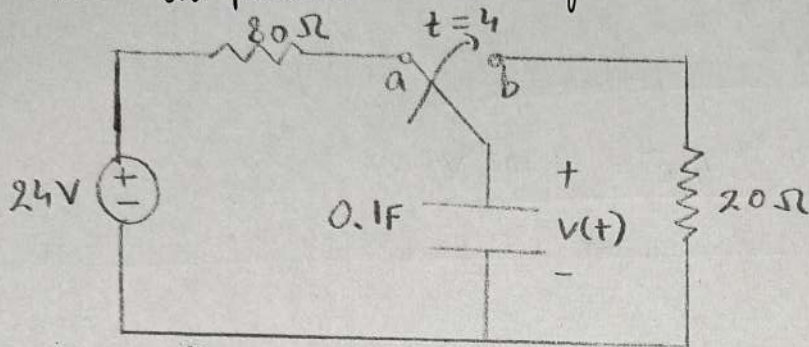


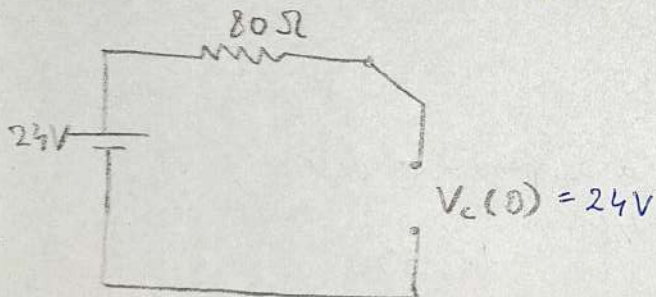
[Question-1]

The switch has been in position for a long time, until $t=4s$ when it is moved to position b and left there. Determine $v(t)$ at $t=10s$.

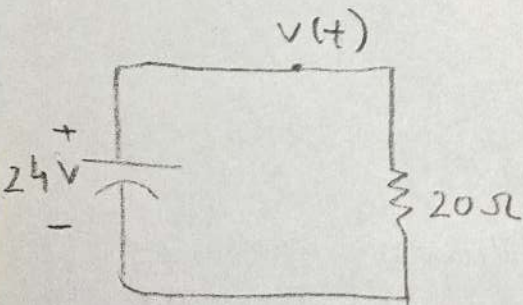


First, we will solve the problem assuming switch is moved from position 'a' to 'b' @ $t=0$ sec.

For $t < 0$, switch is in position 'a' & circuit is in steady state $\Rightarrow$ 'c' can be replaced by open circuit



At $t=0$, switch is moved from position 'a' to 'b'.



Applying KCL at node,

$$0.1 \frac{dv}{dt} + \frac{v}{20} = 0$$

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

$$\Rightarrow \left(0.1 D + \frac{1}{20} \right) V = 0, \quad D \equiv \frac{d}{dt}$$

$$D = \frac{-1}{20 \times 0.1} = \frac{-1}{2} = -0.5$$

$$\Rightarrow v(t) = C e^{-0.5t}$$

Using initial conditions, $v(0) = 24 \Rightarrow v(t) = 24 = C$

$$\therefore v(t) = 24 e^{-0.5t}$$

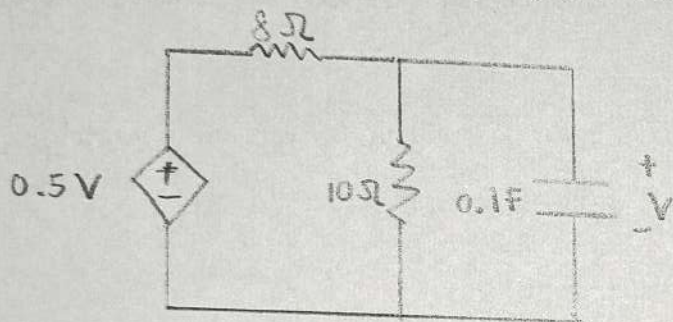
Now, considering that switch is moved from 'a' to 'b' at $t = 4 \text{ sec}$.
We will replace t with $(t-4)$ to get correct solution

$$\therefore v(t) = 24 e^{-0.5(t-4)}$$

$$\therefore v(10) = 24 e^{-0.5(10-4)} = 24 e^{-3} = 1.195 \text{ V}$$

[Question-2]

If $v(0) = 20 \text{ V}$ in the circuit, obtain $v(t)$ for $t > 0$.



