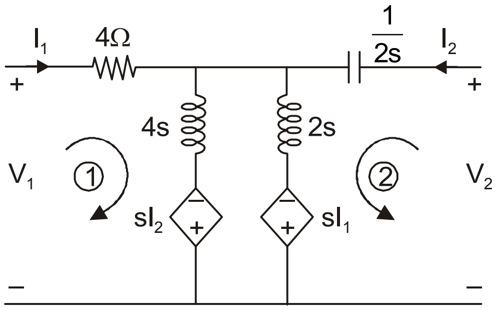
CLASSROOM PRACTICE TEST-02
NETWORK THEORY (SOLUTIONS)

ANSWER KEY

1	(a)	14	(b)	27	(a)	40	(a)	53	(b)
2	(a)	15	(b)	28	(b)	41	(b)	54	(a)
3	(b)	16	(d)	29	(c)	42	(a)	55	(a)
4	(b)	17	(a)	30	(c)	43	(c)	56	(a)
5	(c)	18	(a)	31	(d)	44	(b)	57	(c)
6	(d)	19	(b)	32	(b)	45	(c)	58	(a)
7	(b)	20	(c)	33	(d)	46	(d)	59	(c)
8	(c)	21	(d)	34	(a)	47	(a)	60	(c)
9	(b)	22	(b)	35	(d)	48	(d)	61	(d)
10	(d)	23	(c)	36	(b)	49	(c)	62	(a)
11	(d)	24	(b)	37	(a)	50	(d)	63	(b)
12	(b)	25	(c)	38	(c)	51	(a)	64	(b)
13	(c)	26	(a)	39	(a)	52	(d)	65	(c)

1. **(a)**



Loop-1 :

$$-V_1 + (4+4s)I_1 - sI_2 = 0$$

$$V_1 = (4+4s)I_1 - sI_2$$

Loop-2 :

$$-V_2 + \left(2s + \frac{1}{2s}\right)I_2 - sI_1 = 0$$

$$V_2 = -sI_1 + \left(2s + \frac{1}{2s}\right)I_2$$

From (1) and (2)

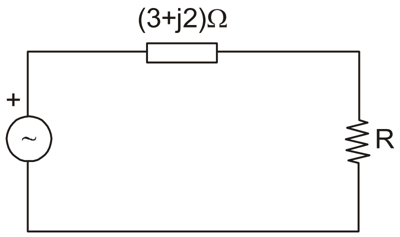
$$Z = \begin{bmatrix} (4+4s) & -s \\ -s & 2s + \frac{1}{2s} \end{bmatrix}$$

2. **(a)**

$L = L_1 + L_2 - 2M$

$X_L = X_1 + X_2 - 2X_m$

$X_L = 2 + 6 - 2 \times 3 = 2\Omega$



For maximum power transfer,

$R = |3 + j2|$

$R = 3.6\Omega$

3. **(b)**

Applying superposition therom, it is known that if all current source value are doubled, then node voltages also are doubled.

4. **(b)**

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

$\therefore$ when C increases, ω_0 will decrease.

$\text{Bandwidth} = \frac{R}{L}$ = thus constant

5. **(c)**

The Δ-connected impedance can be replaced by Y connected impedance using

$$Z_Y = \frac{Z_\Delta}{3}$$

$$Z_Y = \frac{15}{3}$$

$$= 5\Omega$$

6. **(d)**

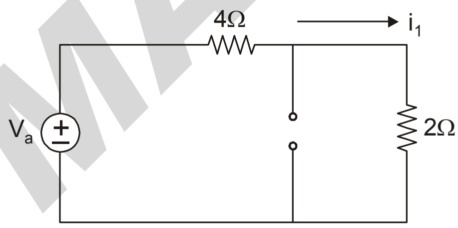
Conditions for two port reciprocal network,

Parameter	Condition
Z	$Z_{12} = Z_{21}$
Y	$Y_{12} = Y_{21}$
h	$h_{12} = -h_{21}$
ABCD	AD–BC = 1

7. **(b)**

The above problem will be solved by the use of superposition principle.

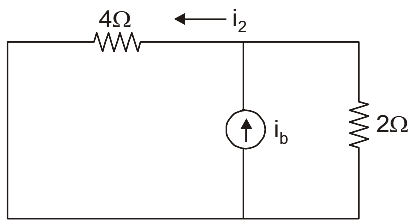
Disabling i_b



$$i_1 = \frac{v_a}{4+2} = \frac{10\sqrt{2}}{6}\cos t$$

$$= 1.67\sqrt{2}\cos t$$

Disabling V_a



$$i_2 = i_b\left(\frac{2}{2+4}\right)$$

$$= \frac{10\sqrt{2}\cos 2t}{3} = 3.33\sqrt{2}\cos 2t$$

$\therefore$ Total current through 4Ω resistor.

$$i = i_1 - i_2$$
$$= 1.67\sqrt{2}\cos t - 3.33\sqrt{2}\cos 2t$$

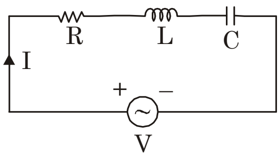
$\therefore$ R_{ms} current through resistor $\quad I = \sqrt{(1.67)^2 + (3.33)^2}$

$$= 3.72 \text{ A}$$

$\therefore$ Power loss in resistor $\quad = I^2R = (3.72)^2 \times 4$

$$= 55.5 \text{ W}$$

8. **(c)**



Total impedance of RLC series circuit is

$$Z = R + j(X_L - X_C)$$

at resonance $\quad X_L = X_C$

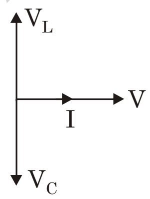
$\therefore \quad Z = R$

$\because \quad X_L = X_C$

$$I\,X_L = I\,X_C$$

$\Rightarrow \quad jI\omega L = \dfrac{I}{j\omega C}$

$$|V_L| = |V_L|$$



At resonance, RLC series circuit voltage across L and C have equal magnitude but 180º out of phase from each other.

9. **(b)**

Transients and linearity is not dependent. A circuit which is linear may have transients. Transients are there when energy storage element like inductor and capacitor are present, both are linear.

10. **(d)**

Transmission Parameters Network ‘b’

$$= \begin{bmatrix} 1 & a \\ 3 & 2 \end{bmatrix}\begin{bmatrix} 1 & a \\ 3 & 2 \end{bmatrix} = \begin{bmatrix} 1+3a & 3a \\ 9 & 3a+4 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

For reciprocity, [AD – BC] = 1

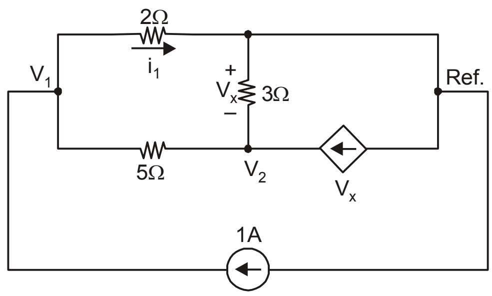
$$(3a+4)(1+3a) - (3a)\times 9 = 1$$

$$9a^2 - 12a + 4 = 1$$

$$a = 1 \text{ or } 1/3$$

11. (d)

Selecting the rightmost node as reference node, and leftmost node as V_1



Now, by nodal analysis

$$\frac{V_1 - V_2}{5} + \frac{V_1}{2} = 1$$

$$7V_1 - 2V_2 = 10 \qquad ....(1)$$

and $\frac{V_2}{3} + \frac{V_2 - V_1}{5} = V_x$

Since, $V_x = -V_2$

$$\therefore \frac{V_2}{3} + \frac{V_2 - V_1}{5} = -V_2$$

or $-3V_1 + 23V_2 = 0 \qquad ...(2)$

[eqn. (1) × 3] + [eqn. (2) × 7] gives

$$155V_2 = 30$$

or $V_2 = 0.1935V$

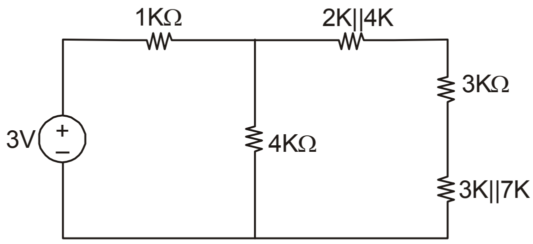
$\therefore$ $V_1 = 1.4839$ V

$$i_1 = \frac{V_1}{2} = \frac{1.4839}{2} = 0.7419\,A$$

or $i_1 = 742$ mA

12. (b)

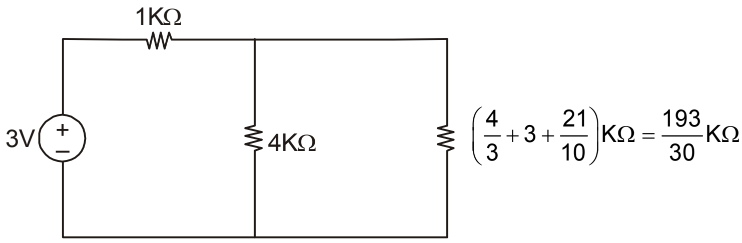
By resistor combinations, the circuit can be simplified as

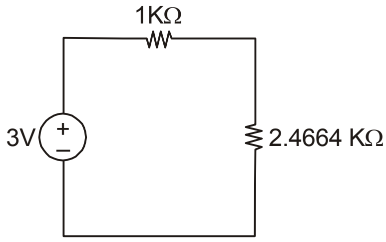


$$2K\Omega \,||\, 4K\Omega = \frac{2 \times 4}{2+4} = \frac{8}{6} = \frac{4}{3}K\Omega$$

$$3K\Omega \,||\, 7K\Omega = \frac{3 \times 7}{3+7} = \frac{21}{10}K\Omega$$

Further





Voltage across $4K\Omega$ resistor

$$V_{4\Omega} = 3\times\left(\frac{2.4664}{2.4664+1}\right)=2.1345\,V$$

$$|V_x| = \text{Voltage across } (3k \,||\, 7k)$$

Thus, $$|V_x| = (2.1345)\times\frac{\left(\frac{21}{10}\right)}{\left(\frac{4}{3}+3+\frac{21}{10}\right)}=0.6968\,v$$

OR $\quad V_x = 0.697V$

13. (c)

Let, P_1 = Power supplied by 2 sin(2t) A source

P_2 = Power supplied by 4 cos(4t) A source

P_3 = Power supplied by 4 sin(2t) A source

So, total power consumed by resistance

$$P = P_1 + P_2 + P_3 \quad \text{...(i)}$$

$$= (I_{1rms})^2 R + (I_{2rms})^2 R + (I_{3rms})^2 R$$

$$P = \left(\frac{2}{\sqrt{2}}\right)^2\times 2+\left(\frac{4}{\sqrt{2}}\right)^2\times 2+\left(\frac{4}{\sqrt{2}}\right)^2\times 2$$

$$P = 36W \quad \text{(answer is wrong)}$$

Note: I

$P = P_1 + P_2 + P_3$ is not valid because 2 sin(2t) and 4 sin(2t) are same frequency terms so first they should be added together and then power consumed should be calculated.

$$i_{(t)} = 6\sin 2t + 4\cos 4t$$

$$P = P_1 + P_2$$

$\therefore \quad P_1$ = Power supplied by 6 sin2t A

P_2 = Power supplied by 4 cos4t A

So,

$$P = (I_1 rms)^2 R + (I_2 rms)^2 R$$

$$= \left(\frac{6}{\sqrt{2}}\right)^2 \times 2 + \left(\frac{4}{\sqrt{2}}\right)^2 \times 2$$

$$P = 52W$$

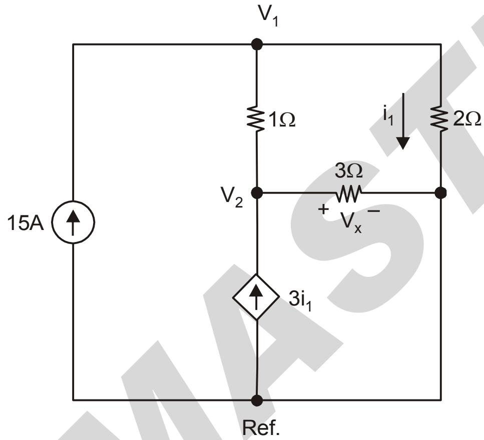
Note : II

Here superposition of power is valid $P = P_1 + P_2$

because two sinusoidal sources of different frequency are acting on a network.

14. (b)

By nodal analysis



At node 1,

$$\frac{V_1 - V_2}{1} + \frac{V_1}{2} = 15$$

or $3V_1 - 2V_2 = 30$ ....(1)

At node 2

$$\frac{V_2 - V_1}{1} + \frac{V_2}{3} = 3i_1$$

Where, $i_1 = \frac{V_1}{2}$

So, $V_2 - V_1 + \frac{V_2}{3} = \frac{3V_1}{2}$

So, $-15V_1 + 8V_2 = 0$ ...(2)

[eq. (1) × 5] + eq. (2), gives

$$-2V_2 = 150$$

or, $V_2 = -75$

∴ $V_1 = -40$ V

Power supplied by dependent source is

$$P = \frac{3V_1}{2} \times V_2 = (-60)(-75) = 4500\,W$$

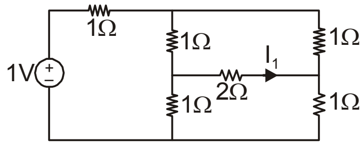
or $$P = 4.5 \text{ kW}$$

15. (b)

Using super position theorem.

