

Q.1 (a)

Transmission Parameter in terms of Z-Parameter

We know that

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

Rearranging the second equation,

$$I_1 = \frac{1}{Z_{21}} V_2 - \frac{Z_{22}}{Z_{21}} I_2$$

Comparing with

$$I_1 = C V_2 - D I_2,$$

$$C = \frac{1}{Z_{21}}$$

$$D = \frac{Z_{22}}{Z_{21}}$$

Also,

$$V_1 = Z_{11} \left[\frac{1}{Z_{21}} V_2 - \frac{Z_{22}}{Z_{21}} I_2 \right] + Z_{12} I_2$$

$$= \frac{Z_{11}}{Z_{21}} V_2 - \frac{Z_{22} Z_{11}}{Z_{21}} I_2 + Z_{12} I_2$$

$$V_1 = \frac{Z_{11}}{Z_{21}} V_2 - \left[\frac{Z_{11} Z_{22} - Z_{12} Z_{21}}{Z_{21}} \right] I_2$$

Comparing with

$$V_1 = A V_2 - B I_2,$$

$$A = \frac{Z_{11}}{Z_{21}}$$

$$B = \frac{Z_{11} Z_{22} - Z_{12} Z_{21}}{Z_{21}} = \frac{\Delta Z}{Z_{21}}$$

b)

(2)

The current due to dependent source $3i_1 = 3 \times 2 = 6A$ flows down through 10Ω resistor. So net current through 10Ω resistance is $6 - 4 = 2A \downarrow$

$$V = 10 \times 2 = 20V \quad \text{.. with Polarities Shown}$$

c) Inductor

For the inductor, the v-i relationship in time domain are

$$v(t) = L \frac{di}{dt}$$

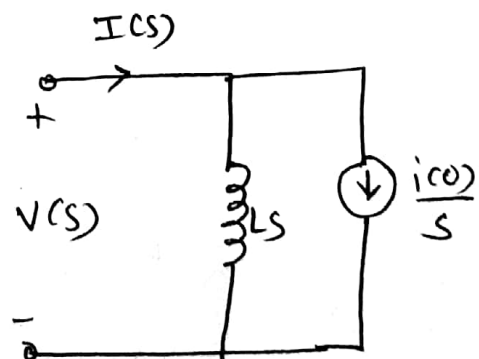
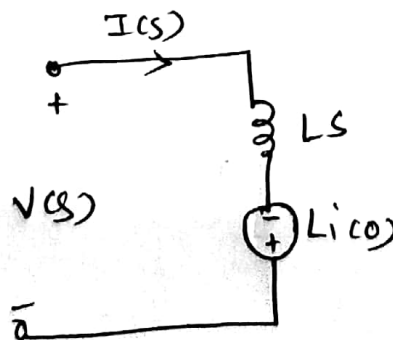
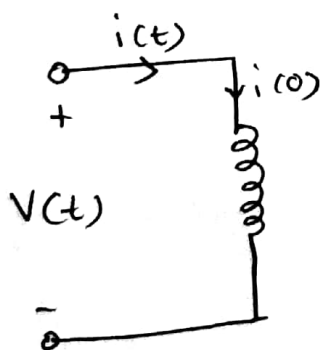
$$i(t) = \frac{1}{L} \int_0^t v(t) dt + i(0)$$

The corresponding frequency domain relation are given as

$$V(s) = Ls I(s) - Li(0)$$

$$I(s) = \frac{1}{Ls} V(s) + \frac{i(0)}{s}$$

The transformed network is



Capacitor:-

③

For capacitor, the v-i relationship in time domain are

$$V(t) = \frac{1}{C} \int_0^t i(t) dt + V(0)$$

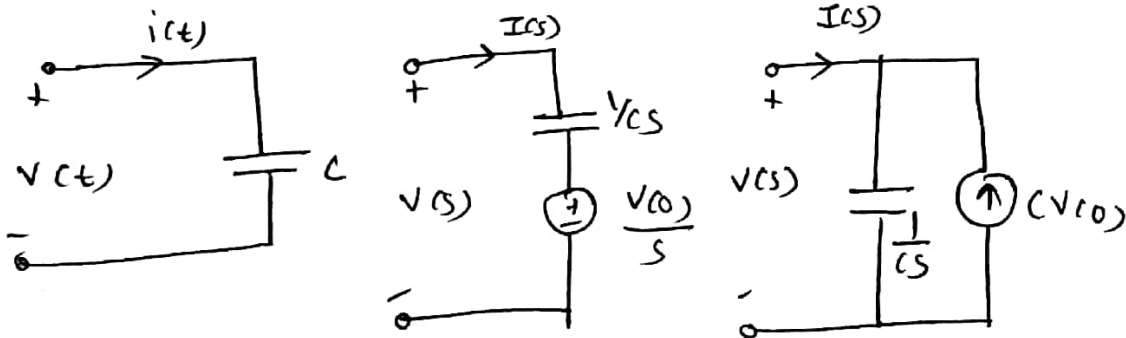
$$i(t) = C \frac{dv}{dt}$$

The corresponding frequency domain relations are given as

$$V(s) = \frac{1}{Cs} I(s) + \frac{V(0)}{s}$$

$$I(s) = CsV(s) - C V(0)$$

The transformed network is shown.



$$d) F(s) = s^4 + s^3 + 4s^2 + 2s + 3$$

$$n(s) = s^3 + 2s$$

$$m(s) = s^4 + 4s^2 + 3$$

$$Q(s) = \frac{m(s)}{n(s)}$$

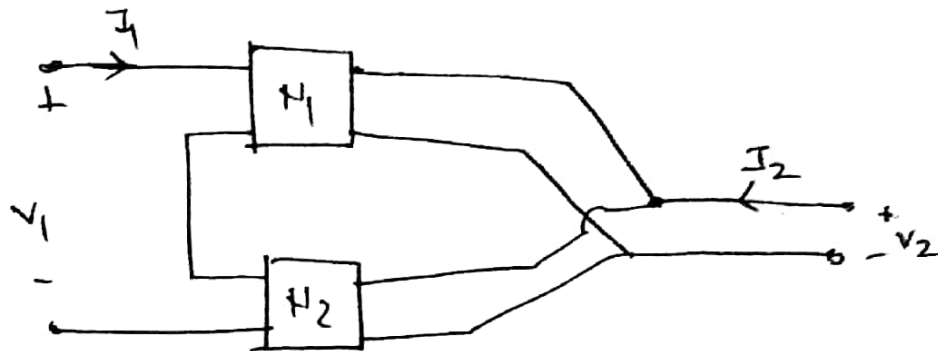
$$Q(s) = \frac{s^4 + 4s^2 + 3}{s^3 + 2s}$$

$$\begin{array}{r}
 s^3 + 2s \quad s^4 + 4s^2 + 3 \quad (s \\
 \underline{s^4 + 2s^2} \\
 2s^2 + 3 \quad) s^3 + 2s \quad (s/2 \\
 \underline{s^3 + \frac{3}{2}s} \\
 \frac{s}{2} \quad) 2s^2 + 3 \quad (4s \\
 \underline{2s^2} \\
 3 \quad) \frac{s}{2} \quad (\frac{s}{6} \\
 \underline{\frac{s}{2}} \\
 0
 \end{array}$$

All the quotients are positive hence the given $F(s)$ is Hurwitz Polynomial.

