Answer keys.
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**Q1. a)** $h_{21} = -h_{12}$ ← condition for reciprocity of h-parameters.

**b)** $L\{f(t)\} = L\{r(t-a)\}$

$$= \frac{e^{-as}}{s^2}$$

**c)** no. of possible trees.

| no. of nodes ↓ / no. of branches → | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 0 |
| 2 | -1 | 0 | 0 | 1 |
| 3 | 0 | -1 | -1 | -1 |

$$|A A^T| = \left| \begin{bmatrix} 1 & 1 & 0 & 0 \\ -1 & 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & -1 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \end{bmatrix} \right|$$

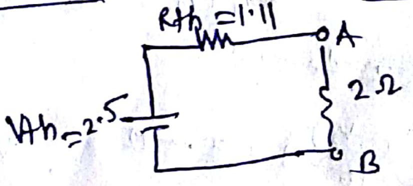
$$= \left| \begin{bmatrix} 1+1+0+0 & -1+0+0+0 \\ -1+0+0+0 & 1+0+1+1 \end{bmatrix} \right| = \begin{vmatrix} 2 & -1 \\ -1 & 3 \end{vmatrix}$$

$$= 6 - (-1) = 7$$

∴ No. of possible trees = 7

**d)** Thevenin's equivalent network across A – B

$V_{th} = 2.5$ volts, $R_{th} = 1.11\ \Omega$




$$I_{2\Omega} = \frac{V_{th}}{R_{th}+2} = \frac{2.5}{1.11+2} = \frac{2.5}{3.11}$$

$I_{2\Omega} = 0.80$ Amps.

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e) Explaination of super node concept

f)

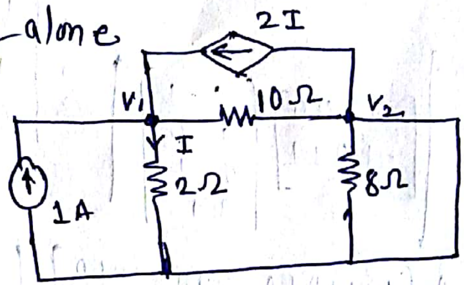
$$\frac{V_1}{I_1} = \frac{s^4 + 2.5\, s^2 + 1}{s^3 + 1.5\, s} \; \Omega$$

$$\frac{V_2}{I_1} = \frac{1}{s^3 + (1.5)\, s} \; \Omega$$

## Que 2

a) Superposition theorem.

Step ①: 1A source acting alone




KCL at node ①

$$-1 - 2I + I + \frac{V_1 - V_2}{10} = 0$$

$$-1 - 2\left(\frac{V_1}{2}\right) + \frac{V_1}{2} + \frac{V_1 - V_2}{10} = 0$$

$$-1 - V_1 + \frac{V_1}{2} + \frac{V_1 - V_2}{10} = 0$$

$$-10 - 10V_1 + 5V_1 + V_1 - V_2 = 0$$

$$-4V_1 - V_2 = 10$$

$$4V_1 + V_2 = -10 \quad \text{—— ①}$$

~~KCL at node ②~~

$$-\cancel{\frac{(V_1 - V_2)}{10} + 2I = 0}, \quad \cancel{V_2 = 0}$$

$$-\cancel{\frac{V_1}{10} + 2\left(\frac{V_1}{2}\right) = 0}$$

$$\cancel{\frac{-V_1}{10} + V_1 = 0}$$

$$\cancel{+10V_1 - V_1 = 0}$$

$$\cancel{V_1 = 0}$$

$$V_2 = 0$$

$$4V_1 = -10$$

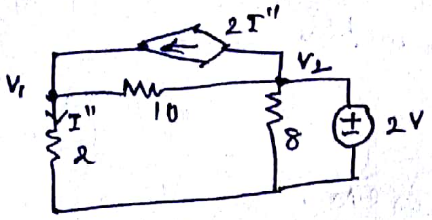
$$V_1 = \frac{-10}{4}$$

$$V_1' = -2.5 \text{ volts.}$$

$$I_1' = \frac{V_1'}{2} = \frac{-2.5}{2}$$

$$I_1' = -1.25 \text{ Amps}$$

step (2) : 2 volt source acting alone




KCL at (1)