For 1V source, let current through 2Ω is I_1

by short circuiting 2V source and open circuiting current source. the equivalent circuit is:

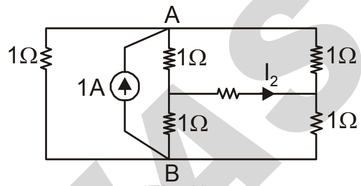


(Fig. 1)

I_1 = 0A because the bridge made by 1Ω is balanced.

for 1A source

By short circuiting the 2V and 1V source, let current flow through 2Ω is I_2

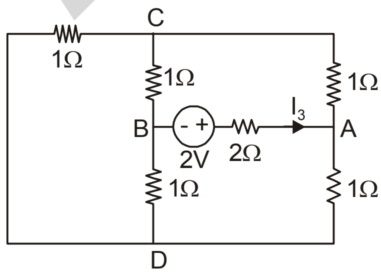


(Fig.2)

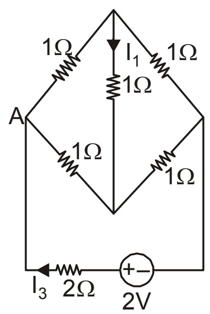
Using current to voltage source transformation the equivalent circuit will be same as fig.(1) so I_2 = 0A.

for 2V ;

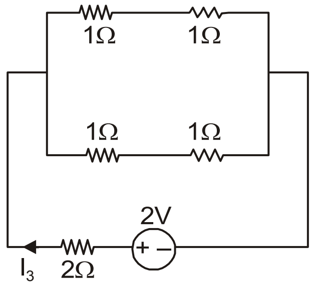
short circuiting 1V source and by open circuiting 1A current sources the equivalent circuit is



redrawing this as



I_1 = 0 (because bridge is balanced)

⇒ 

$$R_{eq} = 3\Omega$$

$$I_3 = \frac{2}{3}\text{ Amp.}$$

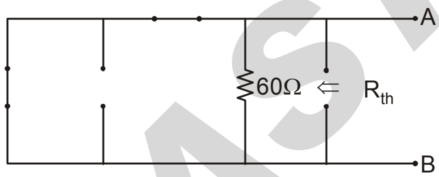
So, $I = I_1 + I_2 + I_3 = 0 + 0 + 2/3$

$$\boxed{I = \frac{2}{3}\text{ Amp.}}$$

16. (d)

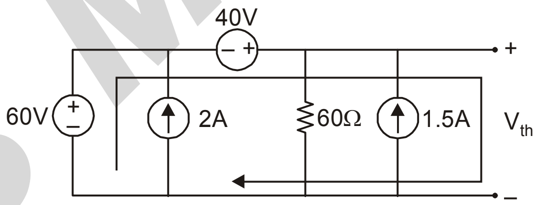
For R_{th},

Short circuiting the voltage sources and open circuiting the current sources.



$R_{th} = 60\Omega$

For V_{th},



Using KVL equation in loop

$$-60 - 40 + V_{th} = 0$$

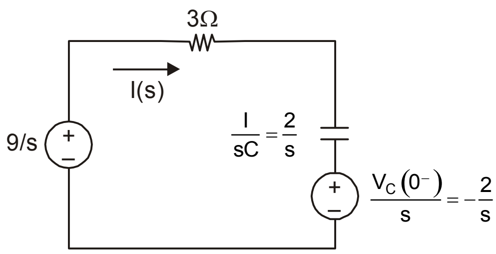
⇒ $Vth = 100\text{ V}$

So, $I_{sc} = \frac{V_{th}}{R_{th}} = \frac{100}{0} = \infty$

⇒ Norton equivalant circuit does not exist.

17. (a)

By drawing frequency-domain equivalent circuit



By KVL

$$\frac{9}{s} = 3I(s) + \frac{2I(s)}{s} - \frac{2}{s}$$

or $$I(s) = \frac{11}{3}\left(\frac{1}{s+\frac{2}{3}}\right)$$

or $$i(t) = \frac{11}{3}e^{(-2/3)t}$$

Now, $$V_C(t) = \frac{1}{C}\int_0^t i(t)\,dt - 2$$

$$= \frac{22}{3}\times\left(-\frac{3}{2}e^{(-2/3)t}\right)\Bigg|_0^t - 2$$

$$= -11e^{(-2/3)t} + 9$$

$\therefore$ $$V_C(t) = \left[9 - 11e^{(-2/3)t}\right]u(t)$$

18. (a)

$$Q_0 = 300\,\mu C \text{ at } 6\,\mu F \text{ capacitor}$$

$\therefore$ $$Q_0 = CV_0$$

$$V_0 = \frac{Q_0}{C} = \frac{300}{6} = 50V$$

The two parallel capacitors have an equivalant capacitance of $3\mu F$. Then this capacitor is in series with $6\mu F$.

Time constant, $$\tau = RC_{eq} = 20\times\left(\frac{3\times 6}{3+6}\right) = 40$$

At, $t = 0^+$

KVL gives $$V_R = \frac{300}{6} = 50V$$

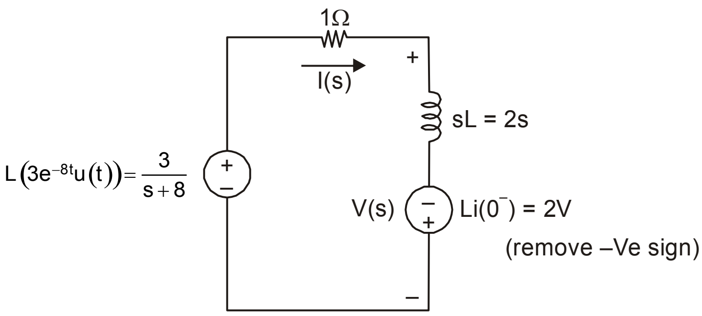
and at $t = \infty$ capacitor behave open circuit

so $$V_R \to 0$$

$\Rightarrow$ $$V_R = 50\,e^{-t/40}V$$

19. (b)

By drawing equivalent frequency-domain circuit including the initial current in the inductor.



$$I(s) = \frac{\frac{3}{s+8}+2}{1+2s} = \frac{s+9.5}{(s+8)(s+0.5)}$$

and $$V(s) = 2sI(s) - 2$$

Thus, $$V(s) = \frac{2s(s+9.5)}{(s+8)(s+0.2)} - 2$$

$$= \frac{2s-8}{(s+8)(s+0.5)} = \frac{A}{(s+8)} + \frac{B}{(s+0.5)}$$

$$A = \left(\frac{2s-8}{s+0.5}\right)_{s=-8} = 3.2$$

$$B = \left(\frac{2s-8}{s+8}\right)_{s=-0.5} = -1.2$$

Thus, $$V(s) = \frac{3.2}{s+8} - \frac{1.2}{s+0.5}$$

Taking inverse (Laplace transform)

$$V(t) = \left[3.2e^{-8t} - 1.2e^{-0.5t}\right]u(t)$$

20. (c)

$$V_C = V_0\, e^{-t/\tau} \quad \text{[discharging of capacitor]}$$

At $t = t_1$, $V_C = V_1$

$$V_1 = V_0\, e^{-t_1/\tau} \quad \text{...(i)}$$

At $t = t_2$, $V_C = V_2$

$$V_2 = V_0\, e^{-t_2/\tau} \quad \text{...(ii)}$$

equation (i) / (ii)

$$\frac{V_1}{V_2} = \frac{e^{-t_1/\tau}}{e^{-t_2/\tau}}$$

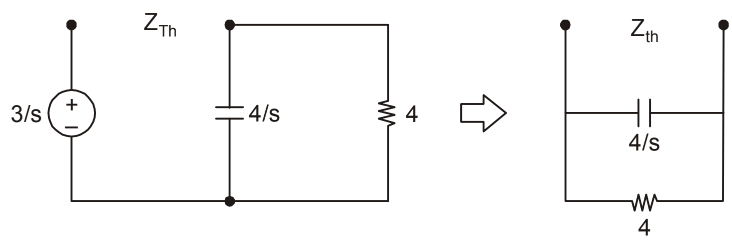
$$\Rightarrow \quad \frac{V_1}{V_2} = e^{-\frac{[t_1-t_2]}{\tau}}$$

$$\Rightarrow \quad \left(\ln\frac{V_1}{V_2}\right) = \frac{t_2-t_1}{\tau}$$

$$\Rightarrow \quad \tau = \frac{t_2-t_1}{\ln V_1 - \ln V_2}$$

21. (d)

In s-domain



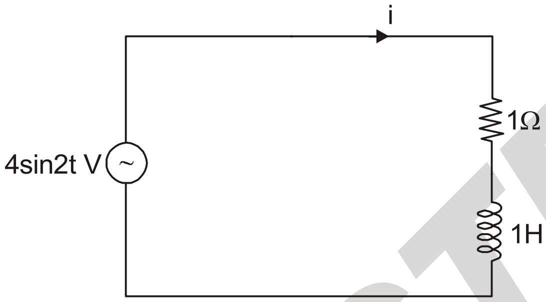
$$Z_{Th} = \frac{4}{s} \parallel 4$$

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

$$Z_{Th} = \frac{4}{s+1}$$

22. **(b)**

s $\rightarrow$ 1 for long time i.e., steady state



$V_s = 4\sin 2t\,;\ \omega = 2$

$\bar{V}_s = 2\sqrt{2}\angle 0°$

$\bar{Z} = 1 + j2 = 2.24\angle 63.4°\ \Omega$

$\bar{I} = \frac{\bar{V}_s}{\bar{Z}} = \underbrace{1.26}_{(rms)}\ \angle -63.4°$ Amp

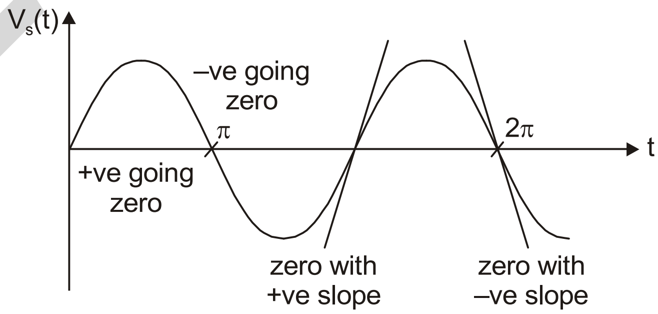
$i(t) = 1.26\sqrt{2}\sin(2t - 63.4°)$

$i(t) = 1.78\sin(2t - 63.4°)$ Amp

$S \rightarrow 1$ for long time,

$V_s(t)$ = 4sin2t Volt

i(t) = 1.78 sin(2t – 63.4°) Amp



$V_s(t) = V_m \sin\omega t = V_m \sin\theta$

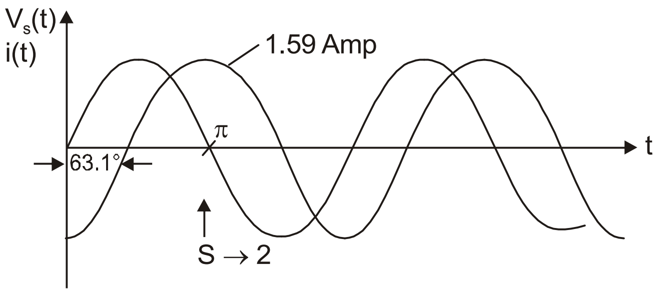
$V_s = 0\ \Rightarrow \theta = 0,\ \pi$ (zero with –ve slope)

So, $V_s(t) = \sin 2t\ \Rightarrow 2t = \pi, t = \frac{\pi}{2}$

So, at 2t = π;   i(t) = 1.78 sin(2t – 63.4°)

$i(t) = 1.78\sin(\pi - 63.4°)$

i(t) = 1.59 Amp

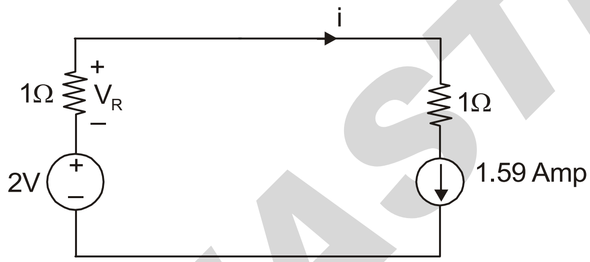


At the instance, $S \to 2$ inductor current, i = 1.59 Amp.