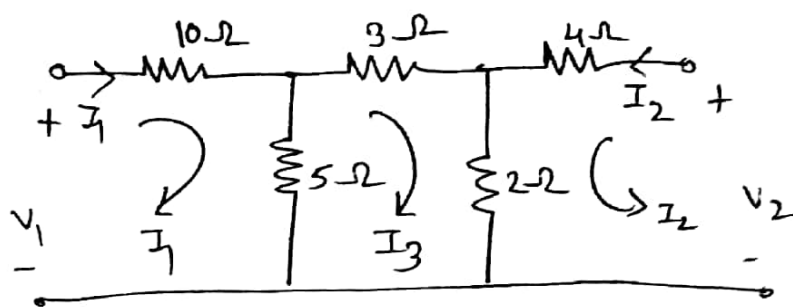
e)	Types of damping	Condition
1	undamped	$\zeta = 0$ $K_1 \cos \omega t + K_2 \sin \omega t$
2	underdamped	$0 < \zeta < 1$ $K_1 e^{-\alpha t} \cos \omega t + K_2 e^{-\alpha t} \sin \omega t$
3	critically damped	$\zeta = 1$ $K_1 e^{-\alpha t} + K_2 t e^{-\alpha t}$
4	overdamped	$1 < \zeta < \infty$ $K_1 e^{s_1 t} + K_2 e^{s_2 t}$

Given Network consist of Network N_1 & N_2 connected in series parallel fashion.



h -Parameter of total Network can be obtained by adding h -Parameter of two networks.

For N_1



$$V_1 = h_{11} I_1 + h_{12} V_2$$

$$I_2 = h_{21} I_1 + h_{22} V_2$$

KVL to loop 1

$$V_1 - 10I_1 - 5(I_1 - I_3) = 0$$

$$V_1 - 10I_1 - 5I_1 + 5I_3 = 0$$

$$V_1 = 15I_1 - 5I_3 \quad \text{--- (i)}$$

KVL to loop 3

$$-3I_3 - 2(I_3 + I_2) - 5(I_3 - I_1) = 0$$

$$10I_3 + 2I_2 - 5I_1 = 0$$

$$10I_3 = 5I_1 - 2I_2$$

$$I_3 = \frac{I_1}{2} - \frac{I_2}{5}$$

KVL to loop 2

$$V_2 - 4I_2 - 2(I_2 + I_3) = 0$$

$$V_2 = 6I_2 + 2I_3 \quad \text{--- (ii)}$$

Putting equation 3 in (i)

$$V_1 = 15I_1 - 5 \left[\frac{I_1}{2} - \frac{I_2}{5} \right]$$

$$V_1 = 12.5I_1 + I_2 \quad \text{--- (4)}$$

Putting equation 3 in (ii)

$$V_2 = 6I_2 + 2 \left[\frac{I_1}{2} - \frac{I_2}{5} \right] = 6I_2 + I_1 - \frac{2}{5}I_2$$

$$V_2 = I_1 + 5.6I_2$$

$$5.6I_2 = V_2 - I_1$$

$$I_2 = \frac{V_2}{5.6} - \frac{I_1}{5.6}$$

$$I_2 = -0.1785I_1 + 0.1785V_2$$

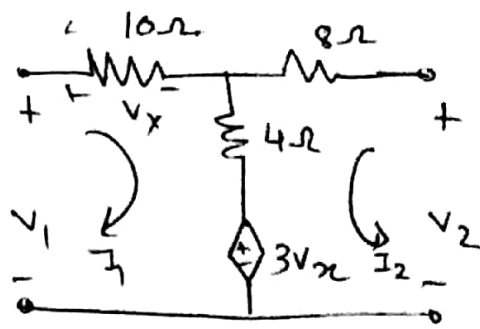
$$\boxed{h_{21} = -0.1785 \quad h_{22} = 0.1785}$$

$$V_1 = 12.5I_1 + 0.1785V_2 - 0.1785I_1$$

$$V_1 = 12.3215I_1 + 0.1785V_2$$

$$\boxed{h_{11} = 12.32 \quad h_{12} = 0.1785}$$

For N_2



$$V_x = 10I_1$$

KVL to loop 1

$$V_1 - 10I_1 - 4(I_1 + I_2) - 3(10I_1) = 0$$

$$V_1 - 10I_1 - 4I_1 - 4I_2 - 30I_1 = 0$$

$$V_1 - 44I_1 - 4I_2 = 0$$

$$V_1 = 44I_1 + 4I_2 \quad \text{--- (i)}$$

KVL to loop 2

$$V_2 - 8I_2 - 4(I_2 + I_1) - 3(10I_1) = 0$$

$$V_2 - 8I_2 - 4I_2 - 4I_1 - 30I_1 = 0$$

$$V_2 - 34I_1 - 12I_2 = 0$$

$$V_2 = 34I_1 + 12I_2 \quad \text{--- (ii)}$$

$$12I_2 = V_2 - 34I_1$$

$$I_2 = -\frac{34}{12}I_1 + \frac{1}{12}V_2$$

$$I_2 = -2.83I_1 + 0.0833V_2 \quad \text{--- (1)}$$

$$\boxed{h_{21} = -2.83 \quad ; \quad h_{22} = 0.0833}$$

$$V_1 = 44 I_1 + 4 (-2.83 I_1 + 0.0833 V_2)$$

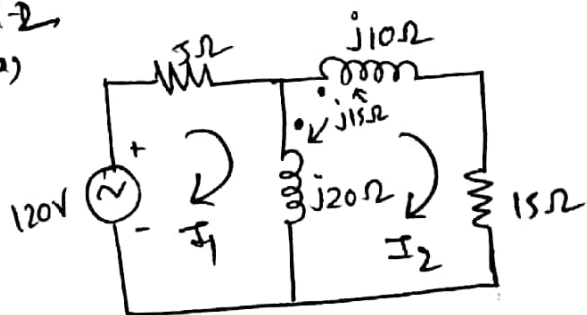
$$V_1 = 44 I_1 - 11.32 I_1 + 0.3332 V_2$$