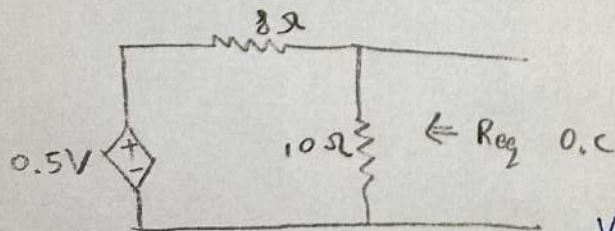
In the given circuit, taking source free response condition

Voltage across capacitor, $V_c(t) = V_0 e^{-t/\tau}$ for $t > 0$

$$\text{Here, } V_0 = V_c(0) = 20 \text{ V}$$

$$\tau = R_{eq} C \quad (\text{time constant})$$

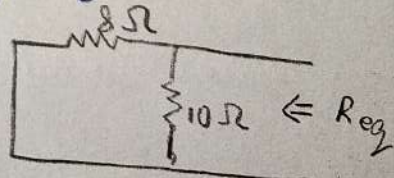
To find R_{eq} ; for $t > 0$



As it has a dependent source, we generally need an external excitation.

But here the dependent source variable V is zero. $\therefore 0.5V = 0$

$$\text{Now, } R_{eq} = 8 \parallel 10 = \frac{8 \times 10}{8 + 10} = \frac{40}{9} = 4.44 \Omega$$



Now, $\tau = R_{eq} C = \frac{40}{9} \times 0.1$

$\therefore \tau = 0.444 \text{ sec}$

$\therefore$ Voltage across capacitor $V(t)$

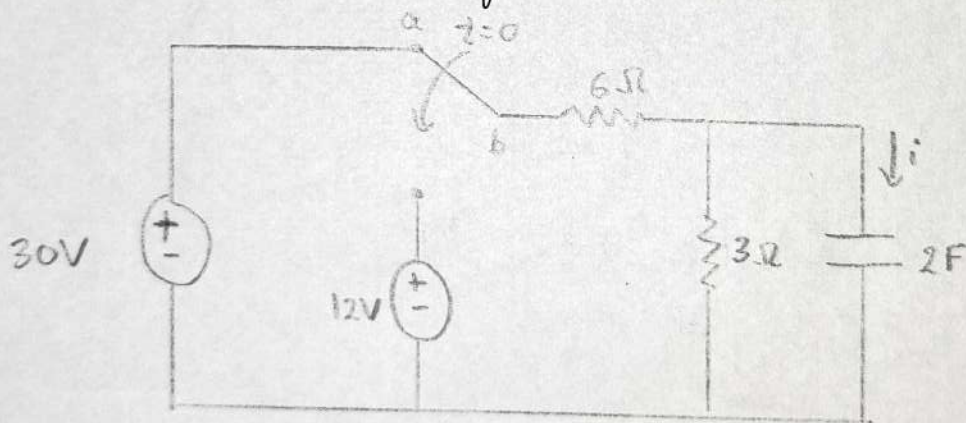
$$v(t) = V_0 e^{-t/\tau}$$

$$= 20 e^{-t/0.44}$$

$\therefore \boxed{V(t) = 20 e^{-2.25t} \text{ volts}}$

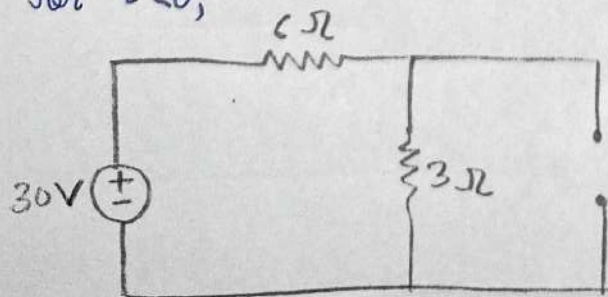
[Question-3]

The switch has been in position for a long time. At $t=0$, it moves to position b. Calculate $i(t)$ for all $t \geq 0$.



For steady state, capacitor acts as an open ckt.

For $t < 0$,



$$V_C(0^-) = \left[\frac{30 \times 3}{3+6} \right] = 10 \text{ V}$$

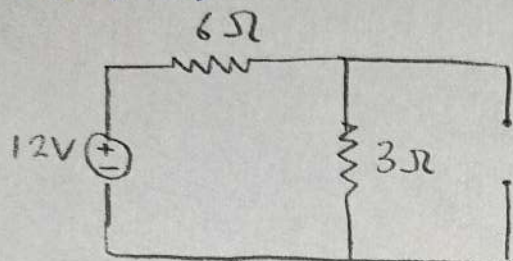
$\therefore V_C(0^-) = 10 \text{ V}$

As capacitor does not allow sudden change of voltage

$$\therefore V_c(0^-) = V_c(0^+) = 10 \text{ V}$$

Now, for $t > 0$ (switch to position b)

