

CLASS TEST

S.No. : 01 LS1_EC_S+T_060819

Network Theory



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CLASS TEST 2019-2020

ELECTRONICS ENGINEERING

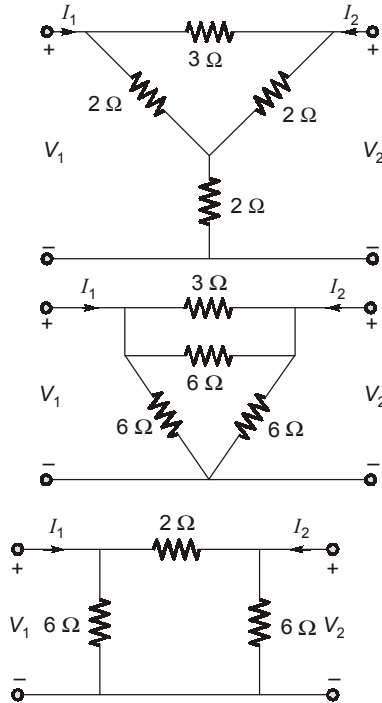
Date of Test : 06/08/2019

ANSWER KEY > Network Theory

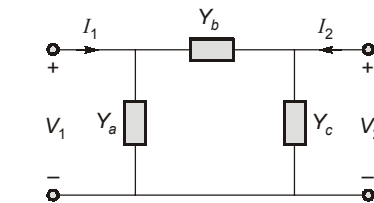
1. (b)	7. (d)	13. (a)	19. (b)	25. (d)
2. (c)	8. (c)	14. (c)	20. (b)	26. (a)
3. (b)	9. (a)	15. (b)	21. (b)	27. (b)
4. (b)	10. (b)	16. (c)	22. (c)	28. (b)
5. (a)	11. (c)	17. (a)	23. (d)	29. (b)
6. (b)	12. (d)	18. (c)	24. (b)	30. (d)

Detailed Explanations

1.(b)



for II-network



$$\therefore [Y] = \begin{bmatrix} Y_a + Y_b & -Y_b \\ -Y_b & Y_b + Y_c \end{bmatrix}$$

for the given problem, $Y_a = \frac{1}{6} \text{ } \Omega^{-1}$

$$Y_b = \frac{1}{2} \text{ } \Omega^{-1}$$

$$Y_c = \frac{1}{6} \text{ } \Omega^{-1}$$

$$\therefore [Y] = \begin{bmatrix} \frac{2}{3} \text{ } \Omega^{-1} & -\frac{1}{2} \text{ } \Omega^{-1} \\ -\frac{1}{2} \text{ } \Omega^{-1} & \frac{2}{3} \text{ } \Omega^{-1} \end{bmatrix}$$

2.(c)

$$\text{Time period } (T) = \frac{2\pi}{\omega}$$

where $\omega = \frac{1}{\sqrt{LC}}$

thus,

$$T = 2\pi\sqrt{LC}$$

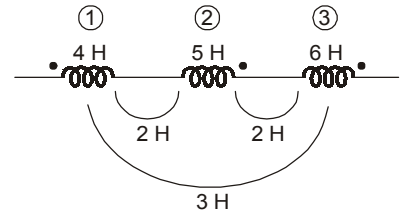
In figure

$$L_{eq} = L_1 + L_2 + L_3 - 2M_{12} + 2M_{23} - 2M_{13}$$

$$= 4 + 5 + 6 - 2(2) + 2(2) - 2(3) = 9 \text{ H}$$

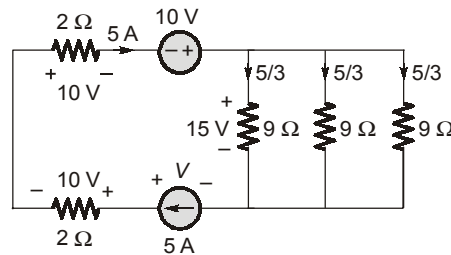
$$C = 1 \text{ F}$$

$$T = 2\pi\sqrt{9} = 6\pi \text{ sec}$$



3.(b)

The circuit can be redrawn by short circuiting inductor and open circuiting capacitor as DC sources are used.