$S \to 2$, t = 0

$i(0^-)$ = 1.59 Amp

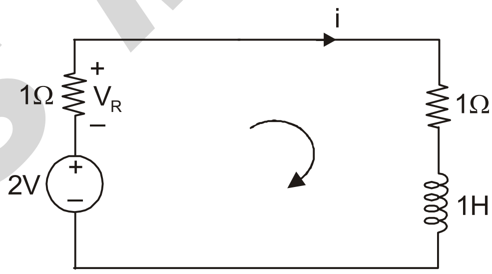
For t = 0^+, $S \to 2$, L $\to$ current source



$V_R = -i$

$V_R(0^+) = -i(0^+) = -1.59$ Volts

For t > 0, $S \to 2$



$$-2 + i + i + \frac{di}{dt} = 0$$

$$\frac{di}{dt} = 2[1 - i(t)]$$

At t = 0^+

$$\frac{di}{dt}(0^+) = 2\left[1 - i(0^+)\right] = -1.18 \text{ A / sec}$$

As $V_R = -i$

$$\frac{d}{dt}V_R(0^+) = -\frac{d}{dt}i(0^+) = 1.18 \text{ V / sec}$$

23. (c)

$$X_C = \frac{1}{2\pi fC}$$

When $X_C = 0$, $Z_1 = R_1$ $\quad I_1 = \frac{V}{R_1} \quad \theta_1 = \tan^{-1}\left(\frac{1}{\omega cR}\right) = \tan^{-1}\left(\frac{-X_C}{R}\right) = 0$

$$\vec{I} = \vec{I}_1 + \vec{I}_2$$

as, $C\downarrow \quad X_C \uparrow$ $\quad Z_1 = \sqrt{R^2 + X_c^2}\uparrow \Rightarrow I_1 \downarrow$ and

$$\theta_1 = \tan^{-1}\left(-\frac{X_C}{R}\right)\uparrow_{se}$$

& I_2 = constant

$$I = I_1 + I_2$$

as $I_1\downarrow \quad I\downarrow$

at $X_C = \infty \Rightarrow C = 0$ $\quad I_1 = 0 \quad I = I_2$

$$\theta_1 = -90°$$

24. (b)

Since the current $V_x/4000\,A$ passes through $2k\Omega$ and 4V source and no current in $3k\Omega$ resistor. The KVL equation

$$4 + (2\times10^3)\left(\frac{V_x}{4000}\right) + 3\times10^3\times(0) - V_x = 0$$

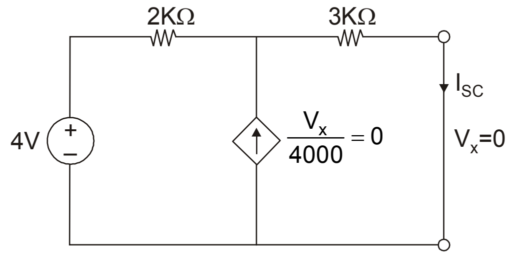
or $\quad 4 + \frac{V_x}{2} - V_x = 0 \quad \therefore V_x = 8V$

or $\quad V_x = V_{Th}$

To find R_{Th}

Due to the presence of dependent source R_{Th} cannot be obtained directly. So it is obatiend by finding short circuit current I_{SC}, then

$$R_{Th} = \frac{V_{OC}}{I_{SC}}$$

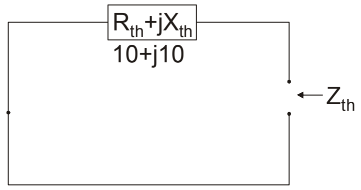


Here, $\quad I_{SC} = \frac{4}{(2+3)K} = 0.8\times10^{-3}\,A$

Therefore, $\quad R_{Th} = \frac{V_{OC}}{I_{SC}} = \frac{8}{0.8\times10^{-3}} = 10K\Omega$

25. (c)

For Z_{th} (equivalant thevenin impedance across load.



$$Z_{th} = 10 + j10 \quad \text{...(i)}$$

for maximum power consumed in the load, when X_L is variable

$$\frac{dP_L}{dX_C} = 0$$

$$\therefore \quad X_C = -X_{th}$$

$$\therefore \quad X_C = -j10\Omega$$

therefore load impedance $Z_L = 10 - j10$ from equation (i)

so maximum load power $P_{max} = (I_{max})^2 R_L$ ...(ii)

when $R_L = 10\Omega$ & $X_C = 10\Omega$

then $I = I_{max}$

$$I = \frac{V_{th}}{10 + j10 + 10 - jX_C}$$

$$I = I_{max} = \frac{100\angle 0°}{10 + j10 + 10 - j10}$$

$$= \frac{100}{20} = 5A$$

so, from equation (ii)

$$P_{max} = (5)^2 \times 10$$

$$P_{max} = 250 \text{ W}$$

Note : We can use,

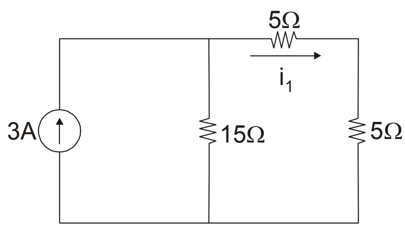
$$P_{max} = \frac{V_{th}^2}{4R_L} \text{ here, it is also valid.}$$

but it is not recommended to use $\frac{V_{th}^2}{4R_L}$ when impedance is given.

26. (a)

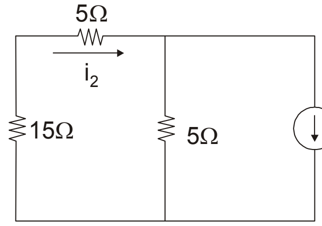
By super position theorem

Using 3A current source only :



$$i_1 = 3 \times \left(\frac{15}{15 + 10}\right) = 1.8\,A$$

Using 5A current source only :



$\Rightarrow$ $$i_2 = \left(\frac{5}{20+5}\right) \times 5 = 1A$$

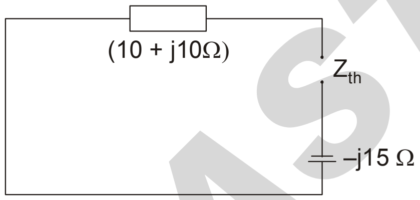
Therefore,

$$\frac{i_2}{i_x} \times 100 = \frac{1}{(1.8+1)} \times 100 = 35.714\%$$

27. (a)

Since R_L is variable

Z_{th} across R_L is by short circuiting $100\angle 0°$ V source, we get



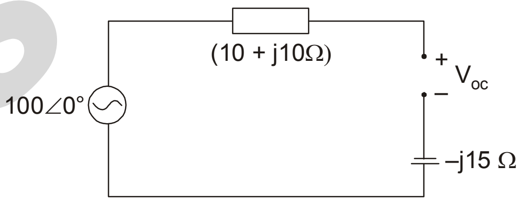
$$Zth = 10 + j10 - j15$$

$$Zth = 10 - j5$$

so, $$R_L = |Z_{th}| = \sqrt{10^2+5^2} = 5\sqrt{5}\,\Omega$$

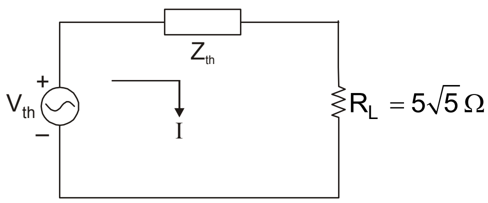
For V_{th}

open circuit voltage across terminal of R_L is



$$V_{oc} = 100\angle 0° \quad \text{(as no current flow in the circuit)}$$

so, Thevenin equivalant circuit is



if, $R_L = 5\sqrt{5}\,\Omega$ then I = I_{max} and corrosponding power consumed in R_L will be maximum

so, $$P_{max} = I_{max}^2 R_L$$

$$= \frac{(100\angle 0°)^2}{(Z_{th}+R_L)^2} \times R_L$$

$$\because \quad I = I_{max} = \frac{V_{th}}{Z_{th} + R}$$

$$= \frac{(100)^2}{(10 - j5 + 5\sqrt{5})^2} \times (5\sqrt{5})$$

$$= \frac{(100)^2}{|21.18 - j5|^2} \times (5\sqrt{5})$$

$$= \frac{(100)^2}{(21.76)^2} \times 5\sqrt{5}$$

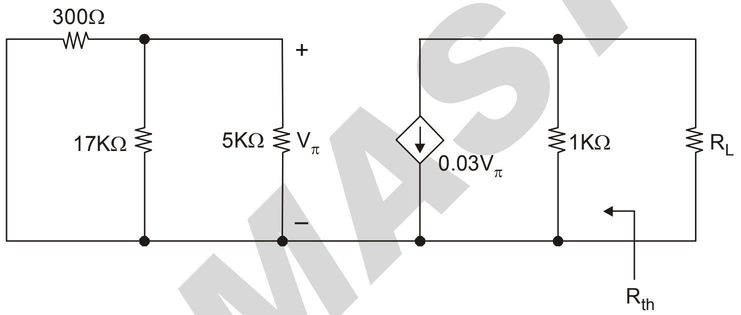
$$P_{max} = 236 \text{ W}$$

Note : If impedance is given don't use

$$P_{max} = \frac{V_{th}^2}{4R_L}$$

28. **(b)**

To find R_{Th}



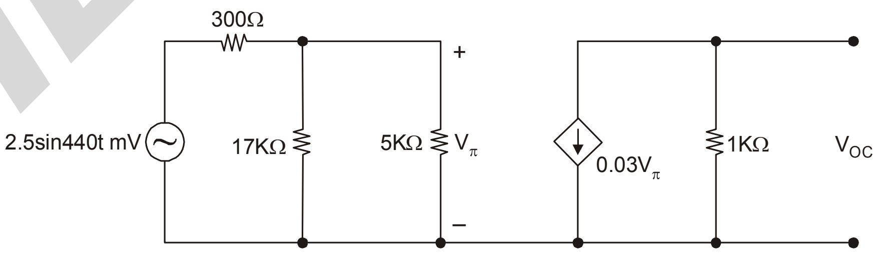
Here, $V_\pi = 0 \Rightarrow 0.03V_\pi = 0$

$$\therefore \quad R_{Th} = 1K\Omega$$

Thus for maximum power transfer to R_L.

$$R_L = R_{Th} = 1K\Omega$$

To find $V_{Th} = V_{OC}$



$$V_{OC} = -0.03V_\pi(1000) = -30V_\pi$$

where $\quad V_\pi = \left(2.5 \times 10^{-3} \sin 440t\right) \times \left(\frac{3864}{3864 + 300}\right)$

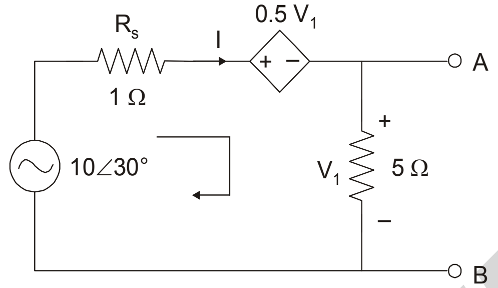
Note : $17K\Omega \,||\, 5K\Omega = 3.864K\Omega$

Now, $\quad V_{OC} = V_{Th} = -30V_\pi = -30 \times 2.5 \times 10^{-3} \times \frac{3864}{(3864 + 300)} \sin 440t$

$$= -69.596 \sin 440t \, mV$$

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = 1.211 \sin^2 440t \, \mu W$$
$$= 1.211 \, \mu W$$

29. (c)



let the current in the circuit is I

$V_1 = 5I \Rightarrow V_{OC} = V_1 = 5I$ ...(i)

using KVL in loop, we get,

$10\angle 30^\circ - I \times 1 - 0.5(5I) - 5I = 0$

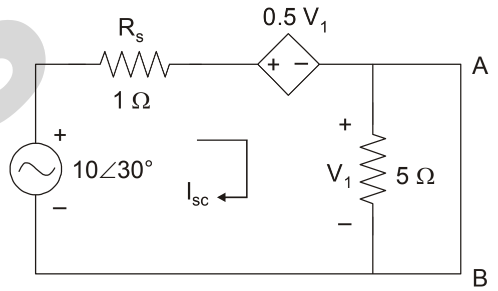
$\Rightarrow \quad I = \dfrac{10\angle 30^\circ}{8.5}$ ...(ii)

from equation (i) and equation (ii)

$$V_{OC} = 5I = \frac{10\angle 30^\circ}{1.7} \text{ volt} \quad ...(iii)$$

for I_{sc}

Short cricuiting the terminal AB,



due to short circuit,

$$V_1 = 0 \quad ...(iv)$$

using KVL in the loop

$$10\angle 30^\circ = I_{SC} R_S \quad ...(v)$$

$$\Rightarrow \quad I_{sc} = \frac{10\angle 30^\circ}{1} = 10\angle 30^\circ \quad ...(vi)$$

$$\because \quad Z_{th} = \frac{V_{OC}}{I_{sc}} = \frac{\frac{10\angle 30^\circ}{1.7}}{10\angle 30^\circ} = 0.588\,\Omega$$

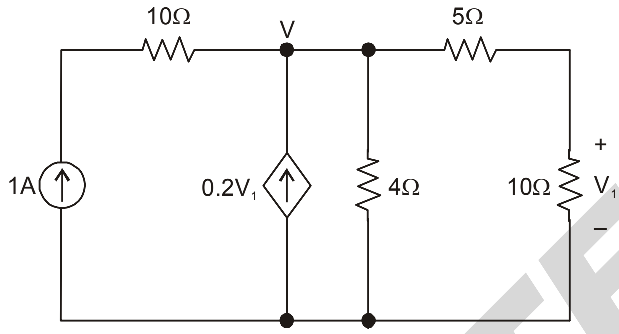
if $R_s = 0\,\Omega$ then $Z_{th} = 0$ because from equation (v)

$$I_{sC} = \frac{10\angle 30^\circ}{R_s} = \frac{10\angle 30^\circ}{0} = \infty$$

$$\Rightarrow \quad Zth = \frac{V_{oc}}{I_{sc}} = \frac{V_{oc}}{\infty} = 0\,\Omega$$