$$V_1 = 32.68 I_1 + 0.33 V_2$$

$$\boxed{h_{11} = 32.68 \quad h_{12} = 0.33}$$

$$\begin{matrix} N_1 \\ \begin{bmatrix} 12.32 & 0.1785 \\ -0.1785 & 0.1785 \end{bmatrix} \end{matrix} + \begin{matrix} H_2 \\ \begin{bmatrix} 32.68 & 0.33 \\ -2.83 & 0.0833 \end{bmatrix} \end{matrix} = \begin{bmatrix} 45 & 0.5085 \\ -3.0085 & 0.2618 \end{bmatrix}$$

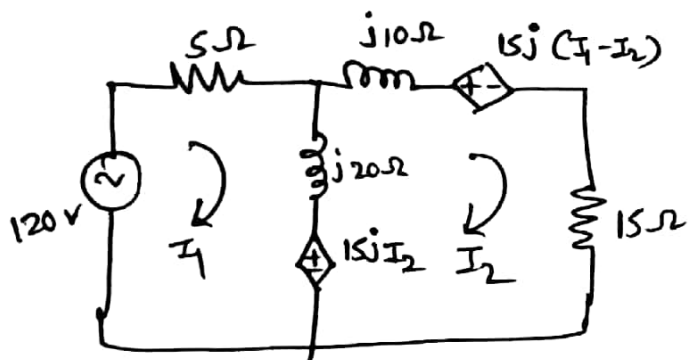
Q1-2
(b)



$$M = j15\Omega$$

Current from $j20\Omega$ is $(I_1 - I_2) \downarrow$ or $(I_2 - I_1) \uparrow$

If we consider $(I_1 - I_2) \rightarrow$ entering
 $I_2 \rightarrow$ entering



Apply KVL in loop 1

$$120 - 5I_1 - 20j(I_1 - I_2) - 15jI_2 = 0$$

$$120 - 5I_1 - 20jI_1 + 20jI_2 - 15jI_2 = 0$$

$$(-5 - 20j)I_1 + (20j - 15j)I_2 = -120$$

$$-(5 + 20j)I_1 + 5jI_2 = -120$$

$$(5 + 20j)I_1 - 5jI_2 = 120 \quad \text{--- (1)}$$

Apply KVL in loop 2

$$-10j I_2 - 15j (I_1 - I_2) - 15 I_2 + 15j I_2 - 20j (I_2 - I_1) = 0$$

$$-10j I_2 - 15j I_1 + 15j I_2 - 15 I_2 + 15j I_2 - 20j I_2 + 20j I_1 = 0$$

$$5j I_1 - 15 I_2 = 0 \quad \text{--- (2)}$$

from eqn (2)

$$5j I_1 = 15 I_2$$

$$I_1 = \frac{15}{5j} I_2$$

$$I_1 = -3j I_2$$

Put the value of I_1 in eq (1)

$$(5 + 20j)(-3j) I_2 - 5j I_2 = 120$$

$$(60 - 15j - 5j) I_2 = 120$$

$$60 - 20j I_2 = 120$$

$$I_2 = 1.8 + 0.6j$$

$$I_2 = 1.897 \angle 18.43^\circ \text{ Amp}$$

Q:-2

(c)

$$F(s) = \frac{2s^4 + 7s^3 + 11s^2 + 12s + 4}{s^4 + 5s^3 + 9s^2 + 11s + 6}$$

Numerator:-

$$2s^4 + 7s^3 + 11s^2 + 12s + 4$$

Even Part = $m(s) = 2s^4 + 11s^2 + 4$

odd Part = $n(s) = 7s^3 + 12s$

By C.F.E

$$\begin{array}{r} 7s^3 + 12s \overline{) 2s^4 + 11s^2 + 4} \left(\frac{2}{7}s \right. \\ \underline{2s^4 + \frac{24}{7}s^2} \\ \frac{53}{7}s^2 + 4 \end{array}$$

$$\begin{array}{r} \frac{53}{7}s^2 + 4 \overline{) 7s^3 + 12s} \left(\frac{49}{53}s \right. \\ \underline{7s^3 + \frac{196}{53}s} \\ \frac{440}{53}s \end{array}$$

$$\begin{array}{r} \frac{440}{53}s \overline{) \frac{53}{7}s^2 + 4} \left(\frac{2809}{3080}s \right. \\ \underline{\frac{53}{7}s^2} \\ \phantom{\frac{53}{7}s^2 +} 4 \end{array}$$

$$\begin{array}{r} 4 \overline{) \frac{440}{53}s} \left(\frac{110}{53}s \right. \\ \underline{\frac{440}{53}s} \\ 0 \end{array}$$

Since all the quotient terms are positive, $N(s)$ is Hurwitz.

$$\begin{array}{r} 2 \overline{) 7 11 -12 +4} \\ \underline{1 5 9 -11 +6} \\ \phantom{2 \overline{) }} -4 +9 -11 +6 \\ \phantom{2 \overline{) }} \phantom{-4 +} -5 -11 +6 \\ \phantom{2 \overline{) }} \phantom{-4 +} \phantom{-5 -} -5 +11 -12 +4 \\ \phantom{2 \overline{) }} \phantom{-4 +} \phantom{-5 -} \phantom{-5 +} 6 -12 +4 \\ \phantom{2 \overline{) }} \phantom{-4 +} \phantom{-5 -} \phantom{-5 +} \phantom{6 -} -6 +4 \end{array}$$

$$D(s) = s^4 + 5s^3 + 9s^2 + 11s + 6$$

Even part of $D(s) = s^4 + 9s^2 + 6$

Odd part of $D(s) = 5s^3 + 11s$

$$\begin{array}{r}
 5s^3 + 11s \overline{) s^4 + 9s^2 + 6} \left(\frac{s}{5} \right. \\
 \underline{s^4 + \frac{11}{5}s^2} \\
 \frac{34}{5}s^2 + 6 \\
 \frac{34}{5}s^2 + 11s \overline{) \frac{34}{5}s^2 + 6} \left(\frac{25}{34}s \right. \\
 \underline{\frac{34}{5}s^2 + \frac{75}{17}s} \\
 \frac{112}{17}s + 6 \\
 \frac{112}{17}s + 6 \overline{) \frac{112}{17}s + 6} \left(\frac{289}{280} \right. \\
 \underline{\frac{112}{17}s + 6} \\
 0
 \end{array}$$

since all quotient terms are positive, $D(s)$ is Hurwitz.