Applying KVL

$$V - 10 - 10 + 10 - 15 = 0$$

$$V = 25 \text{ V}$$

4.(b)

$$\frac{R}{2}\sqrt{\frac{L}{C}} \Rightarrow \frac{R}{2}\sqrt{\frac{L\omega}{C\omega}} = \frac{R}{2}\sqrt{X_L X_C}$$

Unit of R_1 is Ω

Unit of ' X_L ' and ' X_C ' is Ω

$$\text{Unit of } \frac{R}{2}\sqrt{\frac{L}{C}} \text{ is } \Omega \times \sqrt{\Omega \times \Omega} \Rightarrow (\Omega)^2$$

5.(a)

The average value of periodic signal can be calculated by considering one time period

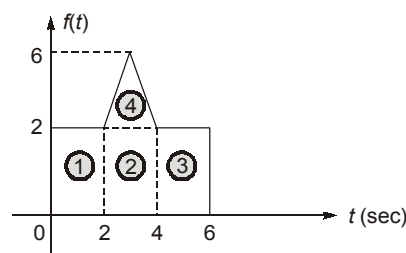
$$= \frac{\text{Total area under the graph for one period}}{T_0}$$

Total area under the graph for one period = Area 1 + Area 2 + Area 3 + Area 4

here Area 1 = Area 2 = Area 3 = Area 4 = 4

and $T_0 = 8 \text{ sec}$

$$\text{Average value} = \frac{4 + 4 + 4 + 4}{8} = \frac{16}{8} = 2$$

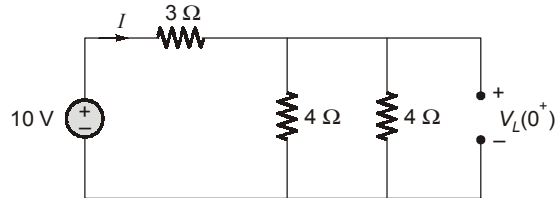


6.(b)

Before closing the switch, the circuit was not energized, therefore, current through inductor and voltage across capacitor are zero.

After closing the switch, at $t = 0^+$ inductor acts as open-circuit and capacitor acts as short-circuit.

Equivalent circuit at $t = 0^+$



$$I = \frac{10}{3 + 4 \parallel 4} = 2 \text{ A}$$

$$V_L(0^+) = I \times (4 \parallel 4) = 2 \times 2 = 4 \text{ V}$$

7.(d)

Applying KVL in both the loops we get

$$V_1 = (j\omega L_1)I_1 + (j\omega M)I_2$$

$$V_2 = (j\omega L_2)I_2 + (j\omega M)I_1$$

$$\frac{V_2}{V_1} = \frac{L_2 I_2 + M I_1}{L_1 I_1 + M I_2}$$

also,

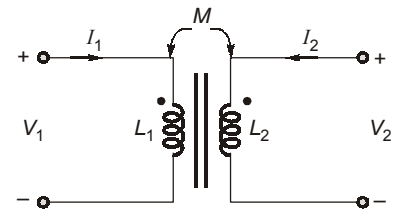
$$M = K\sqrt{L_1 L_2} = \sqrt{L_1 L_2};$$

$\therefore K = 1$ for ideal transformer

$$\frac{V_2}{V_1} = \frac{L_2 I_2 + \sqrt{L_1 L_2} I_1}{L_1 I_1 + \sqrt{L_1 L_2} I_2}$$

$$\therefore \frac{V_2}{V_1} = \frac{\sqrt{L_2}}{\sqrt{L_1}}$$

$$\Rightarrow \frac{V_2}{V_1} = \sqrt{\frac{5}{25}} = \frac{1}{\sqrt{5}}$$



8.(c)