30. **(c)**

By connecting 1A current source at input



By KCL

$$\frac{V}{4} + \frac{V}{15} = 1 + 0.2V_1$$

or $$\frac{V}{4} + \frac{V}{15} = 1 + 0.2\left(\frac{V}{15}\right) \times 10$$

or $$\frac{V}{4} + \frac{V}{15} - \frac{2V}{15} = 1$$

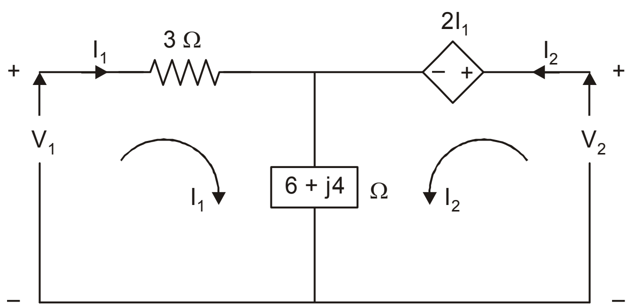
or $$\frac{11}{60}V = 1 \quad \Rightarrow \quad V = \frac{60}{11}$$

Voltage across 1A current source

$$V_{in} = V + 1 \times 10 = \frac{60}{11} + 10 = \frac{170}{11}$$

$$\therefore \quad Z_{in} = \frac{V_{in}}{1} = \frac{170}{11}\Omega$$

31. **(d)**



KVL eq. in loop (i)

$$V_1 = 3I_1 + (6 + j4)I_1 + (6 + j4)I_2$$

$$V_1 = (9 + j4)I_1 + (6 + j4)I_2 \quad \text{...(i)}$$

KVL equation in loop (ii),

$$-V_2 + 2I_1 + (6+j4)I_2 + (6+j4)I_1 = 0$$

$$\Rightarrow \quad V_2 = (8+j4)I_1 + (6+j4)I_2 \quad \text{...(ii)}$$

since,

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \quad \text{...(iii)}$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2 \quad \text{...(iv)}$$

comparing (i) with (iii) and eq. (ii) with eq. (iv) we get,

$$[z] = \begin{bmatrix} 9+j4 & 6+j4 \\ 8+j4 & 6+j4 \end{bmatrix}$$

32. **(b)**

By definition of y-parameters :

$$I_1 = 0.1V_1 - 0.0025V_2 \quad \text{...(1)}$$

$$I_2 = -8V_1 + 0.05V_2 \quad \text{...(2)}$$

$$\frac{1-V_1}{2} = I_1 \quad \text{...(3)}$$

and

$$I_2 = \frac{-V_2}{5} \quad \text{...(4)}$$

From eqn. (4) and (2)

$$\frac{-V_2}{5} = -8V_1 + 0.05V_2$$

$$\therefore \quad 8V_1 = 0.05V_2 + \frac{V_2}{5}$$

or

$$8V_1 = 0.25V_2$$

$$\therefore \quad \frac{V_2}{V_1} = \frac{8}{0.25}$$

or

$$\boxed{\frac{V_2}{V_1} = 32}$$

33. **(d)**

- Since I_1 and I_2 are not independent in circuit (I) the Z parameter can not be found.
- Y parameter of circuit I:

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

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

with

$$V_2 = 0, \quad I_1 = -I_2 \text{ and } V_1 = I_1 R$$

$$\left.\frac{I_1}{V_1}\right|_{V_2=0} = Y_{11} = \frac{1}{R} \text{ and } \left.\frac{I_2}{V_1}\right|_{V_2=0} = -\frac{1}{R} = Y_{21}$$

For circuit II,

- Since V_1 and V_2 are not independent, the Y parameters can not be found.
- For Z parameter (Circuit II):

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

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

Put $I_2 = 0$

$$V_1 = V_2 \quad \text{and} \quad V_1 = I_1R \quad \text{...(i)}$$

$$\left.\frac{V_1}{I_1}\right|_{I_2=0} = R = Z_{11} \quad \text{from eq. (i)}$$

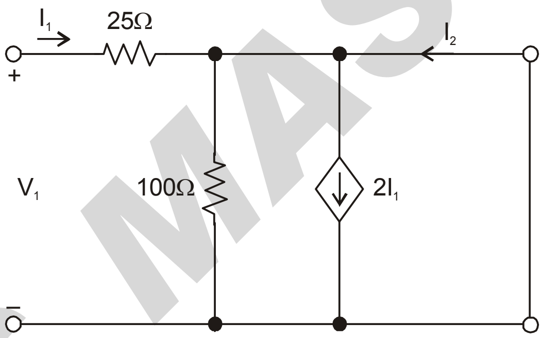
$$\left.\frac{V_2}{I_1}\right|_{I_2=0} = \left.\frac{V_1}{I_1}\right|_{I_2=0} = Z_{11} = Z_{21} = R$$

34. (a)

By definition,

$$y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0}$$

To obtain y_{21}



By KCL

$$I_1 + I_2 = 2I_1$$

or $$I_2 = I_1$$

$$\frac{I_2}{V_1} = \frac{I_1}{V_1} = \frac{1}{25} = 0.045$$

Alternatively :

$$I_1 = \frac{V_1 - V_2}{25} = 0.04V_1 - 0.04V_2 \quad \text{...(1)}$$

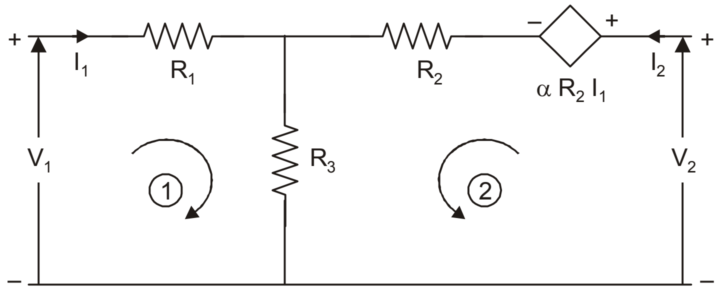
and $$I_1 + I_2 = \frac{V_2}{100} + 2I_1$$

or $$I_2 = \frac{V_2}{100} + I_1 = 0.01V_2 + 0.04V_1 - 0.04V_2$$

or $$I_2 = 0.04V_1 - 0.03V_2$$

$\therefore$ $$y_{21} = 0.04$$

35. (d)



by KVL in loop (i),

$$V_1 = (R_1 + R_3)I_1 + R_3 I_2 \quad ...(i)$$

by KVL in loop (ii),

$$V_2 = (\alpha R_2 + R_3)I_1 + (R_2 + R_3)I_2 \quad ...(ii)$$

On comparing equation (i) and (ii) with standard equation of Z parameter, we have

$$Z_{11} = R_1 + R_3 \quad ...(iii)$$

$$Z_{12} = R_3 \quad ...(iv)$$

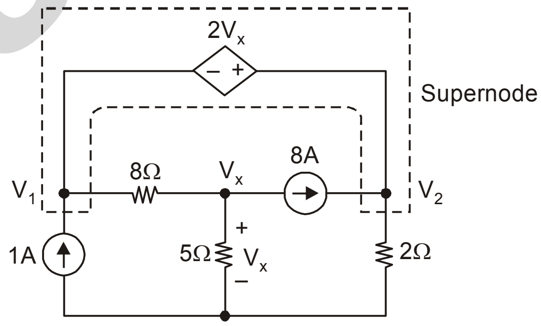
$$Z_{21} = \alpha R_2 + R_3 \quad ...(v)$$

$$Z_{22} = R_2 + R_3$$

as,

- $Z_{12} \neq Z_{21} \Rightarrow$ Network is not reciprocal
- $Z_{11} \neq Z_{22} \Rightarrow$ Network is not symmetrical
- $Z_{21} = \alpha R_2 + Z_{12}$ (option c is wrong) – from eq. (iv) and (v)
- $Z_{11} - Z_{12} = R_1$ (option d is true) – from eq. (iii) and (iv)

36. (b)



By KCL

$$\frac{V_1 - V_x}{8} + \frac{V_2}{2} = 1 + 8$$

or, $V_1 - V_x + 4V_2 = 72 \quad ....(1)$

and $\frac{V_x - V_1}{8} + \frac{V_x}{5} = -8$

or $-5V_1 + 13V_x = -320 \quad .....(2)$

and from super node

$$V_2 - V_1 = 2V_x$$

or, $V_1 - V_2 + 2V_x = 0$ ...(3)

From eqn. (2),

$$V_1 = \frac{13V_x + 320}{5}$$

Substituting in eqn. (1) and (3)

$$\frac{13V_x + 320}{5} - V_x + 4V_2 = 72$$

or $8V_x + 20V_2 = 40$ ....(4)

and $\frac{13V_x + 320}{5} - V_2 + 2V_x = 0$

or $23V_x - 5V_2 = -320$ ..(5)

Eq. (4) $8V_x + 20V_2 = 40$

+ Eq. (5)×4 $92V_x - 20V_2 = -1280$

$$100V_x = -1240$$

or $V_x = -12.4$ V

$\therefore$ $V_1 = \frac{13V_x + 320}{5} = \frac{13 \times (-12.4) + 320}{5}$

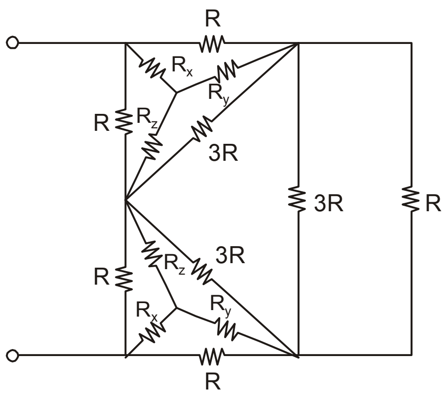
or $V_1 = 31.76$V

Therefore power supplied by 1A source

$$P = (V_1) \times 1 = 31.76\text{W}$$

37. (a)

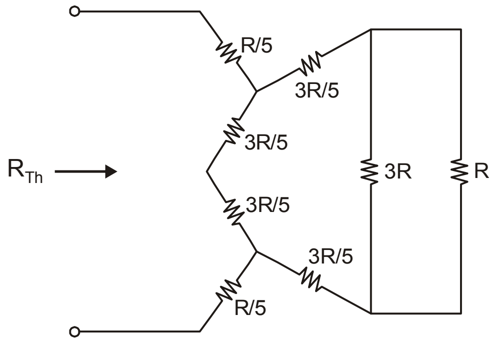
By $Y - \Delta$ conversion

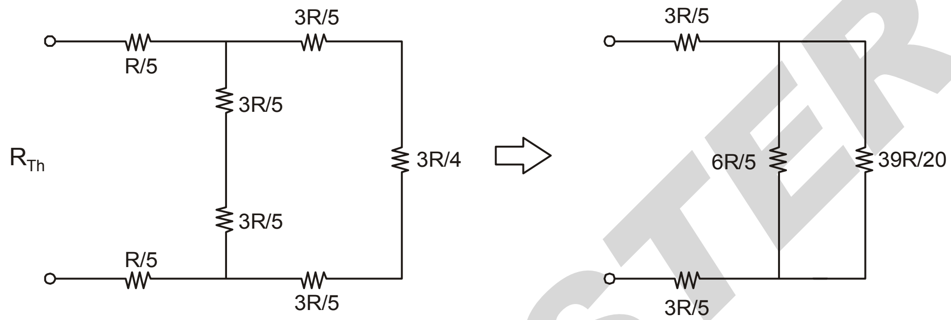


$$R_x = \frac{R \times R}{R + R + 3R} = \frac{R}{5}$$

$$R_y = R_Z = \frac{R \times 3R}{R + R + 3R} = \frac{3R}{5}$$

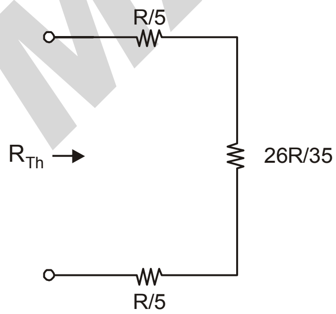
Thus,





$$\frac{6R}{5} \| \frac{39}{20}R = \frac{\frac{6R}{5} \times \frac{39}{20}R}{\frac{6R}{5} + \frac{39}{20}R} = \frac{26}{35}R$$

The circuit reduces as



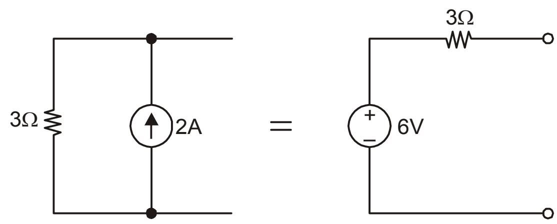
$$R_{Th} = \frac{R}{5} + \frac{26}{35}R + \frac{R}{5}$$