Step 2:- No poles on $j\omega$ axis, Routh test not required.

~~Given~~ $s^4 + 5s^3 + 9s^2 + 11s + 6$

if $s = -1$

eqn will become zero. $\therefore s = -1$ is one of the root of eqn.

$$= (s+1)(s^3 + 4s^2 + 5s + 6)$$

$$= (s+1)(s+3)(s \pm 0.5 \pm 1.32j)$$

Step 3:-

Even part of $N(s) = m_1 = 2s^4 + 11s^2 + 4$

Odd part of $N(s) = n_1 = 7s^3 + 12s$

Even part of $D(s) = m_2 = s^4 + 9s^2 + 6$

Odd part of $D(s) = n_2 = 5s^3 + 11s$

$$A(\omega^2) = m_1 m_2 - n_1 n_2 \big|_{s=j\omega}$$

$$= (2s^4 + 11s^2 + 4)(s^4 + 9s^2 + 6) - \cancel{(s^4 + 9s^2 + 6)} (7s^3 + 11s)(s^3 + 11s)$$

$$= 2s^8 + 18s^6 + 12s^4 + 11s^6 + 99s^4 + 66s^2 + 4s^4 + 36s^2 + 24$$

$$- (35s^6 + 77s^4 + 60s^4 + 132s^2)$$

$$= 2s^8 - 24s^6 + 22s^4 - 22s^2$$

$$= 2s^8 - 6s^6 - 22s^4 - 30s^2 + 24$$

$$= 2(j\omega)^8 - 6(j\omega)^6 - 22(j\omega)^4 - 30(j\omega)^2 + 24$$

$$= 2\omega^8 + 6\omega^6 - 22\omega^4 + 30\omega^2 + 24$$

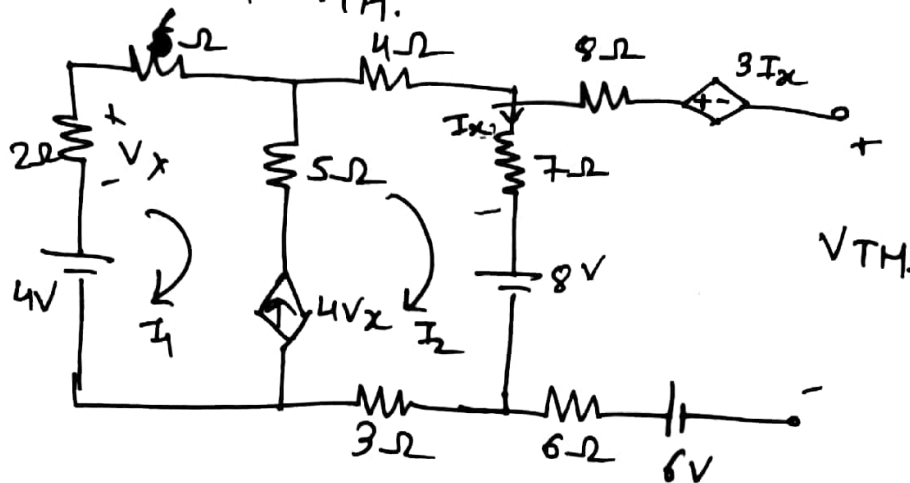
$$A(\omega^2) \geq 0 \text{ for all } \omega \geq 0$$

Since all condition satisfied given function is P.R.F

Q1-3

(a)

To find V_{TH} .



$$I_2 - I_1 = 4V_x$$

Applying KVL to the boundary of loop 1 & loop 2

$$4 - 8I_1 - 4I_2 - 8 = 0$$

$$-8I_1 - 4I_2 = 4$$

$$8I_1 + 4I_2 = -4 \quad \text{--- (i)}$$

$$\text{Also } V_x = -2I_1$$

$$I_2 - I_1 = 4(-2I_1) = -8I_1$$

$$I_2 = -7I_1 \quad \text{--- (ii)}$$

$$7I_1 + I_2 = 0 \quad \text{--- (iii)}$$

~~$$I_1 = \frac{4}{9} \text{ A} \quad I_2 = \frac{4}{13} \text{ A}$$~~

$$I_1 = \frac{2}{45} \quad I_2 = -\frac{14}{45}$$

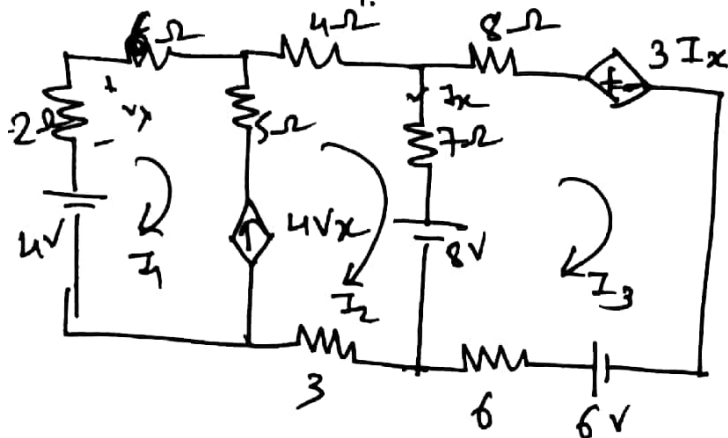
$$V_{TH} = 6 + 8 + 7(I_2) - 3I_2$$

$$V_{TH} = 14 + 4I_2$$

$$= 14 + 4\left(-\frac{14}{5}\right)$$

$$V_{TH} = 12.76V$$

To find R_{TH}



$$I_x = I_2 - I_3$$

$$V_x = -2I_1$$

$$4V_x = I_2 - I_1 \Rightarrow 8I_1 = I_2 - I_1 \Rightarrow 7I_1 + I_2 = 0 \text{ --- (i)}$$