As we know,

$$\text{Real power} = V_{\text{rms}} \cdot I_{\text{rms}} \cos \phi \quad \dots(i)$$

$$\text{Reactive power} = V_{\text{rms}} \cdot I_{\text{rms}} \sin \phi \quad \dots(ii)$$

$$\text{Apparent power} = V_{\text{rms}} \cdot I_{\text{rms}} \quad \dots(iii)$$

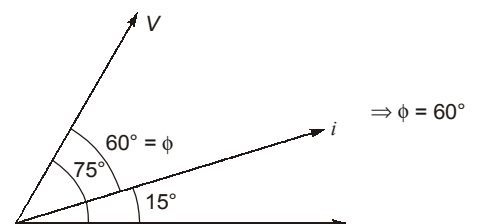
Given that $v(t) = 10\cos(2t + 75^\circ)$

$i(t) = 2\cos(2t + 15^\circ)$

from equation (i)

$$\text{Real power} = \frac{10}{\sqrt{2}} \times \frac{2}{\sqrt{2}} \times \frac{1}{2} = 5 \text{ Watts}$$

from equation (ii)



$$\text{Reactive power} = \frac{10}{\sqrt{2}} \times \frac{2}{\sqrt{2}} \times \frac{\sqrt{3}}{2} = 5\sqrt{3} = 8.66 \text{ VAR}$$

from equation (iii)

$$\text{Apparent power} = \frac{10}{\sqrt{2}} \times \frac{2}{\sqrt{2}} = 10 \text{ VA}$$

9.(a)

$$Y = Y_1 + Y_2$$

$$Y = \frac{1}{R + jX_L} + \frac{1}{R - jX_C}$$

$$Y = \frac{R - jX_L}{(R^2 + X_L^2)} + \frac{(R + jX_C)}{(R^2 + X_C^2)}$$

$$\text{Im}(Y) = \frac{-X_L(R^2 + X_C^2) + X_C(R^2 + X_L^2)}{(R^2 + X_L^2)(R^2 + X_C^2)}$$

For 'Z' to purely resistive

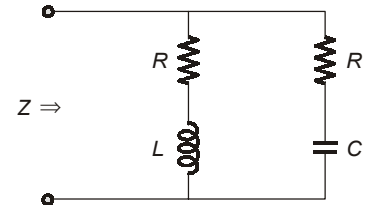
also $\text{Im}(Y) = 0$

$$\Rightarrow X_L(R^2 + X_C^2) = X_C(R^2 + X_L^2)$$

$$R^2 X_L + X_C^2 X_L = R^2 X_C + X_L^2 X_C$$

$$R^2(X_L - X_C) = X_L X_C(X_L - X_C)$$

$$R^2 = X_L X_C = \omega L \times \frac{1}{\omega C} = \frac{L}{C}$$



10.(b)

For parallel resonant circuit

$$Q_0 = R \sqrt{\frac{C}{L}}$$

$$Q_0 = 2000 \sqrt{\frac{54 \times 10^{-6}}{240 \times 10^{-3}}}$$

$$Q_0 = 2000 \sqrt{\frac{9}{4} \times 10^{-4}}$$

$$Q_0 = \frac{2000}{100} \times \frac{3}{2}$$

$$Q_0 = 30$$

11.(c)

$$L_{\text{eq}} = (L + L - 2M) \parallel L$$

Also

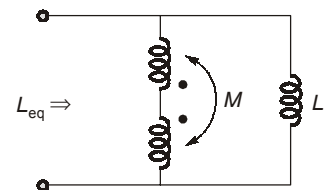
$$M = k\sqrt{L_1 L_2} = M = k\sqrt{L^2} = kL$$

$$L_{\text{eq}} = (L + L - 2kL) \parallel L$$

$$\frac{L}{3} = \frac{(2L - 2kL) \times L}{2L - 2kL + L}$$

on solving, we get

$$k = 0.75$$



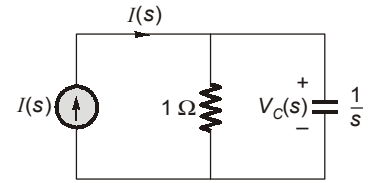
12.(d)

$$V_C(s) = I(s) \times \frac{1}{1 + \frac{1}{s}} \times \frac{1}{s} = I(s) \times \frac{1}{s+1}$$