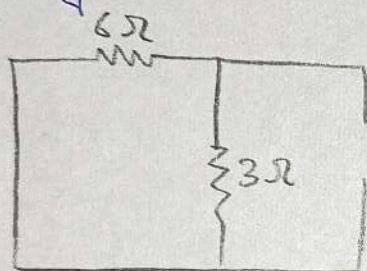
At $t = \infty$



$$V_c(\infty) = \left[12 \times \frac{3}{3+6} \right] = 4 \text{ V}$$

$$\therefore V_c(\infty) = 4 \text{ V}$$

Calculating time constant, $\tau = R_{eq} C$



$$R_{eq} = \frac{6 \times 3}{6+3} = 2 \Omega$$

$$\text{Now, } \tau = R_{eq} \cdot C = 2 \times 2 = 4 \text{ sec}$$

$$\begin{aligned} \text{Now, } V_c(t) &= V_c(\infty) + [V_c(0^+) - V_c(\infty)] e^{-t/\tau} \\ &= 4 + [10 - 4] e^{-t/4} \end{aligned}$$

$$V_c(t) = 4 + 6 e^{-t/4}$$

$$\begin{aligned} \text{Now, } i(t) &= \left[C \times \frac{d}{dt} V_c(t) \right] \\ &= 2 \left[\frac{d}{dt} (4 + 6 e^{-t/4}) \right] \end{aligned}$$

$$= 2 \left[6 \times e^{-t/4} \times \frac{-1}{4} \right]$$

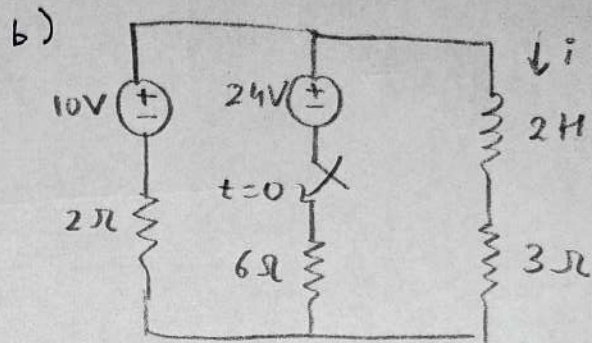
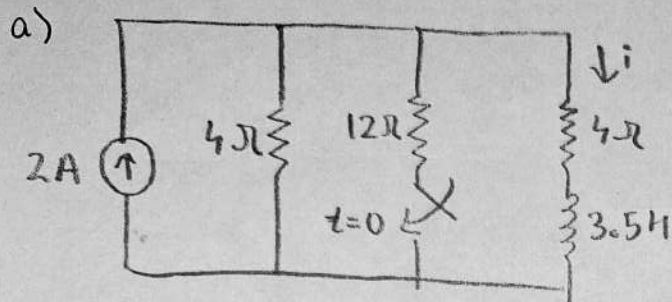
$$= (-3 \times e^{-t/4})$$

$\Rightarrow$

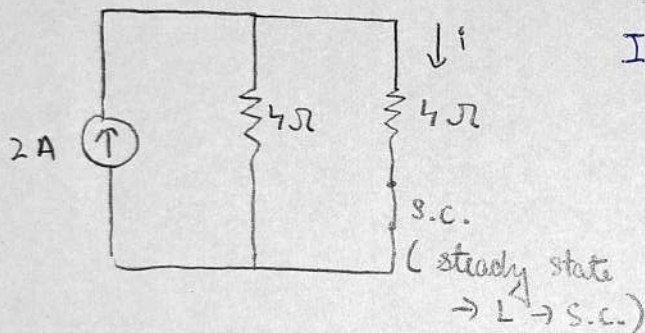
$$i(t) = -3 e^{-t/4} \text{ A}$$

[Question-4]

Obtain the inductor current for both $t < 0$ and $t > 0$ in each of the circuits a & b.

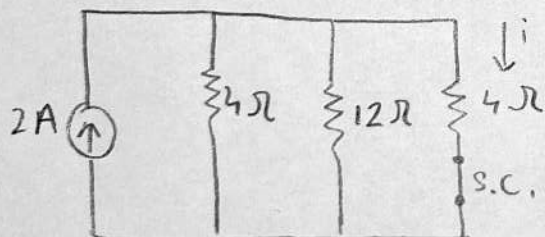


a) For $t < 0$,



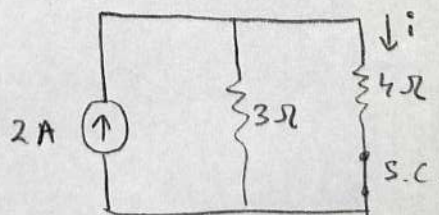
$$I_L(0^-) = I_L(0^+) = \frac{2 \times 4}{4 + 4} = 1 \text{ A}$$

For $t > 0$,



12 and 4 ohm are in parallel

$$= \frac{12 \times 4}{12 + 4} = 3\Omega$$



$$I_L(\infty) = \frac{2 \times 3}{3 + 4} = 0.85 \text{ A}$$

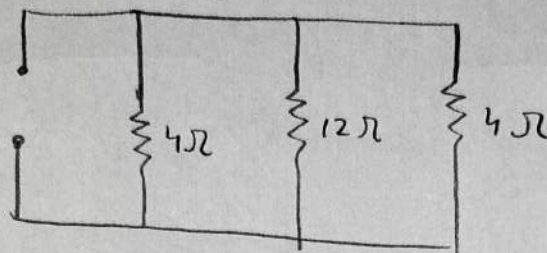
Time constant, $\tau = \frac{L}{R_{eq}}$