$$4 - 8I_1 - 4I_2 - 7(I_2 - I_3) - 8 - 3I_2 = 0$$

$$-8I_1 + 4I_2 + 7I_3 - 4 = 0$$

$$-8I_1 + 4I_2 + 7I_3 = 4 \text{ --- (ii)}$$

$$6 - 2I_3 + 8 - 3(I_2 - I_3) + 7I_2 = 0$$

$$4I_2 - 18I_3 = -14 \text{ --- (iii)}$$

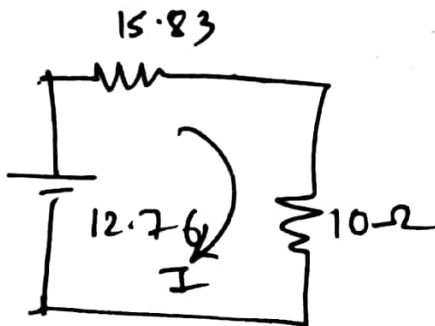
$$I_1 = -\frac{13}{712} = -0.018 \text{ A}$$

$$I_2 = \frac{91}{712} = 0.128 \text{ A}$$

$$I_3 = \frac{287}{356} = 0.8061 \text{ A}$$

$$I_{SC} = I_3 = 0.8061 \text{ A}$$

$$R_{TH} = \frac{V_{TH}}{I_{SC}} = \frac{12.76}{0.8061} = 15.83 \Omega$$



$$I = \frac{12.76}{25.83} = 0.4939 \text{ A}$$

Q1-3

(b)

Applying KVL to mesh 1

$$5\angle 0^\circ - 2j I_1 - 1 I_1 - 2(I_1 - I_2) - 1(I_1 - I_3) - 3j(I_1 - I_3) = 0$$

$$(4 + 5j) I_1 - 2 I_2 - (1 + 3j) I_3 = 5\angle 0 \quad \text{--- (i)}$$

Applying KVL to mesh 2

$$-2(I_2 - I_1) - 3 I_2 + 2j(I_2 - I_3) = 0$$

$$-2 I_1 + (5 - 2j) I_2 + 2j I_3 = 0 \quad \text{--- (ii)}$$

Applying KVL to mesh 3

$$-(1 + 3j)(I_3 - I_1) + 2j(I_3 - I_2) - (1 + j)I_3 = 0$$

$$-(1 + 3j) I_1 + 2j I_2 + (2 + 2j) I_3 = 0 \quad \text{--- (iii)}$$

$$\begin{bmatrix} 4 + 5j & -2 & -(1 + 3j) \\ -2 & (5 - 2j) & 2j \\ -(1 + 3j) & 2j & 2 + 2j \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 0 \end{bmatrix}$$

$$I_2 = \frac{\begin{vmatrix} 4 + 5j & 5 & -(1 + 3j) \\ -2 & 0 & 2j \\ -(1 + 3j) & 0 & 2 + 2j \end{vmatrix}}{\begin{vmatrix} 4 + 5j & -2 & -(1 + 3j) \\ -2 & (5 - 2j) & 2j \\ -(1 + 3j) & 2j & 2 + 2j \end{vmatrix}}$$

$$\begin{vmatrix} 4 + 5j & -2 & -(1 + 3j) \\ -2 & (5 - 2j) & 2j \\ -(1 + 3j) & 2j & 2 + 2j \end{vmatrix}$$

$$I_2 = \frac{-5 \left[-2(2+j) + 2j(1+3j) \right]}{(4+5j) \left[(5-2j)(2+j) - (2j)(2j) \right] + 2 \left[-2(2+j) + 2j(1+3j) \right] - (1+3j) \left[-2 \times 2j + (5-2j)(1+3j) \right]}$$

$$= \frac{50+10j}{42+114j-20-4j+16-42j}$$

$$= \frac{50+10j}{38+68j}$$

$$= \frac{545}{1} 0.6545 \angle -49.492^\circ \text{ A}$$

$$I_3 = \frac{\begin{vmatrix} 4+5j & -2 & 5 \\ -2 & (5-2j) & 0 \\ -(4+3j) & (2j) & 0 \end{vmatrix}}{38+68j}$$

$$= \frac{5 \left(-2(2j) + (1+3j)(5-2j) \right)}{38+68j}$$

$$= \frac{55+45j}{38+68j}$$

$$= 0.912 \angle -21.51^\circ \text{ A}$$

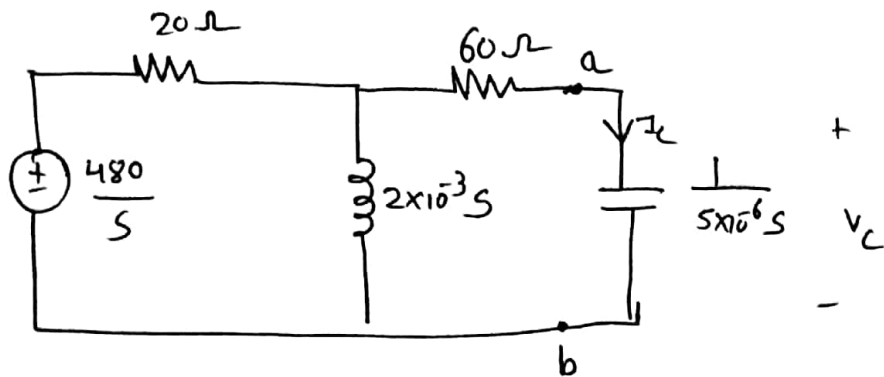
$$V_C = -2j (I_3 - I_2) = (-2j) [0.91 \angle -21.51^\circ - 0.65 \angle 130.51^\circ]$$

$$V_C = 3.03 \angle -123.12^\circ \text{ V}$$

Q: 4(a)

Solution:- Before $t=0$, there is no current through inductor and no voltage across capacitor. That is initial conditions are zero.

$t > 0$



$$V = \frac{Z \cdot R}{R + Z}$$

We will solve this by thevenin's equivalent across

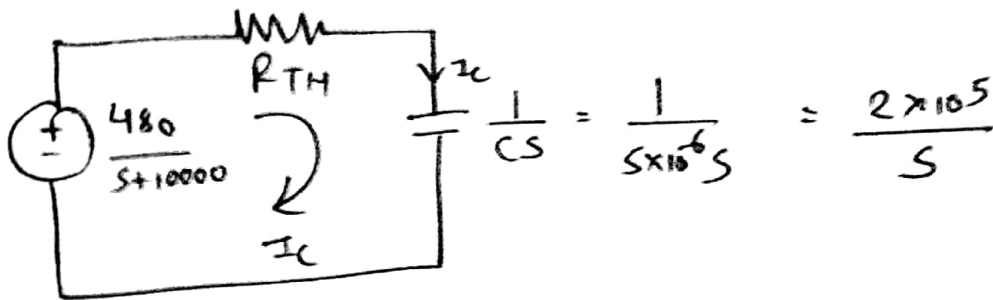
$$\begin{aligned} V_{TH} &= \frac{480}{S} \times 2 \times 10^{-3} S \\ &= \frac{480 (2 \times 10^{-3}) S}{S (20 + 2 \times 10^{-3} S)} \\ &= \frac{480}{S + 10000} \end{aligned}$$