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

$$V_C(s) = \frac{2(s+1)}{(s+1)^2 + 1} \times \frac{1}{1+s} = \frac{2}{(s+1)^2 + 1}$$

$$v_C(t) = 2e^{-t} \sin t \, u(t) \, \text{V}$$



13.(a)

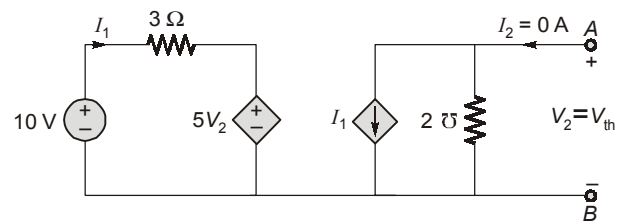
to determine V_{th} :

$$I_1 = \frac{10 - 5V_2}{3} = \frac{10 - 5V_{th}}{3}$$

$$V_{th} = -\frac{I_1}{2} = \frac{5V_{th} - 10}{6}$$

$$6V_{th} = 5V_{th} - 10$$

$$V_{th} = -10 \, \text{V}$$



to determine R_{th} :

$$I_2 = 2V_2 + I_1$$

$$1 \, \text{A} = 2V_2 + I_1$$

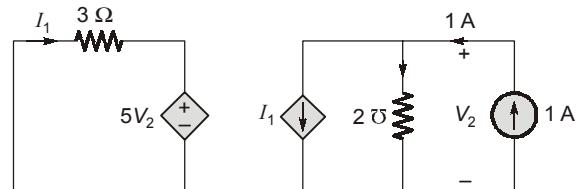
$$0 = 3I_1 + 5V_2$$

$$I_1 = -\frac{5}{3}V_2$$

$$1 \, \text{A} = 2V_2 - \frac{5}{3}V_2$$

$$V_2 = 3 \, \text{V}$$

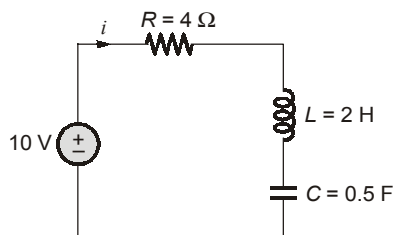
$$R_{th} = \frac{V_2}{1 \, \text{A}} = 3 \, \Omega$$



$$P_{L \max} = \frac{V_{th}^2}{4R_{th}} = \frac{100}{12} \, \text{W} = 8.33 \, \text{W}$$

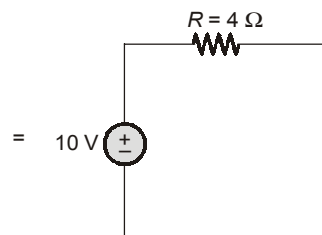
14.(c)

At $(t = 0^-)$

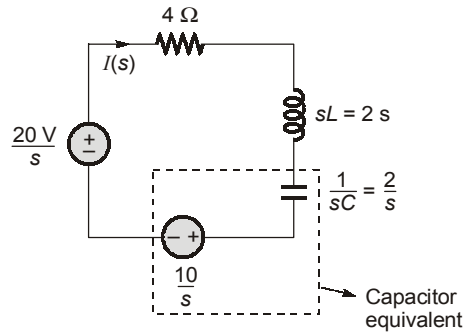


$$V_C(0^-) = 10 \, \text{V}$$

$$i_L(0^-) = 0 \, \text{A}$$



At $(t = 0^+)$



$$I(s) = \frac{10/s}{4 + 2s + \frac{2}{s}} = \frac{10/s}{\frac{4s + 2s^2 + 2}{s}} = \frac{10}{2(s^2 + 2s + 1)}$$

$$I(s) = \frac{5}{(s+1)^2}$$

$$i(t) = 5te^{-t} u(t) \text{ A}$$

15.(b)