$$-2I'' + I'' + \frac{V_1 - V_2}{10} = 0 \qquad V_2 = 2 \text{ volts.}$$

$$-2I'' + I'' + \frac{V_1 - 2}{10} = 0$$

$$-2I'' + I'' + \frac{2I'' - 2}{10} = 0$$

$$-10 I'' + 2I'' - 2 = 0$$

$$-8I'' - 2 = 0$$

$$8I'' = -2$$

$$I'' = -2/8 = -0.25 \text{ Amps.}$$

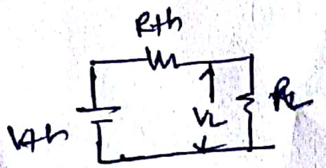
step (3)

current through $2\Omega$ register using superposition Th$^m$.

$$I = I' + I''$$
$$= -1.25 - 0.25$$
$$I = -1.50 \text{ Amps.}$$

b). $V_{th} = \frac{12}{5} = 2.4$ volts. $\quad I_{sc} = 3$ A

$$R_{th} = \frac{V_{th}}{I_{sc}} = \frac{8}{5} = 1.6\ \Omega$$




$$V_L = \frac{1.6}{1.6 + 1.6} \times 2.4$$
$$= 1.2 \text{ volts.}$$

$$P_L = \frac{V_L^2}{R_L} = \frac{(1.2)^2}{1.6} = \frac{1.44}{1.6} = 0.9 \text{ watts.}$$

$P_{max} = 0.9$ watts.

Que 3 a)

Reduced incidence matrix.

no. of branches

$$A = \begin{array}{c|ccccccc} \text{no. of nodes} & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ \hline 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 2 & -1 & 1 & 0 & 0 & 0 & 1 & 0 \\ 3 & 0 & -1 & 1 & 0 & 1 & 0 & 0 \\ 4 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \\ 5 & 0 & 0 & 0 & -1 & -1 & -1 & -1 \end{array}$$

f-tieset matrix

f- cutset matrix

b) millman theorem.

$$R = \frac{1}{G} = \frac{1}{G_1+G_2+G_3} = \frac{1}{\frac{1}{4}+0+\frac{1}{1}} = \frac{1}{\frac{1+0+4}{4}} = \frac{4}{5}$$

$$V_m = \frac{\Sigma VG}{\Sigma G} = \frac{V_1G_1+V_2G_2+V_3G_3}{G_1+G_2+G_3} = \frac{5\times\frac{1}{4}+0+28\times\frac{1}{1}}{\frac{1}{4}+0+\frac{1}{1}}$$

$$= \frac{5/4+28}{\frac{1+4}{4}} = \frac{\frac{5}{4}+28}{\frac{5}{4}}$$

$$= \frac{5+112}{5} = \frac{117}{5}$$

$V_{2\Omega} = \frac{117}{5}$ volts.

Q4 a)

$i(t) = -10\, e^{-0.5t}$ Amps. for $t>0$

$V_c(t) = \frac{20}{3}(1-e^{-0.5t})$ volts. for $t>0$.

b)

$i_1(0^+) = 0.5$ Amps.

$i_2(0^+) = 0.25$ Amps.

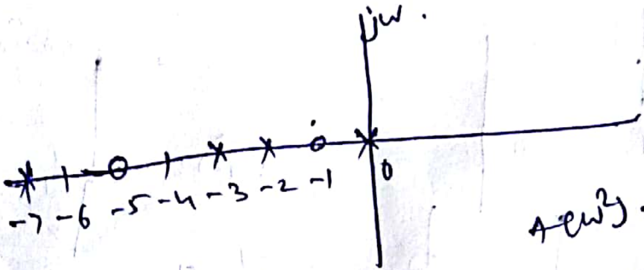
$i_3(0^+) = 0$ Amps.

