Network Analysis - FISAC :

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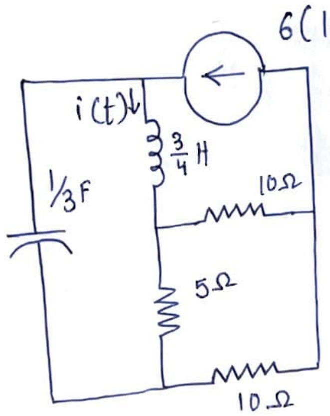
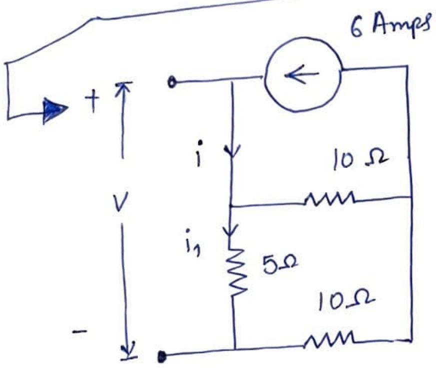
Q1. >



need to calculate $i(t)$ for $t>0$, using laplace transform.

we need to find the initial conditions and transform the circuit into S-domain.



from observation,

$i = 6$ Amperes

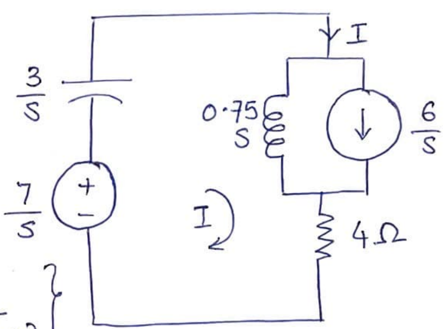
$$i_1 = \frac{6\left[\frac{15\times10}{15+10}\right]}{15} = 2.4 \text{ Amps}$$

$\therefore\ V(0) = 5\times2.4 = 12$ Volts

and $i(0) = 6$ amps

In the S-domain :

$$-\frac{12}{S} + \frac{3}{S}I + 0.75s\left[I-\frac{6}{S}\right] + 4I = 0$$



$$\left[\frac{(S^2+5.33s+4)}{(4S/3)}\right]I = 4.5+\frac{12}{S} = \frac{4.5\times(S+2.67)}{S}$$

OR :

$$I = \frac{6(S+2.67)}{[(S+0.903)(S+4.43)]} = \left\{\frac{A}{(S+0.903)}\right\}+\left\{\frac{B}{(S+4.43)}\right\}$$

here,

$$A = \frac{6(-0.903+2.667)}{(-0.903+4.43)} = \frac{6\times1.764}{3.527} = \underline{3.001} \text{ and}$$

$$B = \frac{6(-4.43+2.667)}{(-4.43+0.903)} = \frac{6\times-1.763}{-3.527} = \underline{2.999}$$

$$\boxed{\therefore\ i(t) = \left[3.001e^{-0.903t} + 2.999e^{-4.43t}\right]u(t)\ A}$$

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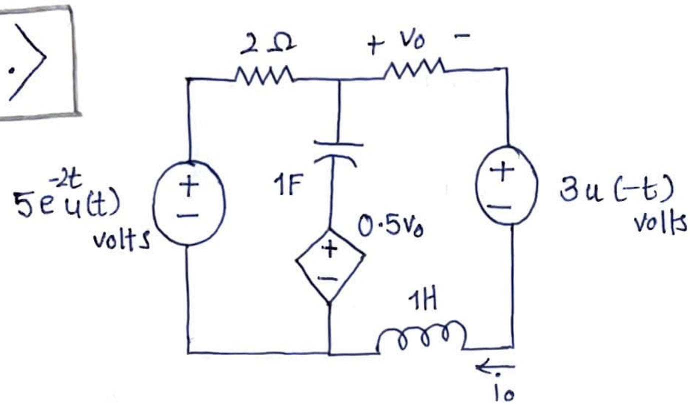
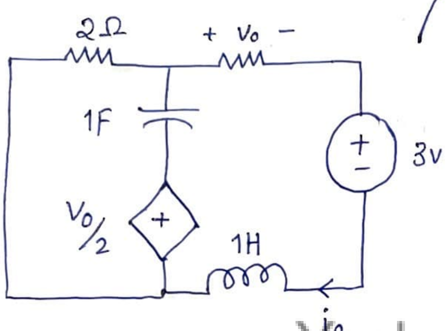
Q2.)



need to find $i_o(t)$ for $t>0$ using laplace transform.