For a series RL circuit with DC excitation,

$$i(t) = \frac{V_s}{R} \left(1 - e^{-\frac{Rt}{L}} \right) u(t) \text{ A}$$

$$v(t) = V_s \left(e^{-\frac{Rt}{L}} \right) u(t) \text{ A}$$

$$A = \frac{V_s}{R}$$

$$B = \frac{R}{L}$$

$$C = V_s$$

$$\frac{AB}{C} = \frac{\frac{V_s}{R} \times \frac{R}{L}}{V_s} = \frac{1}{L}$$

$$= \frac{1}{5 \times 10^{-3}} = 200$$

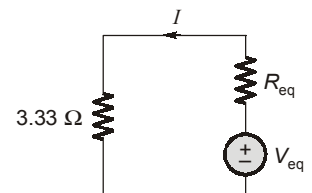
16.(c)

Applying Millman's Theorem

$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{30} + \frac{1}{90} + \dots$$

$$\frac{1}{R_{eq}} = \frac{1}{10} \left(1 + \frac{1}{3} + \frac{1}{9} + \dots \right)$$

$$\frac{1}{R_{eq}} = \frac{1}{10} \left(\frac{1}{1 - \frac{1}{3}} \right) = \frac{3}{10 \times 2} = \frac{3}{20}$$



$$R_{eq} = \frac{20}{3} \Omega$$

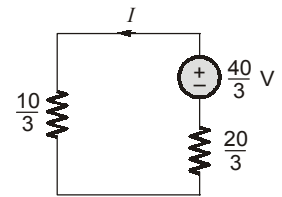
$$V_{eq} = \frac{\frac{E_1}{R_1} + \frac{E_2}{R_2} + \frac{E_3}{R_3} + \dots}{\frac{1}{R_{eq}}}$$

$$= \frac{1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \dots}{\frac{3}{20}} = \frac{1 - \frac{1}{2}}{\frac{3}{20}} = \frac{20}{3} \times 2$$

$$V_{eq} = \frac{40}{3} V$$

$$I = \frac{\frac{40}{3}}{\frac{20}{3} + \frac{10}{3}} = \frac{40}{30} = \frac{4}{3} A$$

$$I = 1.33 A$$



17.(a)

At $(t = 0^-)$, both the switches are opened.

L is initially uncharged $i_L(0^-) = 0$

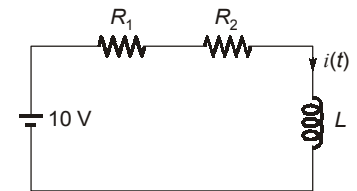
At $(t = 0^+)$

$$i(t) = i(\infty) + (i(0^+) - i(\infty)) e^{-\frac{R_{eq}t}{L_{eq}}}$$

$$R_{eq} = 5 \Omega$$

$$L_{eq} = 1 H$$

$$i(0^+) = 0 A$$



$$i(t) = 2 + (0 - 2)e^{-\frac{5t}{1}} A ; \text{ for } t > 0$$

At $(t = 2^-)$

$$i(2^-) = 2 - 2e^{-\frac{10}{1}} A$$

$$i(2^-) \approx 2 A$$

At $(t = 2^+)$

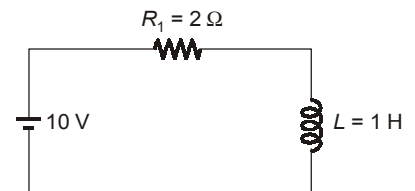
$$i(2^-) = i(2^+) = 2 A$$

for $t > 2$ sec

$$i(t) = i(\infty) + (i(2^+) - i(\infty)) e^{-\frac{R_1(t-2)}{L}} ; \text{ for } t > 2$$