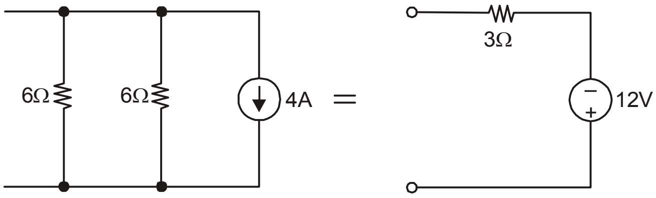
$$R_{Th} = \frac{40}{35}R = 1.1428R$$

or $\quad R_{Th} = 1.143\Omega$

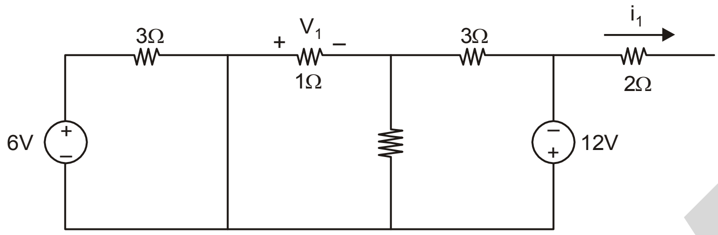
38. (c)

By source transformation



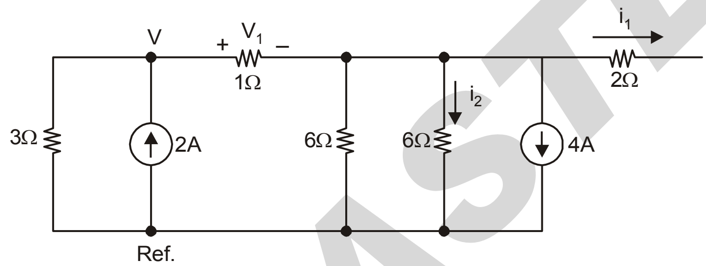


Thus,



$$V_1 = \left(\frac{1}{1+3+3}\right)\times 18 = \frac{18}{7} = 2.571\text{V}$$

Now, in the original circuit



By nodal analysis

$$\frac{V}{3} - 2 + \frac{V_1}{1} = 0$$

or $\frac{V}{3} - 2 + 2.571 = 0$

or $V = -1.7143$ Volts

Voltage across 6Ω resistor $= V - V_1 = -4.2853$ Volts

$\therefore \quad i_2 = \frac{-4.2853}{6} = -0.7142\text{A}$

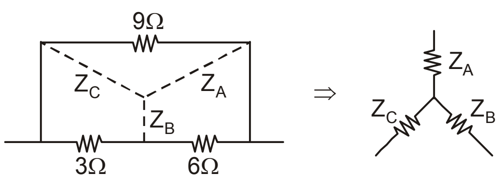
Alternatively:

$$i_2 = \left(\frac{18}{7} - 4\right)\times\frac{1}{2} = -0.7142\text{A}$$

Since, $i_1 = 0$

$\therefore \quad i_1 + i_2 = -0.7142$ A

39. (a)

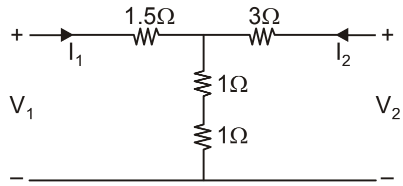


Using conversion delta star

$$Z_A = \frac{9\times 6}{9+6+3} \qquad Z_C = \frac{9\times 3}{9+6+3} \qquad Z_B = \frac{6\times 3}{9+6+3}$$

$Z_A = 3\Omega$ $\quad$ $Z_C = 1.5\Omega$ $\quad$ $Z_B = 1$

The given circuit become as



Using KVL equation at input loop

$V_1 = (1.5+2)I_1 + 2I_2$ ...(1)

Using KVL equation at output loop

$V_2 = (3+1+1)\, I_2 + 2I_1$ ...(2)

Since,

$V_1 = Z_{11}\, I_1 + Z_{12}\, I_2$ ...(3)

& $\quad V_2 = Z_{21}\, I_1 + Z_{22}\, I_2$ ...(4)

On comparing equation (1) with (3) and equation (2) with (4)

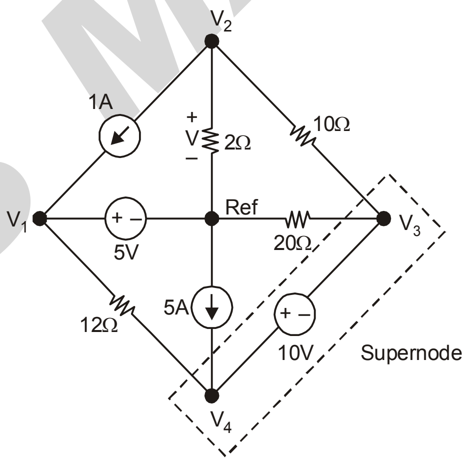
$Z_{11} = 3.5\Omega$

$Z_{12} = 2\Omega$

$Z_{21} = 5\Omega$

$Z_{22} = 2\Omega$

40. (a)



By inspection, $V_1 =$ 5 V ....(1)

Nodes 3 and 4 from a super node. Thus by KCL

$$\frac{V_2}{2} + \frac{V_2 - V_3}{10} = -1$$

or $\quad 6V_2 - V_3 = -10$ ....(2)

$$\frac{V_3 - V_2}{10} + \frac{V_3}{20} + \frac{V_4 - V_1}{12} = 5$$

or $-5V_1 - 6V_2 + 9V_3 + 5V_4 = 300$

or $-6V_2 + 9V_3 + 5V_4 = 325$ ...(3)

Also at supernode,

$V_4 - V_3 = 10$ ...(4)

From eqn. (2), $V_3 = 6V_2 + 10$ ...(5)

From eqn. (4), $V_4 = 10 + V_3$

$= 10 + 6V_2 + 10$

$= 6V_2 + 20$ ...(6)

Substituting V_3 and V_4 in Eqn. (3)

$$-6V_2 + 9(6V_2 + 10) + 5(6V_2 + 20) = 325$$

or $78V_2 = 135$

or $V_2 = 1.73077V$

Since, $V_2 = V$

So, $V = 1.731$ V [upto three decimal places]

41. (b)

Thereninn equivalant circuit across 10Ω in series with 100V battery are drawn in figure 1 and figure (2)

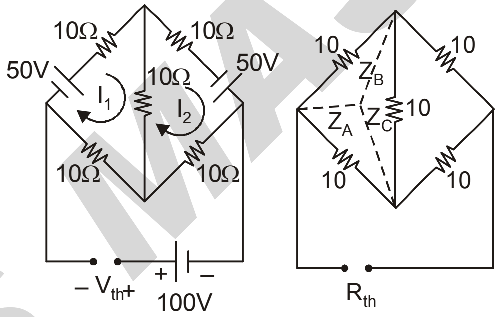


Figure 1 **Figure 2**

In figure (1) by applying KVL equation in loop (1) and loop (2)

We get

$$50 = 30\,I_1 - 10\,I_2 \quad ...(1)$$

and

$$50 = -10\,I_1 + 30\,I_2 \quad ...(2)$$

On solving equation (1) and (2)

$$I_1 = I_2 = 2.5A$$

For the mesh containing V_{th} we have

$$100 - V_{th} + 10(I_1) + 10(I_2) = 0$$

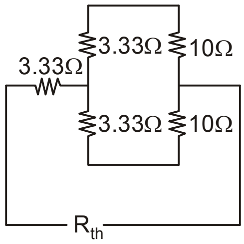
or $V_{th} = 100 + 10(2.5) + 10(2.5)$

$V_{th} = 150$ V

From figure (2) we get

Using $\Delta - Y$ conversion

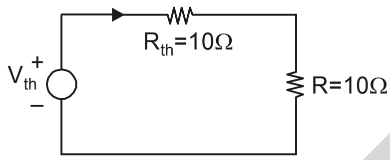
$$Z_A = Z_B = Z_C = \frac{10 \times 10}{10 + 10 + 10} = \frac{10}{3}\Omega$$



$$R_{th} = 3.33 + (10+3.33) \parallel (10+3.33)\Omega = 10\Omega$$

Alternatively: $R_{th} = 10\Omega$ as bridge is balanced

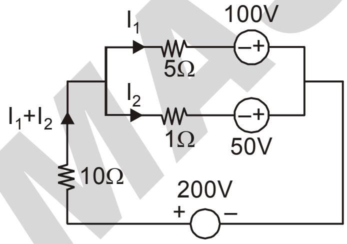
So



$$I = \frac{V_{th}}{R_{th}+R} = \frac{150}{10+10} = 7.5\text{A}$$

42. **(a)**

Given circuit is



Applying KVL to the loops, for the assumed directions of current flow we obtain.

$$5I_1 - 100 + 50 - I_2 = 0$$

& $$-200 + 10(I_1 + I_2) + 5\, I_1 - 100 = 0$$

Thus, $5I_1 - I_2 = 50$ and $15\, I_1 + 10\, I_2 = 300$

on solving

$$I_1 = 12.3077 \text{ A}, \; I_2 = 11.538 \text{ A}$$

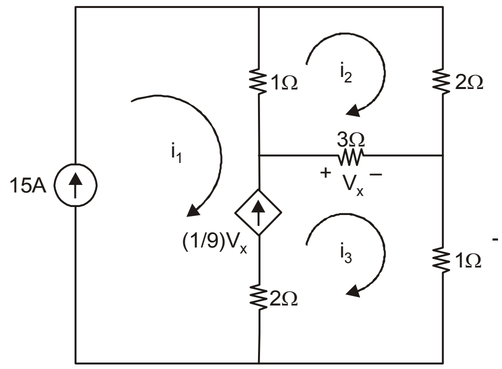
$P_{50V} = I_2 \times 50 = 11.538 \times 50 = 576.9$ W (supplied)

$P_{100V} = I \times 100 = 1230.77 \times 100 = 1230.77$ W (supplied)

$P_{200V} = (I_1 + I_2)200 = 23.8457 \times 200 = 4769.14$ W (supplied)

43. (c)

Using mesh analysis



In mesh 3; ....(1)

$$\frac{V_x}{9} = i_3 - i_1$$

As $\quad V_x = (i_3 - i_2)3$

$$\therefore -i_1 + \frac{i_2}{3} + \frac{2i_3}{3} = 0$$

or $\quad i_2 + 2i_3 = 45$ (using i_1 = 15A) ....(2)

In mesh 2

$$(i_2 - i_1)\times 1 + 2i_2 + 3(i_2 - i_3) = 0$$

or $\quad 6i_2 - 3i_3 = 15$

or $\quad 2i_2 - i_3 = 5$ .....(3)

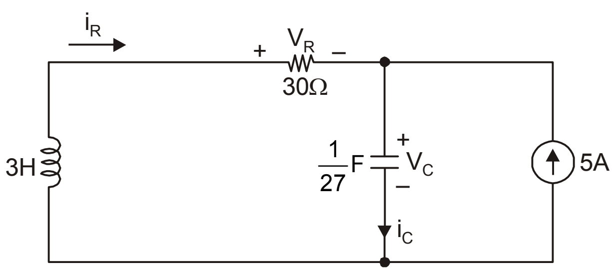
Solving (2) and (3), we get

$$i_2 = 11\text{A}, \quad i_3 = 17\text{A}$$

Now, $\quad V_x = 3(i_3 - i_2) = 3(17 - 11) = 18\text{V}$

44. (b)

For t < 0, 4u(t) = 0, therefore the circuit reduces to



circuit is assumed to be in steady state so

$$V_L(0^-) = 0 \text{ [short circuit]}$$

$$I_C(0^-) = 0 \text{ [open circuit]}$$

$i_R(0^-) = -5A$

$V_R(0^-) = -5 \times 100 = -150\,V$

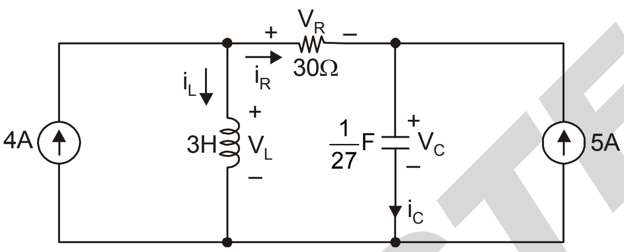
$V_C(0^-) = 150\ V$

$I_L(0^-) = -i_R(0^-) = 5A$

At $t = 0^+$:

Current in inductor and voltage in capacitor do not change instantaneously, so $i_L(0^+) = 5A$, $V_C(0^+) = 150\,V$.