\# according to initial condition for $t<0$, the circuit is:

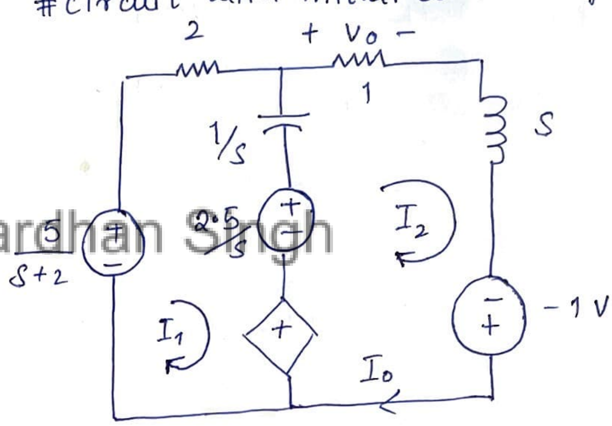


$i_L(0) = i_o = \frac{-3}{3} = 1$ Amp

$V_o = -1V$

$V_c(0) = -(2)(-1) - \left(\frac{-1}{2}\right) = 2.5$ Volts

\#circuit with initial condition for $t>0$:



for mesh 1:

$$= \frac{-5}{s+2} + \left(2+\frac{1}{s}\right)I_1 - \frac{1}{s}I_2 + \frac{2.5}{s} + \frac{V_o}{2} = 0$$ ← here, $V_o = I_o = I_2$

$$= \left(2+\frac{1}{s}\right)I_1 + \left(\frac{1}{2}-\frac{1}{s}\right)I_2 = \frac{5}{s+2} - \frac{2.5}{s} \longrightarrow (1)$$

Similarly, for mesh 2:

$$-\frac{I_1}{s} + \left(\frac{1}{2}+s+\frac{1}{s}\right)I_2 = \frac{2.5}{s} - 1 \longrightarrow (2)$$

now we need to put these in matrix form

$$\begin{bmatrix} 2+\frac{1}{s} & \frac{1}{2}-\frac{1}{s} \\ -\frac{1}{s} & \frac{1}{2}+s+\frac{1}{s} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} \frac{5}{s+2} - \frac{2.5}{s} \\ \frac{2.5}{s} - 1 \end{bmatrix}$$

$$I_o = I_2 = \frac{\Delta_2}{\Delta} = \frac{-2s^2+13}{(s+2)(2s^2+2s+3)} = \frac{A}{s+2} + \frac{Bs+C}{2s^2+2s+3}$$

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$$-2s^2+13 = A(2s^2+2s+3)+B(s^2+2s)+C(s+2)$$

equating coefficients:

$s^2 \Rightarrow -2 = 2A+B$

$s^1 \Rightarrow 0 = 2A+2B+C$

$s^0 \Rightarrow 13 = 3A+2C$

upon solving:

$A = 0.7143$

$B = -3.429$

$C = 5.429$

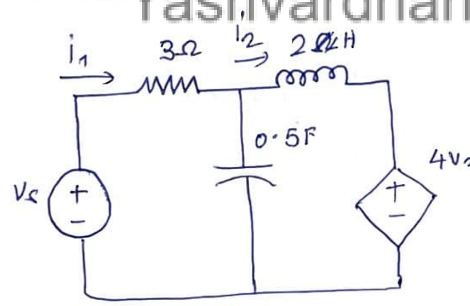
$$I_0 = \frac{0.7143}{s+2} - \frac{3.429s-5.429}{2s^2+2s+3} = \frac{0.7143}{s+2} - \frac{1.7145s-2.714}{s^2+s+1.5}$$

$$I_0 = \frac{0.7143}{s+2} - \frac{1.7145(s+0.5)}{(s+0.5)^2+1.25} + \frac{(3.194)(\sqrt{1.25})}{(s+0.5)^2+1.25}$$

$$\boxed{i_0(t) = \left[0.7143e^{-2t} - 1.7145e^{-0.5t}\cos(1.25t) + 3.194e^{-0.5t}\sin(1.25t)\right]u(t)}$$

$\hookrightarrow$ in amperes (unit).