$$\begin{aligned} R_{TH} &= (20 \parallel 2 \times 10^3 S) + 60 \\ &= \frac{20 \times 2 \times 10^3 S}{20 + 2 \times 10^3 S} + 60 \\ &= \frac{\frac{1}{25} S}{20 + 2 \times 10^3 S} + 60 \end{aligned}$$

$$\begin{aligned} &= \frac{\frac{1}{25} S + 60 (20 + 2 \times 10^3 S)}{20 + 2 \times 10^3 S} \\ &= \frac{0.04 S + 1200 + 0.12 S}{2 \times 10^3 S + 20} \\ &= \frac{0.16 S + 1200}{2 \times 10^3 S + 20} \\ &= \frac{0.16 (S + 7500)}{2 \times 10^3 (S + 10000)} \end{aligned}$$

$$R_{TH} = \frac{80 (S + 7500)}{C S + 10000}$$

Thevenin's equ. circuit



$$I_C = \frac{480}{(s+10000)}$$

$$\frac{80(s+7500)}{(s+10000)} + \frac{2 \times 10^5}{s}$$

$$= \frac{480s}{80s(s+7500) + (2 \times 10^5)(s+10000)}$$

$$= \frac{480s}{80s^2 + 600000s + 200000s + 2 \times 10^9}$$

$$= \frac{480s}{80s^2 + 800000s + 2 \times 10^9}$$

$$= \frac{6s}{s^2 + 10000s + 25 \times 10^6}$$

$$I_C = \frac{6s}{(s+5000)^2}$$

$$\frac{6s}{(s+5000)^2} = \frac{A}{s+5000} + \frac{B}{(s+5000)^2}$$

$$6s = A(s+5000) + B$$

$$\text{Put } s = -5000$$

$$-30000 = B$$

$$B = -30,000$$

$$\text{Put } s = 0$$

$$0 = A(5000) - 30,000$$

$$A = \frac{30,000}{5000} = 6$$

$$I_c = \frac{6}{s+5000} - \frac{30,000}{(s+5000)^2}$$

Taking inverse Laplace.

$$i_c(t) = 6e^{-5000t} - 30,000te^{-5000t}$$

Now voltage across capacitor

$$V_c(s) = I_c(s) \times \frac{2 \times 10^5}{s}$$

$$= \frac{6s}{(s+5000)^2} \cdot \frac{2 \times 10^5}{s}$$

$$V_c(s) = \frac{12 \times 10^5}{(s+5000)^2}$$

$$\frac{12 \times 10^5}{(s+5000)^2} = \frac{A}{s+5000} + \frac{B}{(s+5000)^2}$$

$$12 \times 10^5 = A(s+5000) + B$$

$$\text{Put } s = -5000$$

$$B = 12 \times 10^5$$

$$\text{Put } s = 0$$

$$12 \times 10^5 = A(5000) + 12 \times 10^5$$

$$A = 0$$

$$V_c(s) = \frac{12 \times 10^5}{(s+5000)^2}$$

$$V_c(t) = 12 \times 10^5 e^{-5000t} \cdot t \text{ V}$$

Q4

(b)

$$Z(s) = \frac{s^2 + 4s + 3}{s^2 + 6s + 8}$$

$$\begin{array}{r} 1 \\ s^2 + 6s + 8 \overline{) s^2 + 4s + 3} \\ \underline{s^2 + 6s + 8} \\ -2s - 5 \end{array}$$

It uses Partial fraction expansion. As degree of $num(s)$ & $den(s)$ is same, we divide $num(s)$ by $den(s)$, but this gives negative terms, which are not allowed in synthesis.

Hence obtain partial fraction of $\frac{Z(s)}{s}$.

$$\therefore \frac{Z(s)}{s} = \frac{(s+1)(s+3)}{s(s+2)(s+4)} = \frac{A}{s} + \frac{B}{s+2} + \frac{C}{s+4}$$

$$(s+1)(s+3) = A(s+2)(s+4) + B(s)(s+4) + C(s)(s+2)$$

$$\begin{array}{l} \text{Put } s=0 \\ (1)(3) = A(2)(4) \end{array}$$

$$\boxed{A = 3/8}$$

$$\text{Put } s = -2$$

$$(-1)(1) = B(-2)(2)$$

$$\boxed{B = 1/4}$$

$$\text{Put } s = -4$$

$$(-3)(-1) = C(-4)(2)$$

$$\boxed{C = 3/8}$$

$$\frac{Z(s)}{s} = \frac{3/8}{s} + \frac{1/4}{s+2} + \frac{3/8}{s+4}$$

$$\therefore Z(s) = \frac{3/8}{s} + \frac{1/4 s}{(s+2)} + \frac{3s}{8(s+4)}$$

$$= Z_1(s) + Z_2(s) + Z_3(s)$$

So network is series combination of Z_1 , Z_2 & Z_3

$$Z_1(s) \text{ is } R = \frac{3}{8} \Omega$$

$$Z_2(s) = \frac{s}{4(s+2)} = \frac{1}{\frac{4}{s}(s+2)} = \frac{1}{4 + \frac{8}{s}} = \frac{1}{Y_2(s)}$$

$$\therefore Y_2(s) = 4 + \frac{8}{s} = Y_2'(s) + Y_2''(s)$$

As $Y_2(s)$ is addition of two admittance, $Z_2(s)$ is a combination of two parallel branches.

$$Y_2'(s) \text{ is conductance of } 4\Omega \quad \therefore \frac{1}{4}\Omega$$