$$i(t)|_{t=3s} = 5 + (2 - 5)e^{-\frac{2}{1}(3-2)} = 5 - 3e^{-2}$$

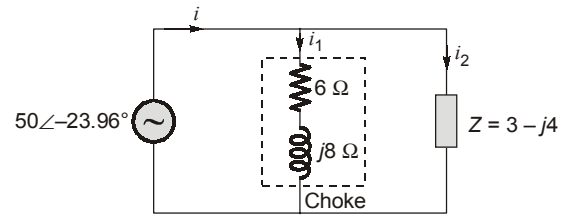
$$= 4.594 A$$



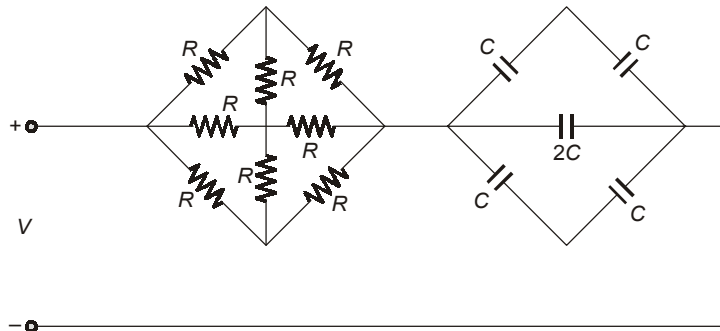
18.(c)

Here, applying KCL

$$\begin{aligned}
 i(t) &= i_1(t) + i_2(t) \\
 &= \frac{V_1}{6 + j8} + \frac{V_1}{3 - j4} \\
 \Rightarrow V_1 \left(\frac{3 - j4 + 6 + j8}{2(3 + j4)(3 - j4)} \right) &= \frac{V_1(9 + j4)}{2 \times 25} \\
 \Rightarrow \frac{50 \angle -23.96^\circ \times \sqrt{97} \angle 23.96^\circ}{50} \text{ A} &= \sqrt{97} \text{ A} \\
 &= 9.85 \text{ A}
 \end{aligned}$$

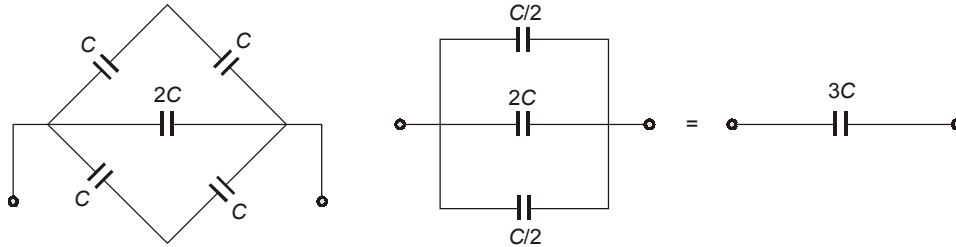


19.(b)

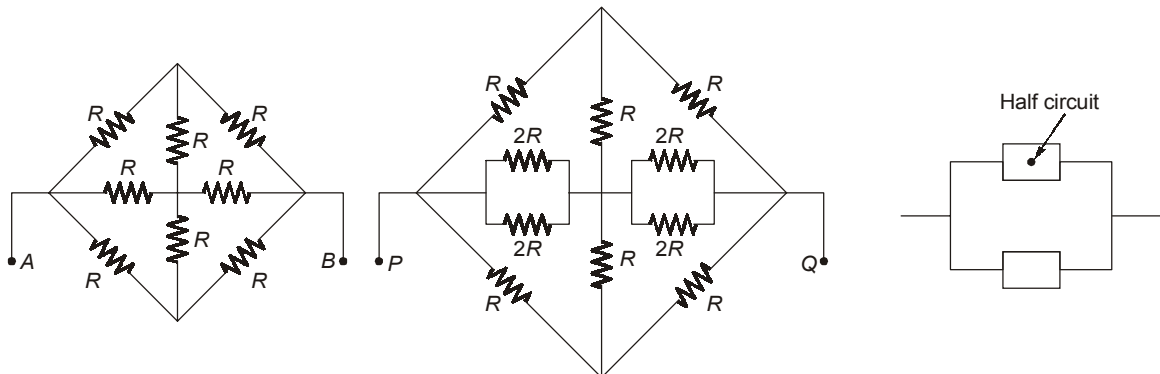


The time constant of an RC circuit is $\tau = R_{eq} C_{eq}$

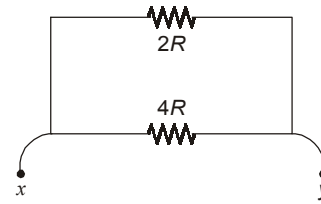
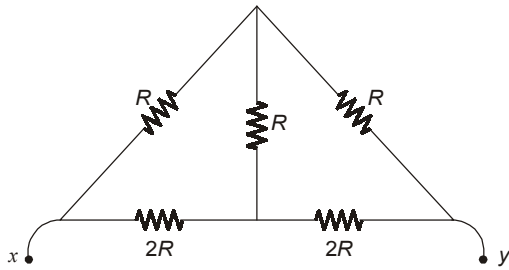
Calculation of C_{eq}