The circuit can be represented as



At left node, by KCL

$4 = i_L + I_R = 5 + i_R$

$\therefore \quad I_R = -1A$

$\therefore \quad V_R(0^+) = (-1) \times 30 = -30\,V$

$i_C(0^+) = -1 + 5 = 4A$

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

$= -30 + 150 = 120V$

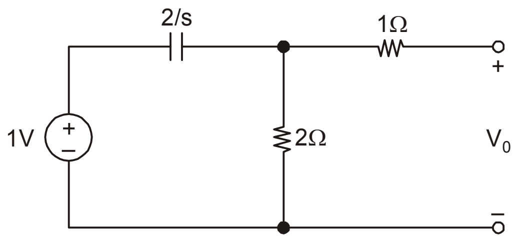
Thus, $V_L(0^+) = 120V, V_R(0^+) = -30V, i_C(0^+) = 4A$

45. (c)

To find impulse response,

$V_{in} = \delta(t)$

$\therefore \quad H(s) = \dfrac{V_0(s)}{1}$



To find H(s)

Therefore, $V_0|_{V_{in}=\delta(t)} = \dfrac{2}{\frac{2}{s}+2} = \dfrac{s}{s+1} = H(s)$

Now, if $V_{in} = 6e^{-t}u(t)$

$\therefore \quad V_0(t) = L^{-1}\{V_{in}(s).H(s)\}$

Since, $V_{in}(s) = \dfrac{6}{s+1}$

$\therefore \quad V_0 = \left(\dfrac{6}{s+1}\right)\left(\dfrac{s}{s+1}\right) = \dfrac{6s}{(s+1)^2}$

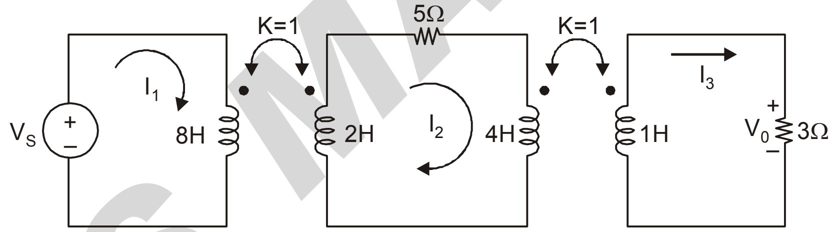
By partial fraction expansion,

$$V_0 = \frac{A}{s+1} + \frac{B}{(s+1)^2} = \frac{6}{s+1} - \frac{6}{(s+1)^2}$$

$\therefore \quad V_0(t) = (6e^{-t} - 6te^{-t})u(t)$

$= 6e^{-t}(1-t)u(t)$

46. (d)



Mutual inductance $= K\sqrt{L_1L_2}$

Between L_1= 8H and L_2= 2H, $M_{12} = 1\sqrt{8\times 2} = 4H$

Between L_3= 4H and L_4= 1H, $M_{34} = 1\sqrt{4\times 1} = 2H$

By KVL

$V_S = j8\omega I_1 - j4\omega I_2$ ....(1)

$0 = -j4\omega I_1 + (5 + j\omega 6)I_2 - j2\omega I_3$ ....(2)

$0 = -j2\omega I_2 + (3 + j\omega)I_3$ ....(3)

$V_0 = 3I_3 \Rightarrow$ It is better to obtain I_3.

From eq. (3)

$$I_2 = \frac{3+j\omega}{2j\omega}I_3$$

From eqn. (1)

$$I_1 = \left[V_S + j4\omega\left(\frac{3+j\omega}{2j\omega}\right)I_3\right]\frac{1}{j8\omega}$$

$$I_1 = \frac{1}{j8\omega}\left[V_S + (6+2j\omega)I_3\right]$$

Subtituting in eq. (2)

$$0 = \frac{-j4\omega}{j8\omega}\left[V_s + (6+2j\omega)I_3\right] + (5+j2\omega)\times\frac{(3+j\omega)}{j2\omega}I_3 - j2\omega I_3$$

or $$I_3\left[-\frac{(6+j2\omega)}{2} + \frac{(15-6\omega^2+j23\omega)}{j2\omega} - j2\omega\right] = \frac{V_s}{2}$$

or $$I_3\left[\frac{-j6\omega+2\omega^2+15-6\omega^2+j23\omega-4\omega^2}{j2\omega}\right] = \frac{V_s}{2}$$

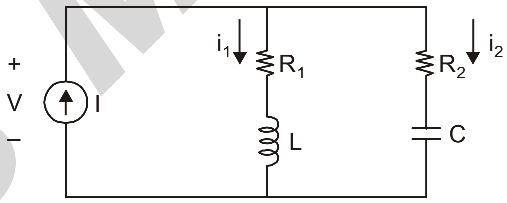
$$I_3\left[\frac{15+j17\omega}{j\omega}\right] = V_s$$

Since, $V_0 = 3I_3$

$$\therefore \quad \frac{V_0}{V_s} = \frac{j3\omega}{15+j17\omega}$$

47. (a)

At t > 0



$$I = i_1 + i_2 \quad ...(1)$$

$$V = R_1 i_1 + L\frac{di_1}{dt} \quad ...(2)$$

$$V = i_2 R_2 + \frac{1}{C}\int i_2 dt \quad ...(3)$$

Differentiating equation (3) wrt time

$$\frac{dv}{dt} = \left(\frac{di_2}{dt}\right)R_2 + \frac{1}{C}i_2 \quad ...(4)$$

Equation (3) can also be written as

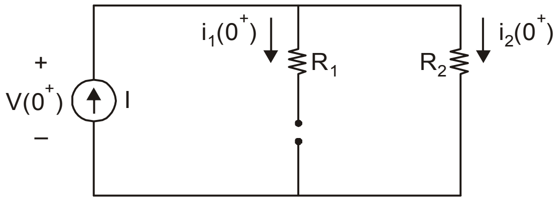
$$V = i_2 R_2 + V_C$$

$$\frac{dv}{dt} = \left(\frac{di_2}{dt}\right)R_2 + \frac{dV_{(C)}}{dt} \quad ...(5)$$

From equation (4) and (5)

$$\frac{dV_C}{dt} = \frac{i_2}{C} \Rightarrow \frac{dV_C(0^+)}{dt} = \frac{I_2(0^+)}{C} \quad ...(6)$$

At t = 0⁺



$V(0^+) = i_2(0^+) \cdot R_2$ $\qquad$ $I = I_1(0^+) + I_2(0^+)$

$I_1(0^+) = 0$

$V(0^+) = I.R_2$ ...(7) $\Rightarrow I_2(0^+) = I$

from (2) and (7)

$$\left.\frac{di_i}{dt}\right|_{t=0^+} = \frac{+R_2 I}{L} = \frac{5 \times 5}{.1} = 250\,\text{A/sec.}$$

from equation (6)

$$\left.\frac{dv_C}{dt}\right|_{t=0^+} = \frac{I_2(0^+)}{C} = \frac{I}{C}$$

$$= \frac{5}{2.5\text{m}} = 2000 \text{ V/sec.}$$

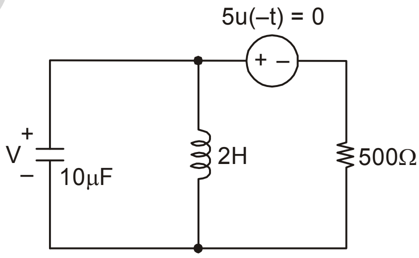
48. (d)

For t < 0

$$V = \left(\frac{100}{100+50}\right) \times 3 = 2\,\text{Volts}$$

Current in inductor $= \frac{5}{500} = 10\,\text{mA}$

At t = 0⁺, the circuit becomes



Now, by nodal analysis

$$\frac{1}{L}\int V\,dt + C\frac{dV}{dt} + \frac{V}{500} = 0$$

As current in inductor can't change instantaneously; so at t = 0⁺

$$\frac{1}{L}\int V\,dt = 10 \text{ mA}$$

Therefore,

$$10 \times 10^{-3} + C\frac{dV}{dt} + \frac{V}{500} = 0$$

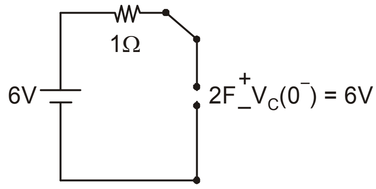
or $$\frac{dV}{dt} = -\frac{2}{10\times10^{-6}\times500}-\frac{10\times10^{-3}}{10\times10^{-6}} = -1400\,V/s$$

49. (c)

Case I

t < 0

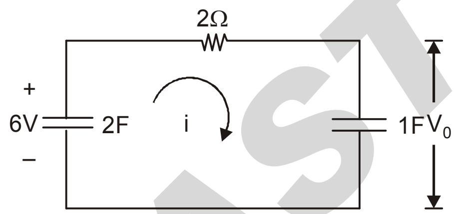
Switch at position 1, circuit under steady state (capacitor O.C.)



$$V_C(0^-) = 6\ V = V_C(0^+)$$

Case II

t > 0



Using KVL equation

$$\frac{1}{2}\int i\,dt+\int i\,dt+2i = 6$$

Taking Laplace transfer

$$\frac{1}{2}\frac{I(s)}{s}+2I(s)+\frac{I(s)}{s} = \frac{6}{s}$$

$$I(s) = \frac{6}{2s+1.5}$$

$$I(s) = \frac{6/2}{s+0.75} = \frac{3}{s+0.75}$$

Taking inverse Laplace

$$i(t) = 3e^{-0.75t}$$

$$V_0(t) = \int_0^t i\,dt$$

$$= \int_0^t 3e^{-0.75t}dt$$

$$= 3\int_0^t e^{-0.75t}dt = \frac{3}{0.75}[1-e^{-0.75t}]$$

$$V_0(t) = 4[1-e^{-0.75t}]$$

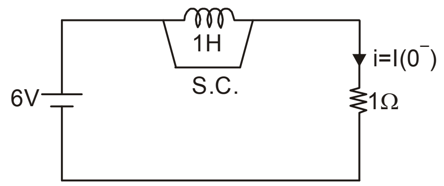
$$V_0(t)\big|_{t=4/3\text{ sec.}} = 4[1-e^{-1}] = 2.528\ V$$

50. (d)

Case I

for t < 0

Switch is at position 1 and inductor is S.C. and under steady state condition.



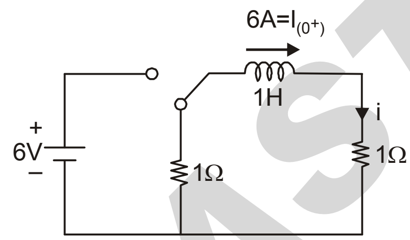
$$I(0^-) = 6/1 = 6A$$

$\Rightarrow$ $$I(0^-) = I(0^+) = 6A$$

Case II

t > 0

$$6A = I(0^+)$$



Current will decay exponentially

$$i(t) = I_0(0^+)e^{-t/\tau}$$

$$i(t) = 6e^{-t/\tau}$$

$\therefore$ $$\tau = \frac{L}{R} = \frac{1}{1+1} = 0.5 = \frac{1}{2}$$

$$i(t) = 6e^{-2t}A$$

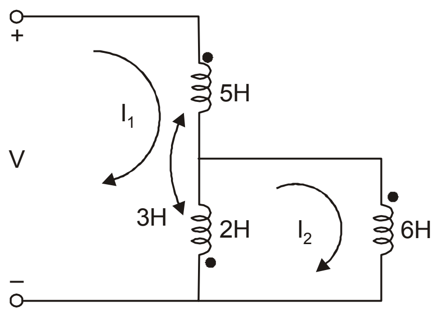
At t = 0.1 sec.

$$i(0.1) = 6\times e^{-2\times 0.1} = 4.912\text{ A}$$

$$w_L = \text{energy stored} = \frac{1}{2}L[i(0.1)]^2$$

$$= \frac{1}{2}\times 1\times(4.912)^2 = 12.065\text{ J}$$

51. (a)



By KVL in Mesh-1 :

$$V = j5\omega I_1 - j3\omega(I_1 - I_2)$$

or $$V = j2\omega I + j3\omega I_2 \quad .....(1)$$

In Mesh-2 :

$$j6\omega I_2 + j2\omega(I_2 - I_1) + j3\omega I_1 = 0$$

or $j8\omega I_2 + j\omega I_1 = 0$

or $$I_2 = \frac{-I_1}{8} \quad ....(2)$$

Substituting in Eqn. (1), we get

$$V = j2\omega I_1 + j3\omega\left(\frac{-I_1}{8}\right) = \frac{j13\omega}{8}$$

$$\frac{V}{I_1} = Z_{in} = j\frac{13}{8}\omega$$

$$L_{eq} = \frac{13}{8} = 1.625$$

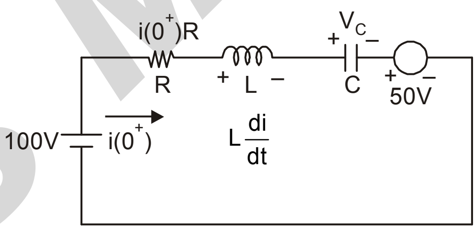
52. (d)

t < 0

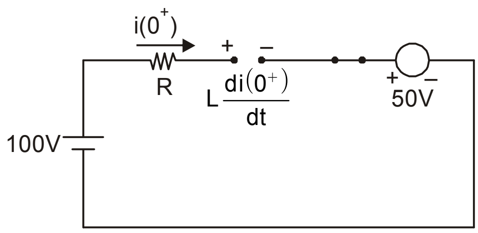
$$V_C(0^-) = \frac{Q_0}{C} = \frac{2500\mu C}{50\mu F} = 50 \text{ V}$$

$\Rightarrow$ $$V_C(0^-) = V_C(0^+) = 50V$$

Draw circuit at t = (0^+)



Since at t = $0^{(+)}$ inductor behave as an open circuit and capacitor behave as short circuit.



as $i(0^+) = 0$ circuit is open

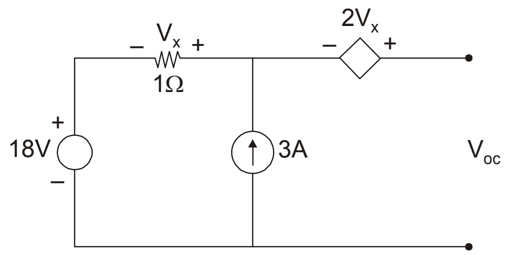
So using KVL

$$-100 + L\frac{di}{dt}\bigg|_{t=0^+} + 50 \Rightarrow 0$$

$$\frac{di}{dt}\bigg|_{t=0^+} = \frac{50}{L} = \frac{50}{0.1} = 500 \text{ A/sec.}$$

53. (b)

V_{th} is the open circuit voltage across terminal ab



Using KVL equation.