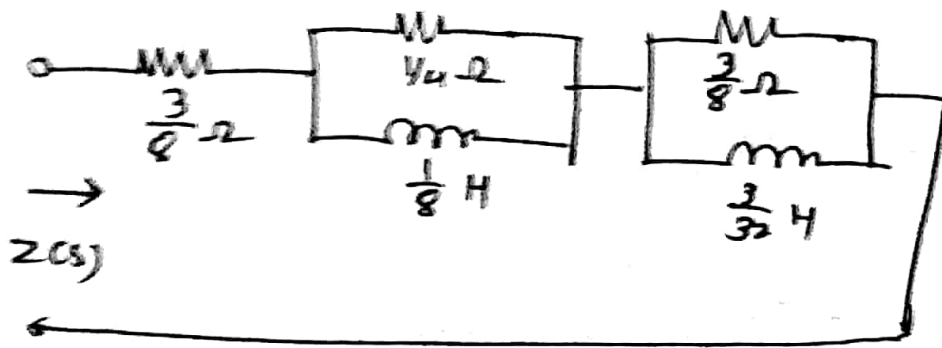
$$Y_2''(s) \text{ is } s \frac{8}{s} = \frac{1}{Ls} \quad \therefore L = \frac{1}{8} \text{ H}$$

similarly

$$\cancel{Y_3(s)} \quad Z_3(s) = \frac{1}{\frac{8}{3s}(s+4)} = \frac{1}{\frac{8}{3} + \frac{32}{3s}}$$

$$Y_3(s) = \frac{8}{3} + \frac{32}{3s}$$

$$R = \frac{3}{8} \Omega \quad \& \quad L = \frac{3}{32} \text{ H}$$



Foster II -

$$Y(s) = \frac{(s+1)(s+4)}{(s+1)(s+3)} = \frac{s^2 + 6s + 8}{s^2 + 4s + 3}$$

$$\begin{array}{r} s^2 + 4s + 3 \overline{) s^2 + 6s + 8} \\ \underline{s^2 + 4s + 3} \\ 2s + 5 \end{array}$$

$$Y(s) = 1 + \frac{2s + 5}{(s+1)(s+3)} = 1 + \frac{A}{s+1} + \frac{B}{s+3}$$

$$2s + 5 = A(s+3) + B(s+1)$$

$$\text{Put } s = -1$$

$$-2 + 5 = A(2)$$

$$\boxed{A = 3/2}$$

$$\text{Put } s = -3$$

$$-1 = -2B$$

$$\boxed{B = 1/2}$$

$$Y(s) = 1 + \frac{3/2}{s+1} + \frac{1/2}{s+3}$$

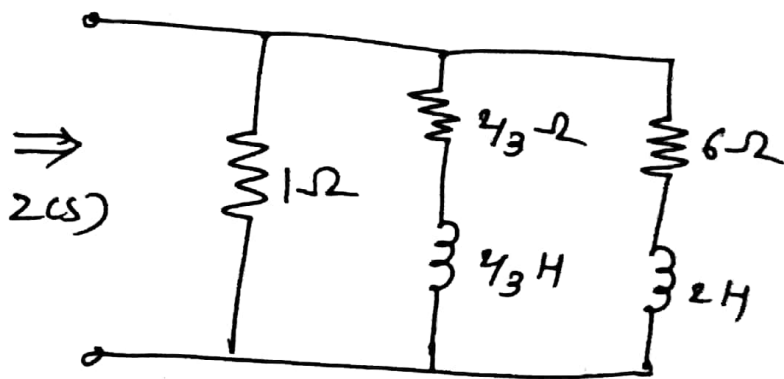
$$= Y_1(s) + Y_2(s) + Y_3(s)$$

$$Y_2(s) = \frac{3/2}{s+1} = \frac{1}{\frac{2s}{3} + \frac{2}{3}} = \frac{1}{Z_2(s)}$$

$$Z_2(s) = \frac{2}{3}s + \frac{2}{3} \Rightarrow L = \frac{2}{3} \text{ H} \text{ \& } R = \frac{2}{3} \Omega$$

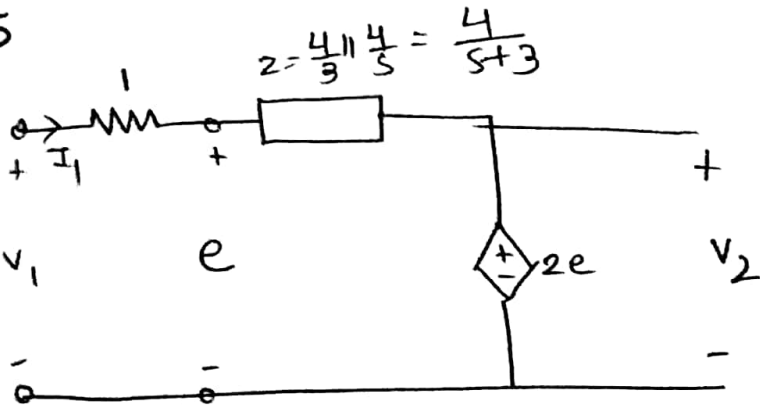
$$Y_3(s) = \frac{1/2}{s+3} = \frac{1}{2s+6} = \frac{1}{Z_3(s)}$$

$$Z_3(s) = 2s+6 \Rightarrow L = 2 \text{ H} \text{ \& } R = 6 \Omega$$



Q.5

(a)



$$v_1 - I_1 - I_1 \left(\frac{4}{s+3} \right) - 2e = 0$$

$$e = v_1 - I_1$$

$$\therefore v_1 - I_1 - I_1 \left(\frac{4}{s+3} \right) - 2(v_1 - I_1) = 0$$

$$\therefore -v_1 = \left(1 + \frac{4}{s+3} - 2 \right) I_1$$

$$\therefore \frac{v_1}{I_1} = - \left(\frac{s+3+4-2s-6}{s+3} \right)$$

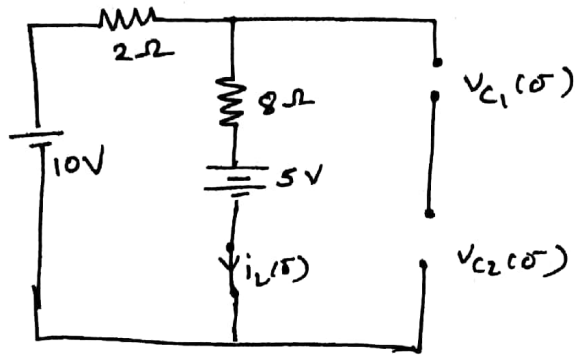
$$= - \left(\frac{-s+1}{s+3} \right)$$

$$\frac{v_1}{I_1} = \left(\frac{s-1}{s+3} \right)$$

Q:-5

(b)