Calculation of R_{eq}



It is Wheatstone bridge.



$$(R_{eq})_{\text{Half circuit}} = \frac{4R \times 2R}{6R} = \frac{4R}{3}$$

$$R_{eq} = (R_{eq})_{\text{Half circuit}} \parallel (R_{eq})_{\text{Half circuit}}$$

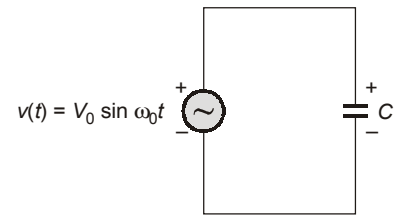
$$= \left(\frac{4R}{3}\right) \parallel \left(\frac{4R}{3}\right) = \left(\frac{2R}{3}\right)$$

∴

$$\begin{aligned} \tau &= R_{eq} C_{eq} \\ &= \frac{2R}{3} \times 3C = 2RC \end{aligned}$$

20.(b)

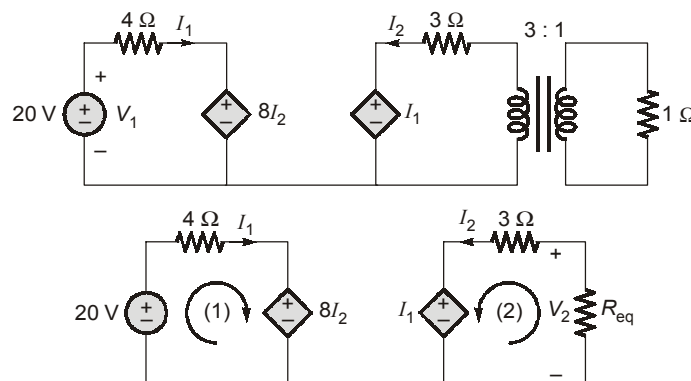
$$\begin{aligned} W(t) &= \frac{1}{2} C v^2(t) \\ &= \frac{1}{2} C V_0^2 \sin^2 \omega_0 t \\ &= \frac{1}{4} C V_0^2 (1 - \cos 2\omega_0 t) \end{aligned}$$



thus only option (b) satisfies this condition.

21.(b)

Network 'N' can be replaced as



$$R_{eq} = (1) \times \left(\frac{3}{1}\right)^2 = 9 \Omega$$

Applying KVL at loop (1)

$$20 = 4I_1 + 8I_2$$

also

$$V_2 = -9I_2 = I_1 + 3I_2$$

$$\begin{aligned} \Rightarrow I_1 &= -12I_2 \\ 20 &= 4(-12I_2) + 8I_2 \\ 20 &= -40I_2 \\ \Rightarrow I_2 &= -0.5 \text{ A} \\ I_1 &= -12(-0.5) = 6 \text{ A} \end{aligned}$$

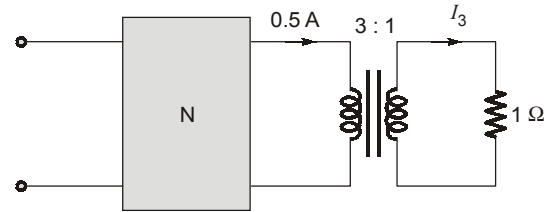
Now,

$$\frac{I_{\text{primary}}}{I_{\text{secondary}}} = \frac{1}{3}$$

$$\begin{aligned} \Rightarrow 3I_{\text{primary}} &= I_{\text{secondary}} \\ 3(-I_2) &= I_3 \end{aligned}$$

