}{12}$ F , $Y_4(s) = \frac{5}{12} s$

$\therefore Z_4(s) = \frac{1}{\frac{5}{12} s}$

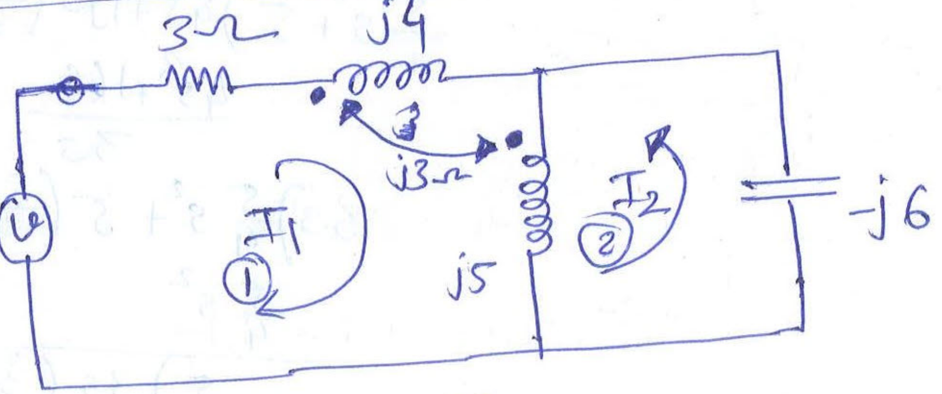
$L_5 = \frac{3}{5}$ H , $Z_5(s) = \frac{3}{5} s$

$\therefore$ First Cauer form is —



(Total = 10m)

Q4 (b)



Applying KVL to Loop (1),

$3 I_1 + j4 I_1 + j5(I_1 + I_2) + j3(I_2 + I_1) + j3 I_1 = 5\angle 45^\circ$

or $(3 + j15) I_1 + (j8) I_2 = 5\angle 45^\circ$

Applying KVL to loop (2)

$j5(I_1 + I_2) - j6 I_2 + j3 I_1 = 0$

or $(j8) I_1 - j I_2 = 0$

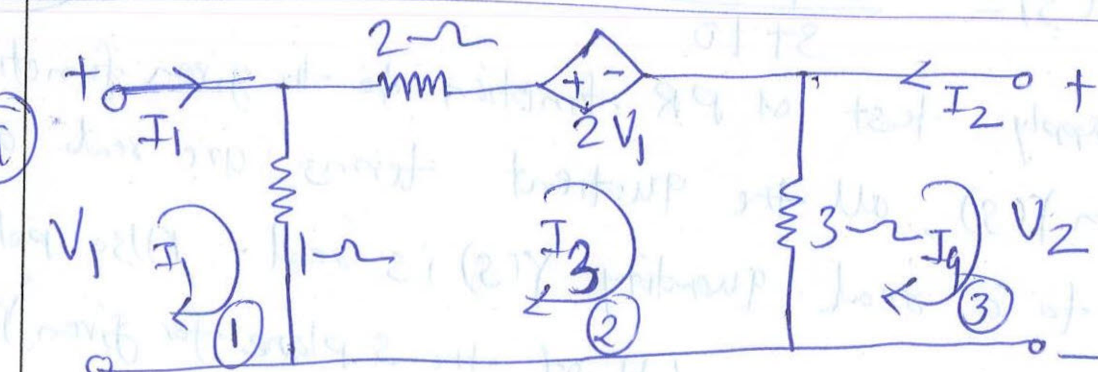
(3m)

In matrix form,

$$\begin{bmatrix} 3 + j15 & j8 \\ +j8 & -j1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 5\angle 45^\circ \\ 0 \end{bmatrix}$$

Q. No.		Marks
	$\therefore I_1 = 0.063 \angle -47.175^\circ$ Amp	
	$I_2 = -0.506 \angle 132.83^\circ$ Amp	3m
	$\therefore$ Drop across 3Ω resister is -	
	$= 3 \times I_1 = 0.189 \angle -47.175^\circ$	2m
	Drop across $-j6\Omega$ Capacitor is	
	$= (-j6)\, I_2 = -3.036 \angle 42.83^\circ$ volt	2m
		Total=10M

Q5 (a)



For loop ①

$$I_1 - I_3 = V_1 \quad \text{—— ①}$$

For loop ②

$$2I_3 + 2V_1 + 3(I_3 - I_4) + 1(I_3 - I_1) = 0$$

$$-I_1 + 3I_2 + 6I_3 = -2V_1 \quad \text{—— ②}$$

$(I_4 = -I_2)$

For Loop ③

$$3(I_4 - I_3) + V_2 = 0$$

$$V_2 = 3I_3 + 3I_2 \quad \text{—— ③}$$

$$V_1 = \frac{5}{4} I_1 + \frac{3}{4} I_2$$

$$V_2 = -\frac{3}{4} I_1 + \frac{3}{4} I_2$$

Total=10m

$$Z_{11} = \frac{5}{4}\,\Omega, \quad Z_{12} = \frac{3}{4}, \quad Z_{21} = \frac{-3}{4}, \quad Z_{22} = \frac{3}{4}$$

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i-5

(b) (I) Properties of positive real function (5-m)

(II) $$Y(s) = \frac{s^2 + 2s + 20}{s + 10}$$ (5-m)

Let us apply test of PR function to the given function.