At $t = 0^-$



KVL to loop

$$10 - 10i - 5 = 0$$

$$i = 0.5 \text{ A}$$

$$V_{C1} + V_{C2} = 5 + (8 \times 0.5) = 9 \text{ V}$$

Since the charges on capacitors are equal when connected in series,

$$Q_1 = Q_2$$

$$C_1 V_1 = C_2 V_2$$

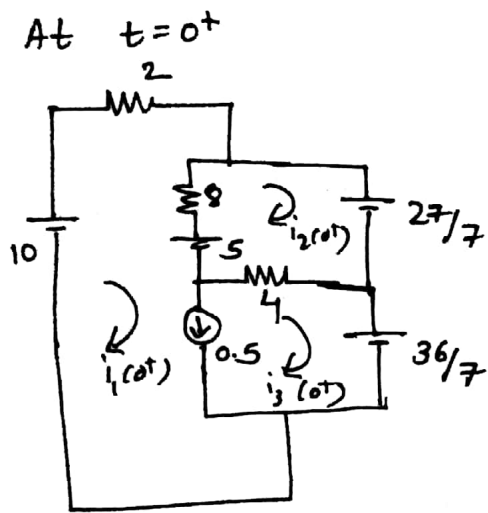
$$\frac{V_1(t)}{V_2(t)} = \frac{C_2}{C_1} = \frac{3}{4}$$

$$V_1 = \frac{3}{4} V_2(t)$$

$$\frac{3}{4} V_{C2}(t) + V_{C2}(t) = 9$$

$$\frac{7}{4} V_{C2}(t) = 9$$

$$V_{C2}(t) = \frac{36}{7} \quad \angle \quad V_{C1}(t) = \frac{27}{7}$$



$$i_1(0^+) - i_3(0^+) = 0.5$$

KVL to loop 1

$$10 - 2i_1(0^+) - \frac{27}{7} - \frac{36}{7} = 0$$

$$i_1(0^+) = 0.5 \text{ A}$$

$$\therefore i_3(0^+) = 0 \text{ A}$$

KVL to Loop 2

$$5 - \frac{27}{7} - 12i_2(0^+) + 4i_3(0^+) + 0.5i_1(0^+) = 0$$

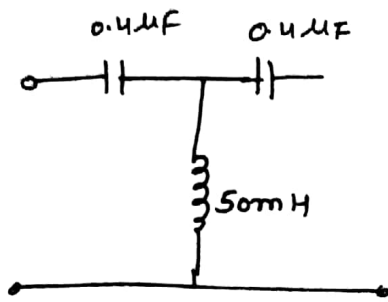
$$5 - \frac{27}{7} - 12i_2(0^+) + 8 \times 0.5 = 0$$

$$i_2(0^+) = 0.429 \text{ A}$$

$$\therefore i_1(0^+) = 0.5 \text{ A} ; i_2(0^+) = 0.429 \text{ A} ; i_3(0^+) = 0 \text{ A}$$

Q1-6

(a)



⇒ The network is a high pass filter

$$2C = 0.4 \mu F, \quad L = 50 \text{ mH} ; \quad C = 0.2 \mu F$$

a) Characteristic impedance

$$K = \sqrt{\frac{L}{C}} = \sqrt{\frac{50 \times 10^{-3}}{0.2 \times 10^{-6}}} = 500 \Omega$$

b) Cut-off frequency

$$f_c = \frac{1}{4\pi\sqrt{LC}} = \frac{1}{4\pi\sqrt{50 \times 10^{-3} \times 0.2 \times 10^{-6}}} = 795.77 \text{ Hz}$$

c) Pass band

The pass band is from 795.77 Hz to infinite frequency.

Q1-6

(b)

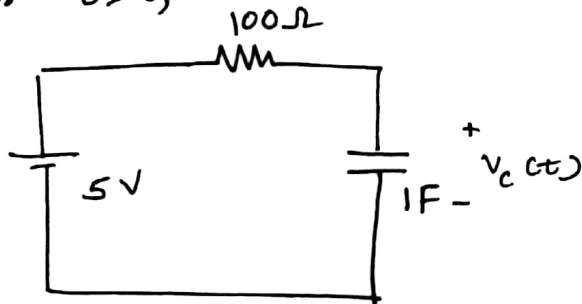
$$\text{At } t=0^-, V_C(0^-) = 0$$

since the voltage across the capacitor cannot change instantaneously,

$$V_C(0^+) = 0$$

since the resistor of 3Ω is connected in parallel with the voltage source of $5V$, it becomes redundant.

for $t > 0$,



writing KCL equation for $t > 0$,

$$\frac{V_C - 5}{100} + \frac{dV_C}{dt} = 0$$

$$100 \frac{dV_C}{dt} + V_C = 5$$

$$\frac{dV_C}{dt} + 0.01 V_C = 0.05$$

comparing with the differential equation

$$\frac{dv}{dt} + pV = Q$$

$$p = 0.01, Q = 0.05$$

$$V_C(t) = \frac{Q}{p} + K e^{-pt}$$

$$V_C(t) = 5 + K e^{-0.01t}$$

At $t=0$, $V_C(0)=0$

$$0 = 5 + k$$

$$k = -5$$

$$V_C(t) = 5 - 5e^{-0.01t}$$

$$V_C(t) = 5(1 - e^{-0.01t}) \quad \text{for } t > 0$$

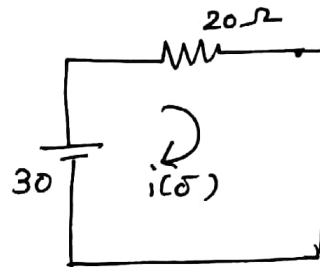
Q1-6

(c)

At $t=0^-$, the network attains steady-state condition.

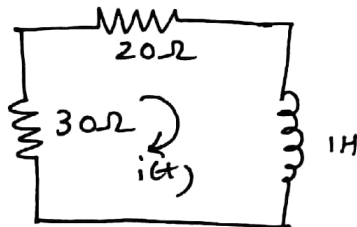
Hence, the inductor acts as a short circuit.

$$\begin{aligned} i(0) &= \frac{30}{20} \\ &= 1.5 \text{ A} \end{aligned}$$



At $t=0^+$; $i(0^+) = 1.5 \text{ A}$

for $t > 0$



$$-20i(t) - 30i(t) - 1 \frac{di}{dt} = 0 \quad \text{--- ci)}$$

$$-50i(t) = \frac{di(t)}{dt}$$

$$\begin{aligned} \frac{di(0^+)}{dt} &= -50 \times 1.5 \\ &= -75 \text{ A/s} \end{aligned}$$

differentiating eqn (i)

$$-50 \frac{di}{dt} - \frac{d^2i}{dt^2}(t) = 0$$

$$-50 \frac{di}{dt}(0^+) = \frac{d^2i}{dt^2}(0^+)$$

$$\frac{d^2i}{dt^2}(0^+) = -50 \times -75$$

$$\boxed{\frac{d^2i}{dt^2}(0^+) = 3750 \text{ A/s}^2}$$