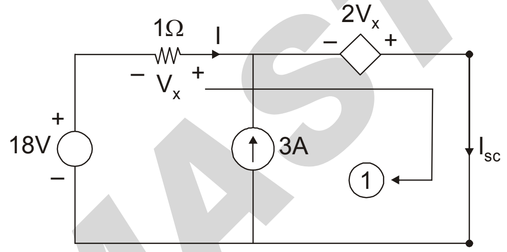
$$18 + V_x + 2V_x - V_{OC} = 0$$

$$\Rightarrow \quad V_{OC} = 18 + 2V_x + V_x$$

$$\because \quad V_x = +3\times1\ V$$

$$\Rightarrow \quad V_{OC} = 18 + 3(+3) = 27V$$

By short circuiting the 6Ω resistor



Using KVL equation in given loop (1)

$$18 + V_x + 2V_x = 0$$

$$\Rightarrow \quad V_x = -6V$$

The current through 1Ω resistor is I

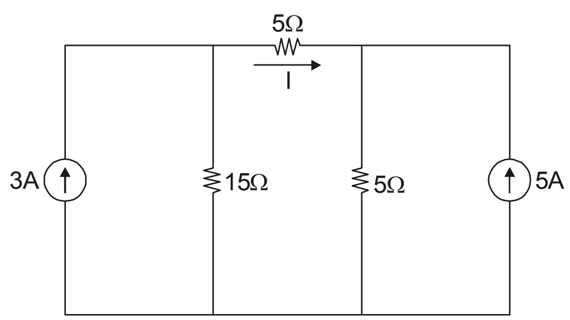
$$I = \frac{6}{1} = 6A$$

So $\quad I_{sc} = I + 3 = 9A$

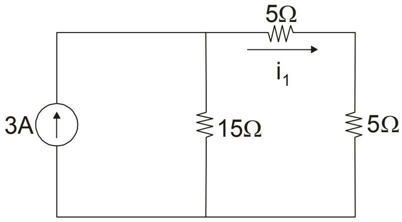
Thus $\quad R_{th} = \frac{V_{oc}}{I_{sc}}$

$$R_{th} = \frac{27}{9} = 3\Omega$$

54. (a)

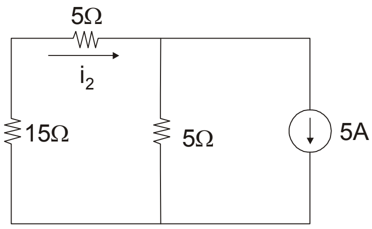


Using 3A source only :



$\Rightarrow i_1 = \frac{15}{25} \times 3 = 1.8\,A$

Using 5A source only :



$\Rightarrow i_2 = -\left(\frac{5}{25}\right) \times 5 = -1A$

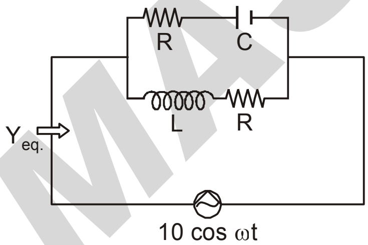
Therefore, $i = i_1 + i_2 = 1.8 - 1 = 0.8\,A$

$\therefore$ Statement 1 is correct.

Superposition theorem doesn't apply to power as power is a nonlinear quantity. Hence statement 2 is not correct.

55. (a)

Given circuit



$\because \quad Y_1 = \frac{1}{R + j\omega L}$

$$Y_2 = \frac{1}{R + \frac{1}{j\omega C}}$$

So, $\quad Y_{eq} = Y_1 + Y_2$

$$Y_{eq} = \frac{1}{R + j\omega L} + \frac{1}{R + \frac{1}{j\omega C}} \qquad \ldots(1)$$

$$= \frac{R - j\omega L}{R^2 + (\omega L)^2} + \frac{j\omega C(1 - j\omega RC)}{(1 + jR\omega C)(1 - jR\omega C)}$$

$$\Rightarrow \quad y_{eq} = \frac{R - j\omega L}{R^2 + (\omega L)^2} + \frac{j\omega C}{1 + \omega^2 R^2 C^2} + \frac{\omega^2 C^2 R}{1 + \omega^2 C^2 R^2}$$

At resonance Img(Y_{eq}) = 0 (j term of Y_{eq} will be zero)

$$\Rightarrow \quad \frac{\omega L}{R^2 + \omega^2 L^2} = \frac{\omega C}{1 + \omega^2 R^2 C^2}$$

$$\Rightarrow \quad L + \omega^2 R^2 C^2 L = \omega^2 L^2 C + CR^2$$

$$\Rightarrow \quad L - CR^2 = \omega^2 L^2 C - \omega^2 R^2 C^2 L$$

$$\Rightarrow \quad L - CR^2 = \omega^2 LC(L - CR^2)$$

$$\Rightarrow \quad \omega = \sqrt{\frac{1}{LC}} = \frac{1}{\sqrt{4 \times 4}} = \frac{1}{4}\text{ rad/sec.} \quad \ldots(2)$$

At $\omega = \frac{1}{4}$ rad/sec. from eqn. (1) and (2)

$$Y_{eq} = \frac{1}{2 - j1} + \frac{1}{2 + j1} = \frac{4}{5}\mho \Rightarrow z_{eq} = \frac{5}{4}\Omega = R_{eq.}$$

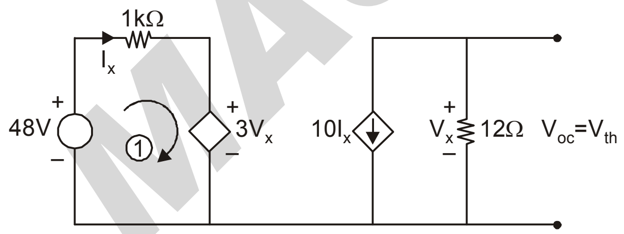
$$P = (I_{rms})^2 R_{eq} = \left(\frac{V_{rms}}{R_{eq}}\right)^2 \cdot R_{eq.}$$

$$P = \frac{\left(\frac{10}{\sqrt{2}}\right)^2}{\frac{5}{4}} = \frac{100}{2 \times 5} \times 4 = 40\text{W}$$

56. (a)

First determine thevenin equivalant circuit and then calculate the current through 24Ω to find the power consumed.

Open circuiting the 24Ω resistor.



$$V_{th} = -10\, I_x .\, 12 = -120\, I_x = V_x \quad \ldots(1)$$

But in loop (1)

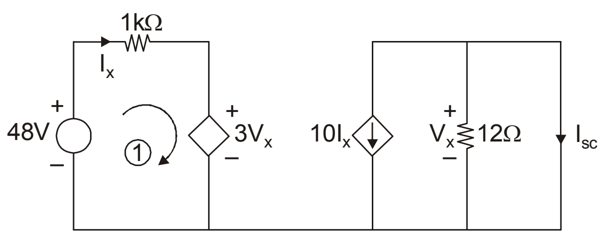
$$I_x = \frac{48 - 3V_x}{1000} = \frac{48 - 3V_{th}}{1000} \quad \ldots(2)$$

On solving equation (1) and (2)

$$V_{th} = -120\left(\frac{48 - 3V_{th}}{1000}\right)$$

$$V_{th} = -9\text{V} = V_{oc}$$

Now by short circuting the 24Ω resistor



as $\quad V_x = 0$ and $I_{sc} = -10\, I_x$

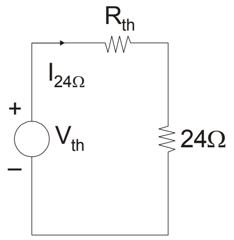
but in loop (1) using KVL equation

$$48 = 1000 \times I_x$$

$$I_x = 48 \text{ mA}$$

$\Rightarrow$ $$I_{sc} = -480 \text{ mA}$$

Hence $$R_{th} = \frac{V_{th}}{I_{sc}} = \frac{9}{.48} = 18.75\Omega$$



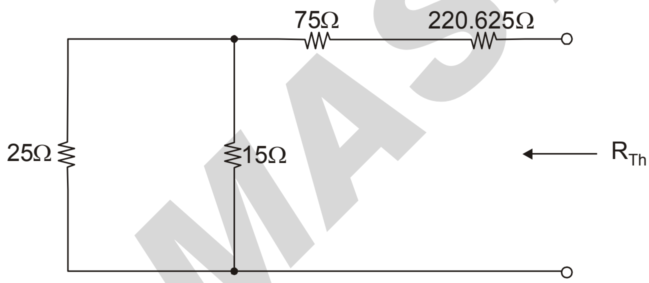
$$I_{24\Omega} = \frac{V_{th}}{R_{th}+24} = \frac{9}{24+18.75}$$

$$I_{24\Omega} = 0.21\text{A}$$

So power consumed by 24Ω = $I^2 R = (.21)^2 \times 24 = 1.0584$ w

57. **(c)**

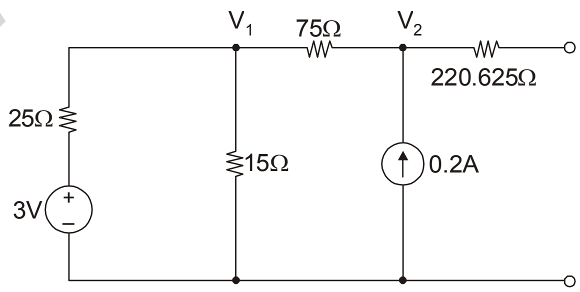
To Find R_{Th} :



$$R_{Th} = (25 \,||\, 15) + 75 + 220.625$$

$$= \frac{25 \times 15}{40} + 75 + 220 = 305\Omega$$

To find V_{Th} :



By KCL

$$\frac{V_1 - 3}{25} + \frac{V_1 - V_2}{75} + \frac{V_1}{15} = 0$$

or, $$\frac{3V_1 - 9 + V_1 - V_2 + 5V_1}{75} = 0$$

or $$9V_1 - V_2 = 9 \quad \text{...(1)}$$

Also $\frac{V_2 - V_1}{75} = 0.2$

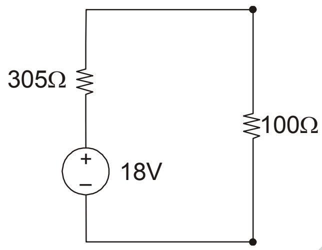
or $-V_1 + V_2 = 15$ ...(2)

Solving (1) and (2)

$$V_1 = 3V \quad V_2 = 18V$$

$V_{Th} = V_2$ as no current flows in 220.625Ω resistor.

The equivalent ckt now becomes



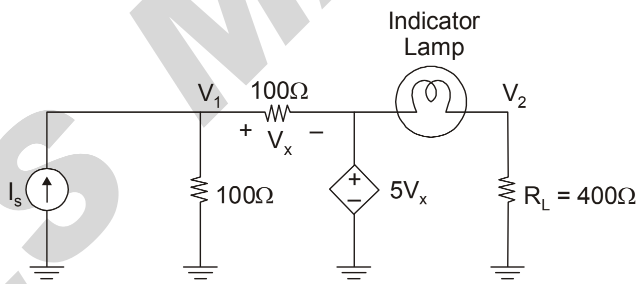
Power delivered to 100Ω resistor is

$$P = \left(\frac{18}{305+100}\right)^2 \times 100$$

$$= 0.19753 \text{ W}$$

or $P = 0.1975$ W [upto power decimal places]]

58. **(a)**



Given, $P_{RL} = 1$ W

$\therefore$ $P_{RL} = \frac{V_2^2}{400} = 1$

$\therefore$ $V_2|_{max} = 20$ V

For $V_2 = 20$ V

$$I_L = \frac{V_2}{R_L} = \frac{20}{400} = 0.05\,A < 1A$$

$\Rightarrow$ resistance of lamp is 20Ω.