Q3. > given circuit:

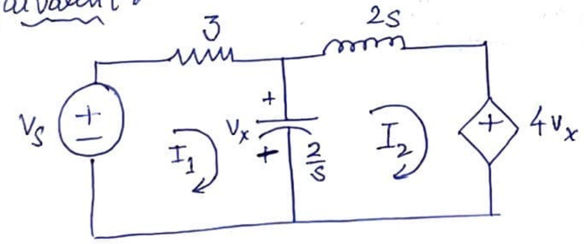


we need to find:

(a) I_1/V_s

(b) I_2/V_x

Laplace equivalent:



mesh 1:

$$V_s = \left(3+\frac{2}{s}\right)I_1 - \frac{2}{s}I_2 \rightarrow (1)$$

mesh 2:

$$0 = 4V_x + \left(2s+\frac{2}{s}\right)I_2 - \frac{2}{s}I_1$$

$$V_x = (I_1 - I_2)(2/s)$$

$$\Rightarrow \frac{8}{s}(I_1 - I_2) + \left(2s+\frac{2}{s}\right)I_2 - \frac{2}{s}I_1 = 0 \rightarrow *$$

$$\Rightarrow 0 = \frac{-6}{s}I_1 + \left(\frac{6}{s}-2s\right)I_2 \rightarrow (2)$$

now we need to put eqn (1) and (2) in matrix form

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Q3. > continued

$$\begin{bmatrix} V_s \\ 0 \end{bmatrix} = \begin{bmatrix} 3+2/s & -2/s \\ -6/s & 6/s - 2s \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\Delta = \frac{18}{s} - 6s - 4$$

$$\Delta_1 = \left[\frac{6}{s} - 2s\right] V_s \qquad \Delta_2 = \frac{6}{s} V_s$$

$$I_1 = \frac{\Delta_1}{\Delta} = \left(\frac{6/s - 2s}{18/s - 6s - 4}\right) V_s \Rightarrow \frac{I_1}{V_s} = \frac{3/s - s}{9/s - 5}$$

$$\boxed{\therefore \; I_1/V_s = \frac{s^2 - 3}{3s^2 + 2s - 9}} \longrightarrow$$ answer for Q3. part (a)

<Q3. (b)>

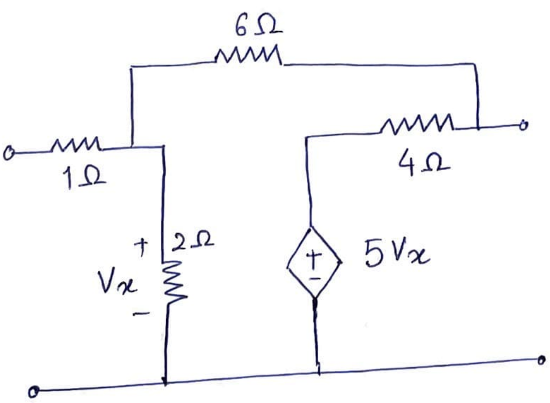
$$I_2 = \frac{\Delta_2}{\Delta}$$

$$V_x = 2/s \left[\frac{\Delta_1 - \Delta_2}{\Delta}\right] = \frac{-4V_s}{\Delta}$$

$$I_2/V_x = \frac{6/s \cancel{V_s}}{-4\cancel{V_s}} = \frac{-3}{2s}$$

$$\boxed{\therefore \; I_2/V_x = \frac{-3}{2s}} \longrightarrow$$ answer for Q3 part (b)

Q4. >



we need to find the A, B, C, D parameters.

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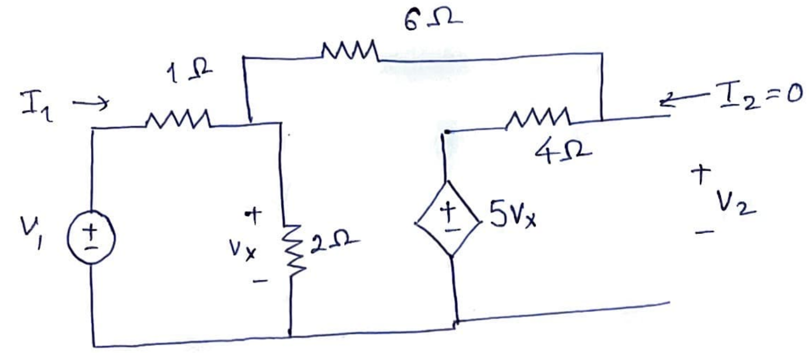
To get A and C, consider the following circuit :