$$R_{eq} = (4 \parallel 12) + 4$$

$$= \frac{4 \times 12}{4 + 12} + 4$$

$$= 3 + 4$$

$R_{eq} \Rightarrow$



$$R_{eq} = 7\Omega$$

$$\therefore \tau = \frac{L}{R_{eq}} = \frac{3.5}{7} = 0.5 \text{ sec}$$

Now,

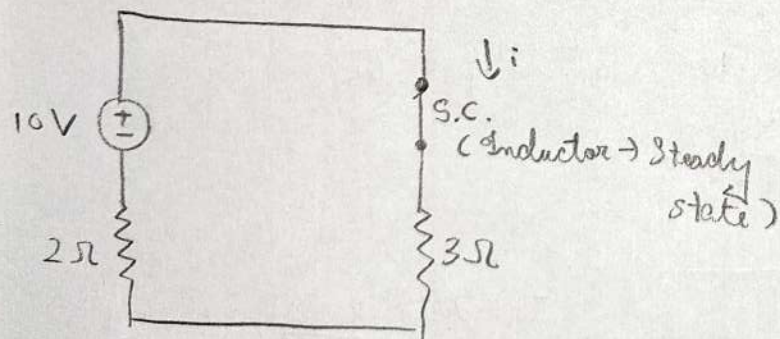
$$I(t) = I(\infty) + [I(0^+) - I(\infty)] e^{-t/\tau}$$

$$= 0.85 + [1 - 0.85] e^{-t/0.5}$$

$$I(t) = (0.85 + 0.15 e^{-2t}) \text{ A}$$

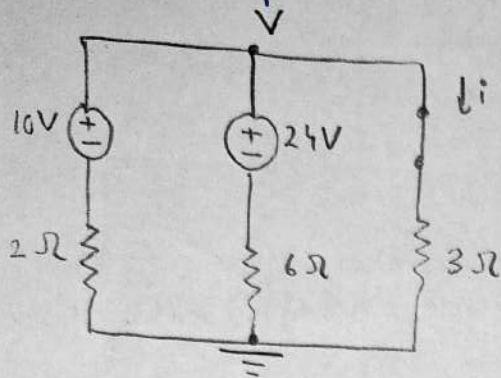
b)

At $t < 0$,



$$I_L(0^-) = I_L(0^+) = \frac{10}{2+3} = \frac{10}{5} = 2 \text{ A}$$

Now, for steady state at $t > 0$,



Applying KCL,

$$\frac{V-10}{2} + \frac{V-24}{6} + \frac{V-0}{3} = 0$$

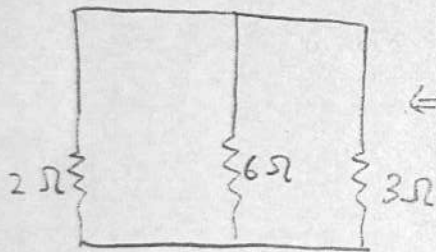
$$\frac{3V-30 + V-24 + 2V}{18} = 0$$

$$6V = 54$$

$$V = 9 \text{ Volts}$$

$$\text{Now, } I_2(\infty) = \frac{9}{3} = 3 \text{ A}$$

Calculating time constant, $\tau = L/R_{eq}$



$$\Leftarrow R_{eq} = (2 \parallel 6) + 3$$

$$= \frac{2 \times 6}{2+6} + 3$$

$$= 1.5 + 3$$

$$R_{eq} = 4.5 \Omega$$

$$\tau = L/R_{eq} = \frac{2}{4.5} = \frac{20}{45} \text{ sec}$$

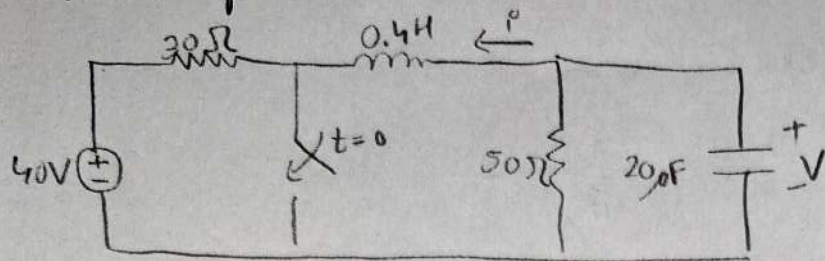
$$\therefore I(t) = I(\infty) + [I(0^+) - I(\infty)] e^{-t/\tau}$$

$$= 3 + [2 - 3] e^{-t/20/45}$$

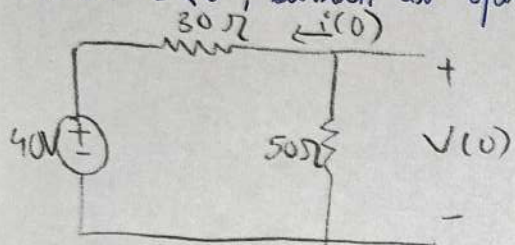
$$I(t) = 3 - e^{-45/20 t}$$

[Question-5]