* In given Y(s), all the quotient terms are real and for s to a real quantity Y(s) is real. Also poles and zeros are on LH of the s-plane for given Y(s).
* Next let us see the positive realness of given function in the jw domain

$$Re[Y(jw)] = Re\left[\frac{(jw)^2 + 2(jw) + 20}{jw + 10}\right]$$

$$= Re\left[\frac{-w^2 + 2jw + 20}{jw + 10}\right]\left[\frac{-jw + 10}{-jw + 10}\right]$$

$$= Re\left[\frac{-8w^2 + 200 + jw^3}{w^2 + 100}\right]$$

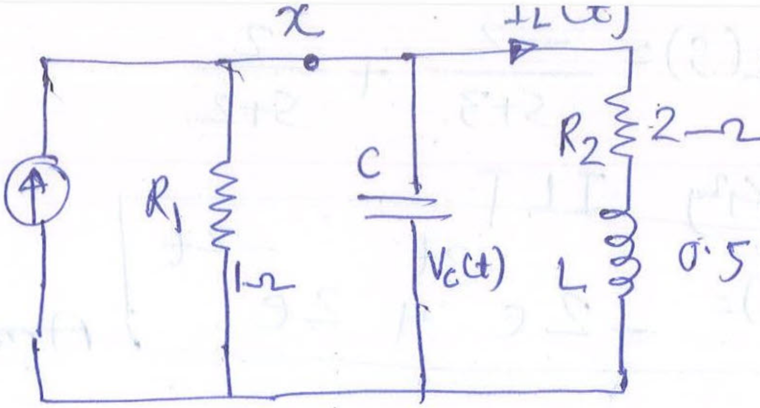
Total=5m

$$Re[Y(jw)] = \frac{-8w^2 + 200}{w^2 + 100}$$

Since for all values of ω, $Re[Y(jw)] \ngeq 0$, this test certifies that given function Y(s) <u>is not PRF</u>.

Q. No. Marks

Q 6 (a)



Using Nodal analysis to node x.

$$\delta(t) = \frac{V_C(t)}{R_1} + \frac{V_C(t)}{X_C} + \frac{V_C(t)}{Z_L} \quad \text{—(1)}$$

$$R_1 = 1\Omega, \quad X_C = \frac{1}{jwC} = \frac{1}{jw \times 1} = \frac{1}{jw}$$

$$Z_L = R_2 + jwL = 2 + j0.5w = 2 + 0.5s$$

Taking Laplace transform of eqn (1)

$$1 = \frac{V_C(s)}{1} + \frac{V_C(s)}{1/s} + \frac{V_C(s)}{2+0.5s}$$

OR $$V_C(s) = \frac{s+4}{s^2+5s+6} = \frac{s+4}{(s+3)(s+2)} = \frac{A}{s+3} + \frac{B}{s+2}$$

Taking ILT and using partial fraction –

$$A = -1, \quad B = 2$$

$$\boxed{V_C(t) = -e^{-3t} + 2e^{-2t} \text{ volt}}$$

6m

$$I_L(s) = \frac{V_C(s)}{Z_L(s)} = \frac{\frac{s+4}{(s+3)(s+2)}}{2+0.5s}$$

OR $$I_L(s) = \frac{2}{(s+3)(s+2)} = \frac{K_1}{s+3} + \frac{K_2}{s+2}$$

$$K_1 = -2, \quad K_2 = 2$$

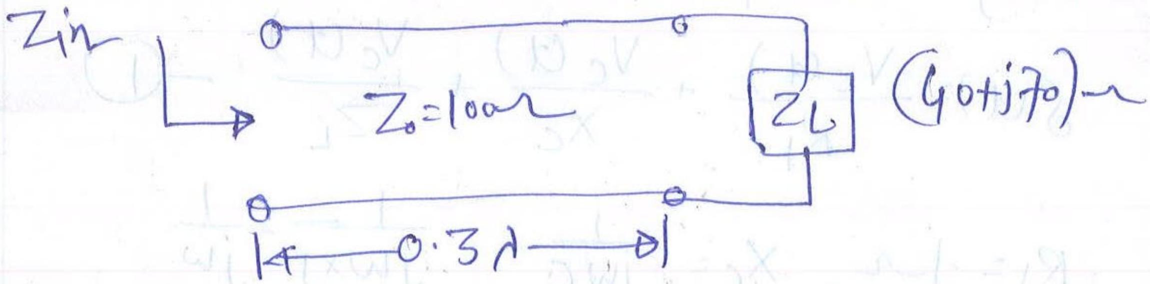
$$I_L(s) = \frac{-2}{s+3} + \frac{2}{s+2}$$

Taking ILT

$$\boxed{I_L(t) = -2e^{-3t} + 2e^{-2t}} \text{ Amp} \quad 4m$$

Total = 10m

6 (b)



(I) $Z_{in} = Z_0 \dfrac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}$ 4m

$Z_{in} = (36.5 - j61.1)\Omega$

(II) Load admittance at load $(Y_L) = \dfrac{1}{Z_L} = \dfrac{1}{40+j70} \times \dfrac{40-j70}{40-j70}$

$Y_L = \dfrac{40-j70}{(40)^2 + (70)^2} =$ 2m

(III) Reflection coefficient at load $= \Gamma_{load} = \dfrac{Z_L - Z_0}{Z_L + Z_0}$

$\Gamma_{load} = \dfrac{40+j70-100}{40+j70+100} = 0.59 \angle 104°$ 2m

(IV) VSWR along the line $(\rho) =$ 2m

$\rho = \dfrac{1 - |\Gamma_{load}|}{1 + |\Gamma_{load}|} = \dfrac{1+0.59}{1-0.59}$

$\rho = \dfrac{1.59}{0.41} = 3.878$

Total = 10m