$$\frac{V_1 - V_x}{1} = \frac{V_x}{2} + \frac{V_x - 5V_x}{10} \rightarrow V_1 = 1.1\,V_x$$

$$V_2 = 4(-0.4V_x) + 5V_x = 3.4\,V_x \rightarrow A = \frac{V_1}{V_2} = \frac{1.1}{3.4} = 0.3235$$

$$I_1 = \frac{V_1 - V_x}{1} = 1.1\,V_x - V_x = 0.1\,V_x$$

$$\rightarrow C = I_1/V_2 = 0.1/3.4 = 0.02941$$

for B and D,

$$\frac{V_1 - V_x}{1} = \frac{V_x}{6} + \frac{V_x}{2} \rightarrow V_1 = \frac{10}{6} V_x$$

$$I_2 = -\frac{5}{4} V_x - \frac{V_x}{6} = -\frac{17}{12} V_x$$

$$V_1 = I_1 + V_x$$

$$\Rightarrow I_1 = V_1 - V_x = \frac{4}{6} V_x \rightarrow D = -\frac{I_1}{I_2} = \frac{4}{6}\left(\frac{12}{17}\right) = 0.4706$$

$$\Rightarrow B = \frac{-V_1}{I_2} = \frac{10}{6}\left(\frac{12}{17}\right) = 1.176$$

- A = 0.3235
- B = 1.1760
- C = 0.0294
- D = 0.4706

$$T = \begin{bmatrix} 0.3235 & 1.176 \\ 0.02941 & 0.4706 \end{bmatrix}$$

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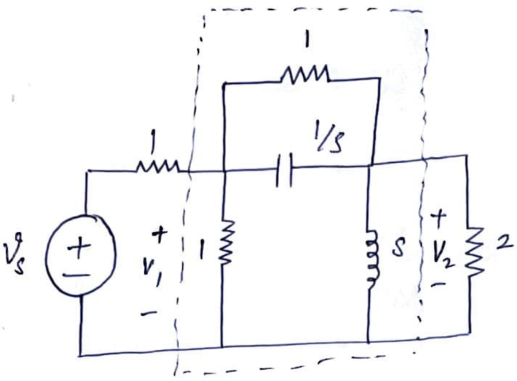
<Q5.>



(a) need to find "y"- parameters for 2-port network.

$$-y_{12} = \frac{1}{\left(\frac{1}{1/s}\right)} = 1+s \Longrightarrow y_{12} = -(s+1)$$

$$y_{11} + y_{12} = 1 \longrightarrow y_{11} = 1 - y_{12} = \underline{\underline{s+2}}$$

$$y_{22} + y_{12} = s \longrightarrow y_{22} = \frac{1}{s} - y_{12} = \frac{1}{s} + s + 1 = \frac{s^2 + s + 1}{s}$$

$$\boxed{[y] = \begin{bmatrix} s+2 & -(s+1) \\ -(s+1) & \frac{s^2+s+1}{s} \end{bmatrix}}$$

(b) need to find $V_2(s)$ for $v_s = 2u(t)$ V.

1) $V_s = I_1 + V_1$ or $V_s - V_1 = I_s$
2) $V_2 = -2I_2$
3) $I_1 = y_{11}V_1 + y_{12}V_2$
4) $I_2 = y_{21}V_1 + y_{22}V_2$

- using equations (1) and (3):

$$V_s = (1+y_{11})V_1 + y_{12}V_2 \rightarrow (5)$$

- from equations (2) and (4):

$$V_1 = -\frac{(0.5+y_{22})V_2}{y_{21}} \rightarrow (6)$$

Substitute (6) into (5):

$$V_2 = \frac{2/s}{\left\{y_{12} - \frac{1}{y_{21}}(1+y_{11})[0.5+y_{22}]\right\}}$$

$$V_2 = \frac{0.8(s+1)}{(s^2+1.8s+1.2)}$$

$$\boxed{V_2(s) = \frac{0.8(s+1)}{s^2+1.8s+1.2}}$$