Find $v(t)$ for $t > 0$ in the RLC circuit



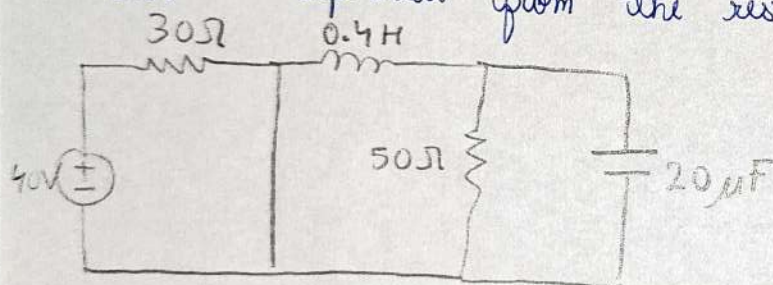
when $t < 0$, switch is open, capacitor will be open & inductor will be short



$$V(0) = \frac{50 \times 40}{50 + 30} = 25 \text{ V}$$

$$i(0) = \frac{-40}{50 + 30} = -0.5 \text{ A}$$

For $t > 0$, switch is closed. The voltage source along with 30Ω resistor is separated from the rest of the circuit



$$\alpha = \frac{1}{2RC} = 500$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = 354$$

Now, characteristic equation

$$s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$$

$$= -500 \pm 354$$

$$s_1 = -854$$

$$s_2 = -146$$

$\therefore \alpha > \omega_0$, then we have overdamped response

$$v(t) = A_1 e^{-854t} + A_2 e^{-146t} \quad \text{--- (1)}$$

At $t=0$,

$$v(0) = 25 = (A_1 + A_2)$$

$$A_2 = 25 - A_1 \quad \text{--- (2)}$$

Taking derivative of $v(t)$

$$\frac{dv(t)}{dt} = -854 A_1 e^{-854t} - 146 A_2 e^{-146t}$$

at $t=0$

$$\frac{dv(0)}{dt} = -854 A_1 - 146 A_2 = 0$$

$$854 A_1 + 146 A_2 = 0 \quad \text{--- (3)}$$

Solving (2) & (3),

$$A_1 = -5.156$$

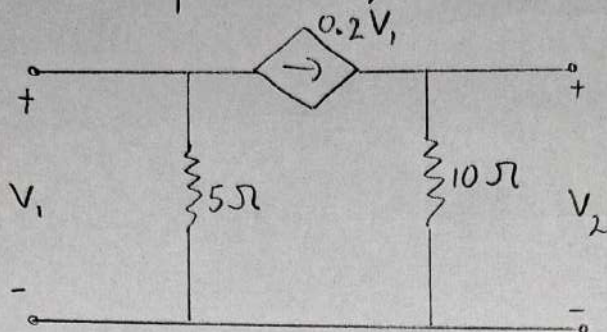
$$A_2 = 30.16$$

$v(t)$ for $t > 0$ from eq (1)

$$v(t) = -5.156 e^{-854t} + 30.16 e^{-146t} \quad V$$

[Question- 6]

Obtain the admittance parameter equivalent circuit.



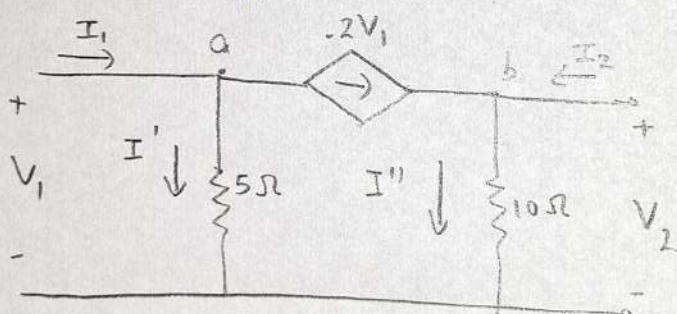
For 2-port network,

$$[I] = [Y][V]$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

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

$$I_2 = Y_{21} V_1 + Y_{22} V_2$$



We will first short V_2 and then V_1 .