Now, by Nodal analysis

$$\frac{V_1}{100} + \frac{V_1 - 5V_x}{100} = I_s$$

or $2V_1 - 5V_x = 100I_s$ .....(1)

Also, $\frac{V_2}{400} + \frac{V_2 - 5V_x}{20} = 0$

$\therefore$ $21V_2 - 100V_x = 0$ ...(2)

As, $V_x = V_1 - 5V_x$

$V_x = \frac{V_1}{6}$ ....(3)

Substituting in eqn. (1) and (2)

$2V_1 - \frac{5V_1}{6} = 100\ I_s$

or $7V_1 = 600\ I_s$ ...(4)

Similarly, $21V_2 - \frac{100V_1}{6} = 0$

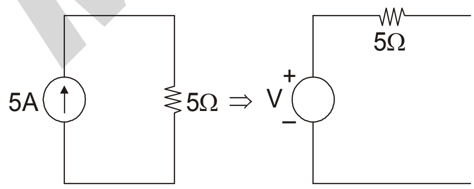
As $V_2 = 20\ V$

$21 \times 20 - \frac{100V_1}{6} = 0$ ....(5)

From Eqn. (4), we get

$I_s = \frac{7V_1}{600} = \frac{7 \times 25.2}{600} = 0.294\ A$

59. **(c)**

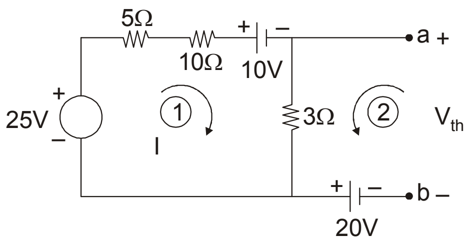


(Using current source to voltage source transformation)

$V = 5 \times 5 = 25$ volt

For V_{th}

V_{th} is the open circuit voltage across ab so equivalent circuit.



Using KVL in loop (1)

$-25 + (5+10+3)\ I + 10 = 0$

$I = \frac{15}{18} = \frac{5}{6} A$

Using KVL equation in loop (2)

$$-V_{th} + 3I + 20 = 0$$

$$V_{th} = +20+3I$$

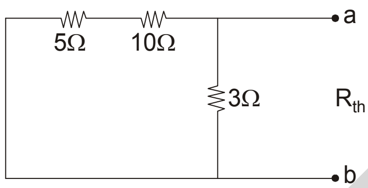
$$= 20+\frac{5}{6}\times 3 = 20+\frac{15}{6}$$

$$V_{th} = 22.5V$$

For R_{th}

By short circuiting the all independent voltage sources & open circuiting independent current source.

The equivalant circuit is



$$R_{th} = (5+10)\parallel 3$$

$$= 15\parallel 3$$

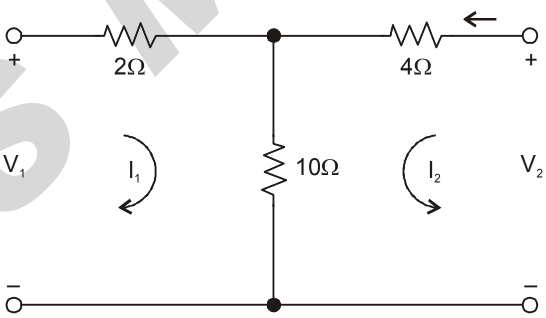
$$= \frac{15\times 3}{15+3} = 2.5\Omega$$

60. **(c)**

By definition of transmission parameters

$$V_1 = AV_2 + B(-I_2)$$

$$I_1 = CV_2 + D(-I_2)$$



$$V_1 = 2I_1 + 10(I_1 + I_2) = 12I_1 + 10I_2 \quad ...(1)$$

$$V_2 = 4I_2 + 10(I_1 + I_2) = 10I_2 + 14I_2 \quad ...(2)$$

From equation (2)

$$I_1 = \frac{1}{10}(V_2 - 14I_2)$$

$$I_1 = 0.1V_2 - 1.4I_2$$

$$I_1 = 0.1V_2 + 1.4(-I_2) \quad ...(4)$$

Substituting value of I_1 in eqn. (1)

$$V_1 = 12(0.1V_2 - 1.4I_2) + 10I_2$$

$$V_1 = 1.2V_2 - 6.8I_2$$

$$V_1 = 1.2V_2 + 6.8(-I_2) \quad ...(5)$$

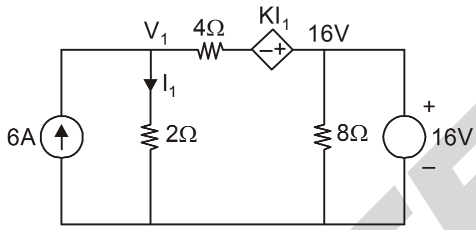
From eqn. (5) and (4)

$$V_1 = 1.2V_2 + 6.8(-I_2)$$

$$I_1 = 0.1V_1 + 1.4(-I_2)$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1.2 & 6.8 \\ 0.1 & 1.4 \end{bmatrix}$$

61. **(d)**



Using node equation at node 1

$$\frac{V_1}{2} + \frac{V_1 - 16 + KI_1}{4} = 6$$

$$\Rightarrow \quad V_1 - 16 + K\,I_1 + 2V_1 = 24 \qquad \because V_1 = 2I_1$$

$$\Rightarrow \quad V_1 + \frac{KV_1}{2} + 2V_1 = 16 + 24$$

$$V_1\,[2 + K + 4] = 80$$

$$V_1\,[6 + K] = 80$$

$$V_1 = \frac{80}{6+K} \quad ...(1)$$

Since $P_{2\Omega} = 2I_1^2 \le 50\text{W}$

$$I_1 \le \sqrt{\frac{50}{2}} \le 5\text{A}$$

$$V_1 = 2I_1$$

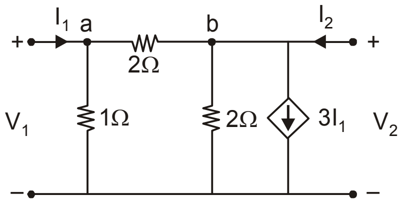
$$V_1 \le 10\text{V} \quad ...(2)$$

from equation (1) and (2)

$$\frac{80}{6+K} \le 10\text{V}$$

$$\frac{80}{10} \le 6 + K \quad \Rightarrow \quad K \ge 2$$

62. (a)



Using KCL equation at node 'a'

$$I_1 = \frac{V_1}{1} + \frac{V_1 - V_2}{2}$$

$$I_1 = V_1\,(1.5) - .5V_2 \qquad ...(1)$$

Using KCL equation at node 'b'

$$\frac{V_2}{2} + \frac{V_2 - V_1}{2} + 3I_1 - I_2 = 0$$

$$V_2\left(\frac{1}{2} + \frac{1}{2}\right) - V_1(.5) + 3I_1 - I_2 = 0$$

$$\Rightarrow \quad V_2 - .5V_1 + 3I_1 = I_2 \qquad ...(2)$$

We know

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

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

as $\quad I_2 = 0,\ \frac{V_1}{I_1} = Z_{11}$ and $\frac{V_2}{I_1} = Z_{21}$

and as $\quad I_1 = 0,\ \frac{V_1}{I_2} = Z_{12}$ and $\frac{V_2}{I_2} = Z_{22}$

Putting $I_2 = 0$ in equation (2) and putting the value of V_2 in equation (1) we get

$V_2 = .5V_1 - 3I_1,$ $\qquad I_1 = V_1(1.5) - .5(5V_1 - 3I_1)$

$$I_1 = V_1(1.5) - .25V_1 + 3I_1 \times .5$$

$$I_1 = +1.25\,V_1 + 1.5\,I_1$$

$$-.5\,I_1 = 1.25\,V_1 = \frac{V_1}{I_1} = \frac{-.5}{1.25} = -.4\Omega$$

Putting value of V_1 in equation (1)

We get $\qquad \frac{V_2}{I_1} = Z_{21} = -3.2\Omega$

Put $I_1 = 0$ in equation (1) and (2)

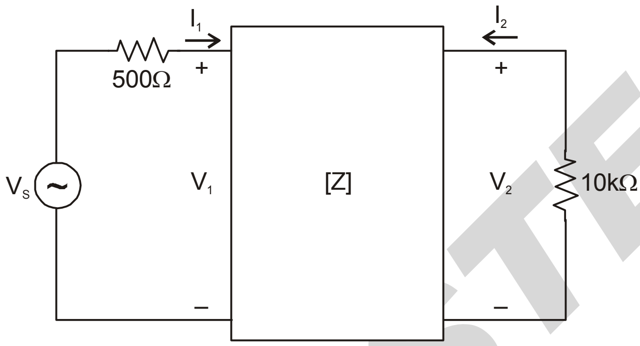
Put V_1 in equation (2)

$$V_1 = \frac{1}{3}V_2,\ I_2 = (V_2)\left(\frac{1}{2}+\frac{1}{3}\right) = \frac{5}{6}\vec{V}_2$$

$$\Rightarrow \quad \frac{V_2}{I_2} = Z_{22} = \frac{6}{5}\Omega$$

$$Z_{12} = \left(\frac{1}{3}\right)\left(\frac{6}{5}\right) = .4\Omega$$

63. **(b)**



Equation for the two-port are

$$V_1 = 10^3 I_1 + 10 I_2 \quad ...(1)$$

$$V_2 = -10^6 I_1 + 10^4 I_2 \quad ...(2)$$

The characterizing equations of the input and output networks are

$$V_S = 500\ I_1 + V_1 \quad ...(3)$$

$$V_2 = -10^4\ I_2 \quad ...(4)$$

Substituting V_2 in eqn. (2)

$$-10^4\ I_2 = -10^6\ I_1 + 10^4\ I_2$$

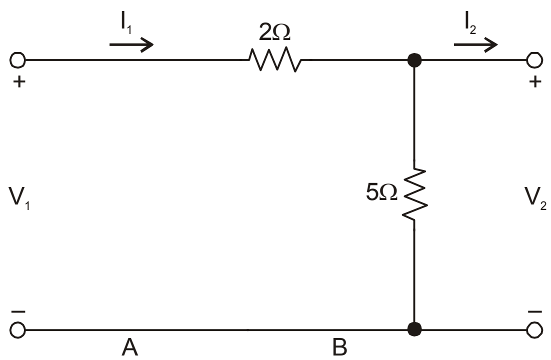
or

$$I_2 = \frac{10^6}{2\times 10^4}I_1 = 50\ I_1 \quad ...(5)$$

$$\frac{I_2}{I_1} = 50$$

64. **(b)**

Considering section A



$$V_1 = 2I_1 + V_2 \quad ...(1)$$

$$I_2 = \frac{V_2}{5} + I_1 = -0.2V_2 + I_1 \quad ...(2)$$

From eqn. (2)

$$I_1 = +0.2V_2 + I_2 \quad ...(3)$$

Substituting in eqn. (1)

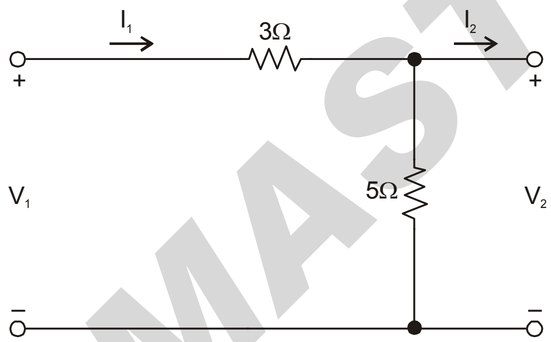
$$V_1 = 2(+0.2V_2 + I_2) + V_2$$

or $$V_1 = 1.4V_2 + 2I_2 \quad ...(4)$$

From eqn. (3) and (4)

$$\begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} = \begin{bmatrix} 1.4 & 2 \\ 0.2 & 1 \end{bmatrix}$$

Similarly for network B



$$V_1 = 3I_1 + V_2 \text{ and } I_2 = -\frac{V_2}{5} + I_1$$

$\therefore$ $$I_1 = I_2 + 0.2V_2 = 0.2V_2 + I_2$$

$\therefore$ $$V_1 = 3(I_2 + 0.2V_2) + V_2 = 1.6V_2 + 3I_2$$

Therefore, $$\begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} = \begin{bmatrix} 1.6 & 3 \\ 0.2 & 1 \end{bmatrix}$$

The equivalent ABCD matrix

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix}\begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix}$$

$\therefore$ $$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1.4 & 2 \\ 0.2 & 1 \end{bmatrix}\begin{bmatrix} 1.6 & 3 \\ 0.2 & 1 \end{bmatrix}$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 2.64 & 6.2 \\ 0.52 & 1.6 \end{bmatrix}$$

65. **(c)**

For the two-port network

$$[Y] = \begin{bmatrix} 0.005 & -0.004 \\ 0.05 & 0.03 \end{bmatrix}$$

Therefore,

$$I_1 = 0.005V_1 - 0.004V_2 \quad ...(1)$$

$$I_2 = 0.05V_1 + 0.03V_2 \quad ...(2)$$

$$\frac{100 - V_1}{R_S} = I_1 \quad ...(3)$$

$$\therefore \quad \frac{100 - V_1}{25} = 0.005\ V_1 - 0.004\ V_2$$

or $$100 = 1.125\ V_1 - 0.1\ V_2 \quad ...(4)$$

Also, $$I_2 = -\frac{V_2}{R_L} = -\frac{V_2}{100} \quad ...(5)$$

$$\therefore \quad -\frac{V_2}{100} = 0.05V_1 + 0.03V_2$$

or $$0.05V_1 + 0.04V_2 = 0 \quad ...(6)$$

From eqn. (6), $V_2 = -\frac{5}{4}V_1$ so eqn. (4) becomes

$$100 = 1.125V_1 - 0.1\left(-\frac{5}{4}V_1\right)$$

or $$V_1 = \frac{100}{1.25} = 80\ V$$