**Q5**

a) $F(s) = s^4 + s^3 + 5s^2 + 3s + 4$

Polynomial is Hurwitz.

b) $$F(s) = \frac{s^2+6s+5}{s^2+9s+14}$$




$$A(\omega^2) = s^4 - 35s^2 + 70 \Big|_{s=j\omega}$$

$$= \omega^4 + 35\omega^2 + 70$$

$A(\omega^2)$ is positive for all $\omega \geq 0$

$\therefore$ function is PRF

c) Y-Parameter

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 8s^3+10s^2+8s+3 & 8s^2+2s+2 \\ 4s^3+4s^2+3s+1 & 4s^2+1 \end{bmatrix}$$

$$Y = \begin{bmatrix} \frac{D}{B} & -\frac{\Delta T}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{bmatrix} = \begin{bmatrix} \frac{4s^2+1}{8s^2+2s+2} & \frac{-\Delta T}{8s^2+2s+2} \\ \frac{-1}{8s^2+2s+2} & \frac{8s^3+10s^2+8s+3}{8s^2+2s+2} \end{bmatrix}$$

$$\Delta T = AD - BC$$

$$= (8s^3+10s^2+8s+3)(4s^2+1) - (8s^2+2s+2)(4s^3+4s^2+3s+1)$$

$=$

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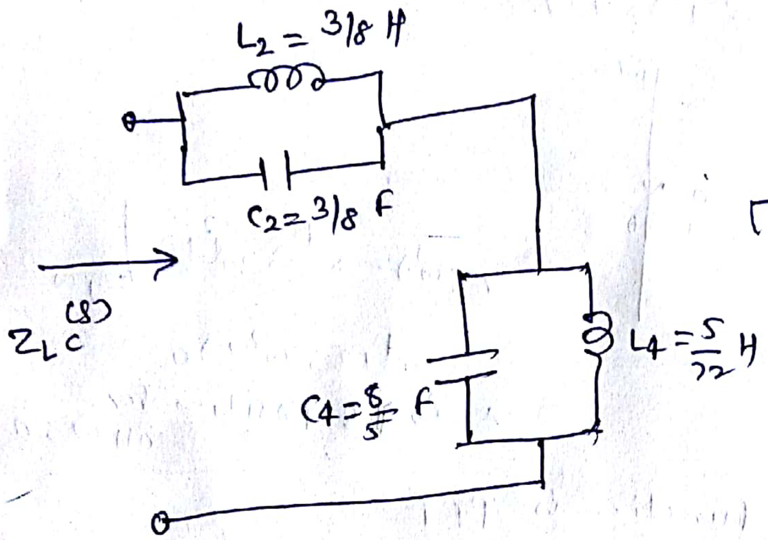
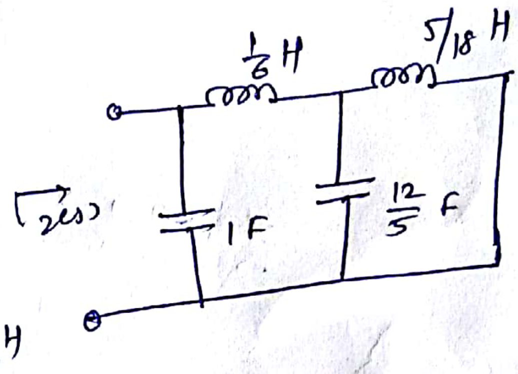
6/6

Q6. a) $Z(s) = \frac{s(s^2+4)}{(s^2+1)(s^2+9)}$  Foster-I
Cauer-I

Foster-I




Cauer-I




b) $\frac{V_2(s)}{V_1(s)} = \frac{(s'+1)(s'+4)}{s'^2+5s'+6} = \frac{(s'+1)(s'+4)}{(s'+2)(s'+3)}$