Applying KCL at node a,

$$I' + 0.2V_1 = I_1$$

$$I' = I_1 - 0.2V_1$$

$$\text{Now, } V_1 = I' \times 5$$

$$V_1 = (I_1 - 0.2V_1) \times 5$$

$$V_1 = 5I_1 - V_1$$

$$I_1 = \frac{2}{5} V_1 \quad \text{--- ①}$$

Applying KCL at node b

$$0.2V_1 + I_2 = I''$$

$$\text{and } V_2 = 10(I'')$$

$$V_2 = 10(0.2V_1 + I_2)$$

$$V_2 = 2V_1 + 10I_2$$

$$10I_2 = V_2 - 2V_1$$

$$I_2 = -0.2V_1 + 0.1V_2 \quad \text{--- ②}$$

From ① & ②, we get y parameters as

$$y_{11} = 2/5 = 0.4$$

$$y_{12} = 0$$

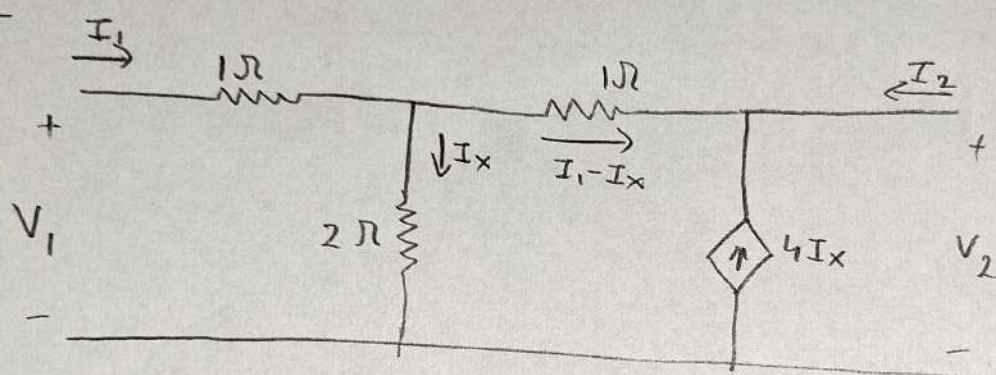
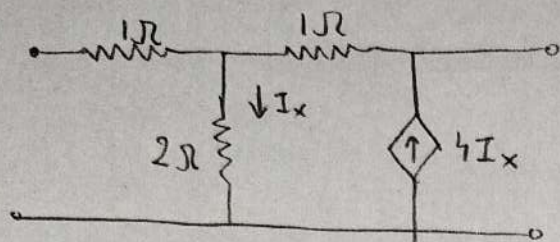
$$y_{21} = -0.2$$

$$y_{22} = 0.1$$

$$\therefore \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 2/5 & 0 \\ -0.2 & 0.1 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

[Question-7]

Find the transmission parameters.



For transmission parameters,

$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

By Kirchhoff's current law, we have

$$I_1 - I_x + 4I_x + I_2 = 0$$

$$3I_x = -(I_1 + I_2)$$

$$I_x = \frac{-(I_1 + I_2)}{3}$$

Taking a supermesh,

$$V_2 = -(I_1 - I_x) \cdot 1 + 2I_x$$

$$V_2 = -I_1 + I_x + 2I_x = -I_1 + 3I_x$$

$$V_2 = -I_1 - (I_1 + I_2)$$

$$V_2 = -I_1 - I_1 - I_2$$

$$V_2 + I_2 = -2I_1$$

$$I_1 = \frac{-1}{2} V_2 - \frac{1}{2} I_2 \quad \text{--- ①}$$

Comparing, we get $C = \frac{-1}{2} S$ and $D = \frac{1}{2}$

Now,

$$V_1 = I_1 \times 1 + 2I_x = I_1 + 2 \left[\frac{-(I_1 + I_2)}{3} \right]$$

$$V_1 = I_1 - \frac{2}{3} I_1 - \frac{2}{3} I_2$$

$$V_1 = \frac{1}{3} I_1 - \frac{2}{3} I_2$$

$$V_1 = \frac{1}{3} \left(\frac{-1}{2} V_2 - \frac{1}{2} I_2 \right) - \frac{2}{3} I_2 \quad (\text{from ①})$$

$$V_1 = \frac{-1}{6} V_2 - \frac{1}{6} I_2 - \frac{2}{3} I_2$$

$$V_1 = \frac{-1}{6} V_2 - \frac{5}{6} I_2$$

Comparing, we get $A = \frac{-1}{6}$ and $B = \frac{5}{6} \Omega$

$$\therefore A = \frac{-1}{6} S$$

$$B = \frac{5}{6} \Omega$$

C =

$$A = \frac{-1}{6}$$

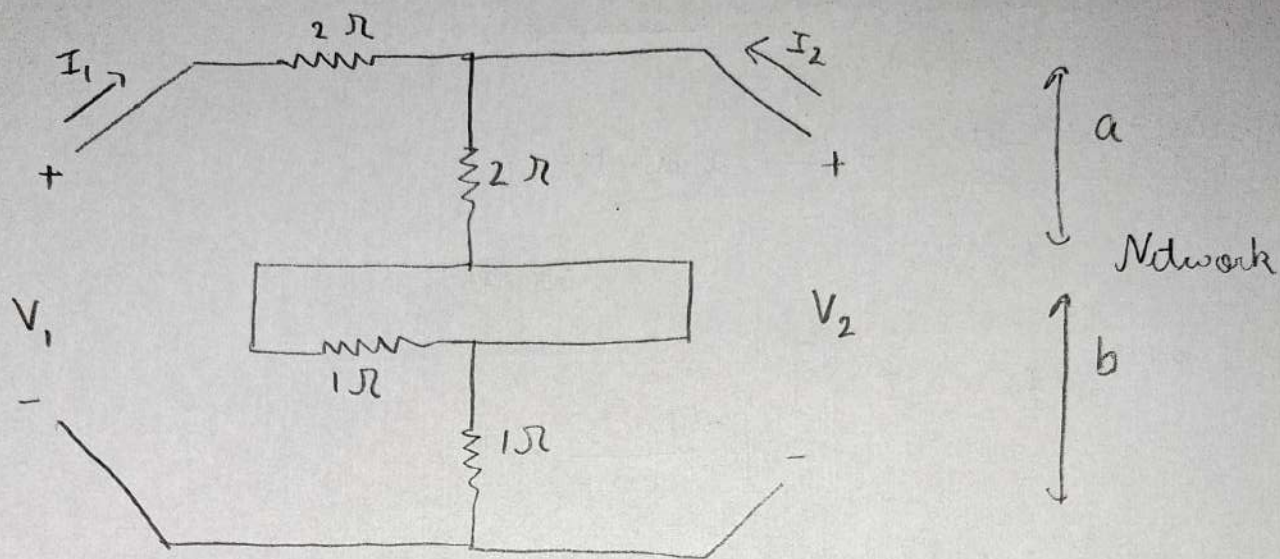
$$B = \frac{5}{6} \Omega$$

$$C = \frac{-1}{2} S$$

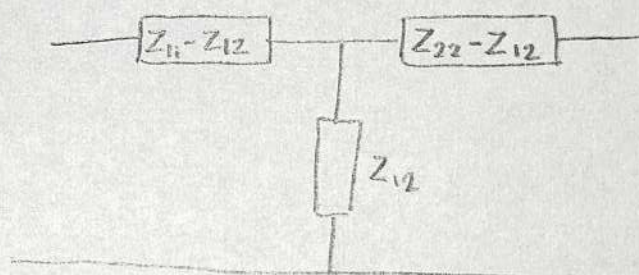
$$D = \frac{1}{2}$$

[Question-8]

Find the Y Parameter.



We know that T equivalent,



For network a,

$$Z_{11} = Z_{12} = 2$$

$$Z_{11} = 2 + 2 = 4 \Omega$$

$$Z_{12} = 2 \Omega$$

$$Z_{21} = 2 \Omega$$

$$Z_{22} = Z_{12} + 2$$

$$Z_{22} = 2 + 2 = 4 \Omega$$

$$\therefore [Z_a] = \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix} \Omega$$

For network b,

$$Z_{12} = Z_{21} = 1 \Omega$$

$$Z_{11} - Z_{12} = 1$$

$$Z_{11} = 1 + Z_{12} = 1 + 1$$

$$Z_{11} = 2 \Omega$$

$$Z_{22} - Z_{21} = 1$$

$$Z_{22} = 1 + Z_{21} = 1 + 1$$

$$Z_{22} = 1 + 1 = 2 \Omega$$

$$\therefore [Z_b] = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \Omega$$

$$\text{Now, } [Z] = [Z_a] + [Z_b]$$

(For series network)

$$= \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix} + \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$$

$$[Z] = \begin{bmatrix} 6 & 3 \\ 3 & 6 \end{bmatrix} \Omega$$

$$|Z| = 36 - 9 = 27$$

Now, by conversion

$$y_{11} = \frac{Z_{22}}{|Z|} = \frac{6}{27} = \frac{2}{9} \text{ } \Omega^{-1}$$

$$y_{12} = \frac{-Z_{12}}{|Z|} = \frac{-3}{27} = -\frac{1}{9} \text{ } \Omega^{-1}$$

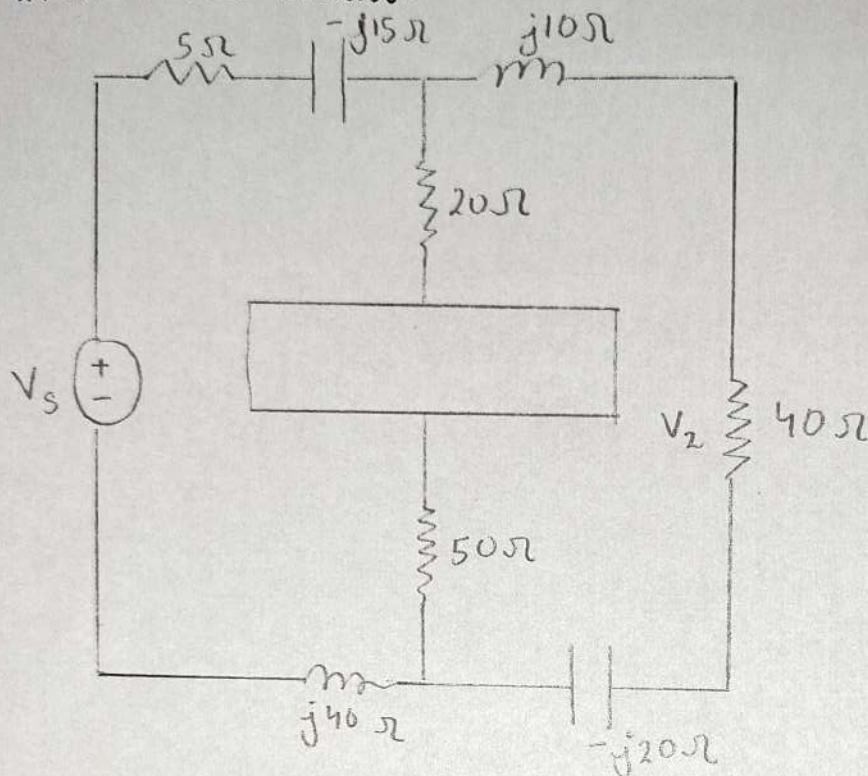
$$y_{21} = \frac{-Z_{21}}{|Z|} = \frac{-3}{27} = -\frac{1}{9} \text{ } \Omega^{-1}$$

$$y_{22} = \frac{Z_{11}}{|Z|} = \frac{6}{27} = \frac{2}{9} \text{ } \Omega^{-1}$$

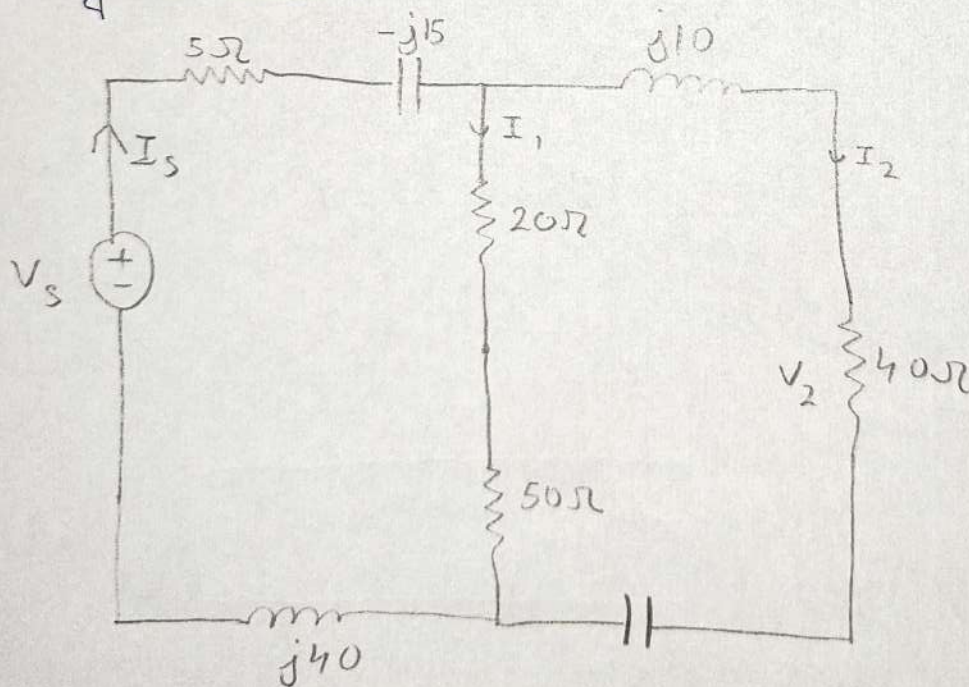
$$[Y] = \begin{bmatrix} 0.22 & -0.11 \\ -0.11 & 0.22 \end{bmatrix} \Omega^{-1}$$

[Question-9]

Find V_2/V_s in the circuit.



Redrawing the circuit,



$$\text{Now, } V_s = I_s \cdot R_{\text{total}}$$

$$R_{\text{total}} = 5 - j15 + 40j + (70 \parallel (j10 + 40 - j20))$$

$$= 5 + j25 + \frac{(40 - j10) \times 70}{110 - j10}$$

$$= 5 + 25j + \frac{2800 - 700j}{110 - j10}$$

$$= \frac{550 - 50j + 2750j + 250 + 2800 - 700j}{110 - j10}$$

$$= 30.83 + j21$$

$$V_s = (30.83 + j21) I_s$$

$$\text{Now, } I_2 = \frac{I_s \times 70}{70 + 40 - j10} = \frac{I_s \times 7}{11 - j}$$

$$V_2 = 40 I_2 = \frac{40 I_s \times 7}{11 - j}$$

$$\text{Now, } \frac{V_2}{V_s} = \frac{40 \times 7 I_s}{11 - j} \times \frac{1}{(30.83 + j21) I_s} = \frac{280}{(11 - j) \times (30.83 + j21)}$$

$$\frac{V_2}{V_s} = \frac{280}{360.13 + j200.17} = \frac{280}{412.02 \angle 29.05}$$

$$\boxed{\frac{V_2}{V_s} = 0.6799 \angle -29.05}$$