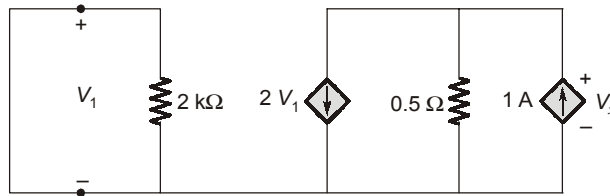
$$\Rightarrow I_3 = 1.5 \text{ A}$$

$$\begin{aligned} \text{Power delivered to } 1 \Omega &= (I_3)^2 \times R_L = (1.5)^2 \times 1 \\ &= 2.25 \text{ Watts} \end{aligned}$$



22.(c)

Calculating R_{th}



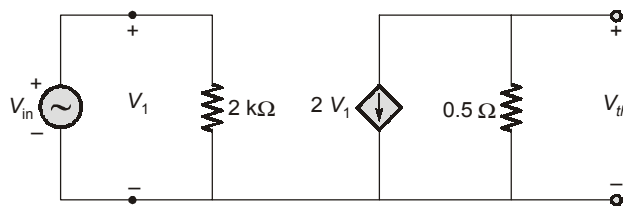
$$1 \text{ A} = \frac{V_x}{0.5} + 2V_1$$

$\therefore V_1 = 0$
independent voltage source is short circuited)

(As

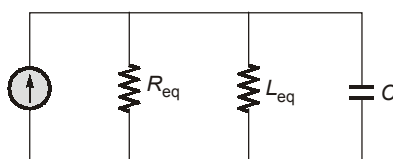
$$\begin{aligned} \Rightarrow V_x &= 0.5 \text{ V} \\ R_{th} &= 0.5 \Omega = 500 \text{ m}\Omega \end{aligned}$$

Calculating V_{th}



$$\begin{aligned} V_{th} &= -2V_1 \times 0.5 \\ V_1 &= V_{in} = 5 \angle 0^\circ \text{ V} \\ V_{th} &= -2 \times 5 \times 0.5 = -5 \angle 0^\circ \\ &= 5 \angle 180^\circ \text{ V} \end{aligned}$$

23.(d)

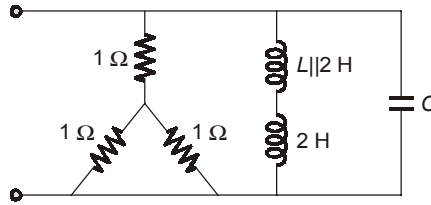


For a parallel resonant circuit

the damping ratio $\xi = \frac{1}{2Q} = \frac{1}{2R_{eq}} \sqrt{\frac{L_{eq}}{C}} = \frac{1}{\sqrt{2}}$

...(i)

given



$$R_{eq} = 1 \parallel 1 + 1 = 1.5 \Omega$$

$$L_{eq} = 2 + \frac{2L}{L+2}$$

$$C_{eq} = \frac{4}{9}$$

From equation (i)

$$\frac{L_{eq}}{C} = \frac{4R_{eq}^2}{2} = 2R_{eq}^2$$

or

$$L_{eq} = 2R_{eq}^2 C = 2 \times (1.5)^2 \times \frac{4}{9} = 2 \text{ H}$$

∴

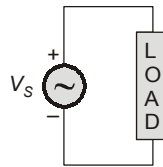
$$L_{eq} = 2H + \frac{2L}{L+2}$$

$$2 + \frac{2L}{L+2} = 2 \text{ H}$$

⇒

$$L = 0 \text{ H}$$

24.(b)



pf = 0.50 lagging

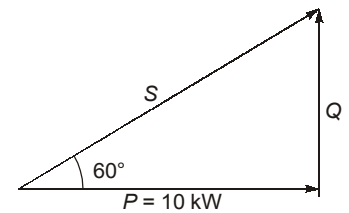
cosφ = 0.5

φ = 60°

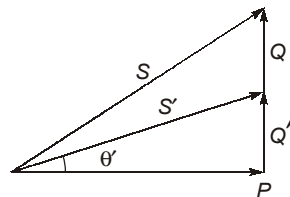
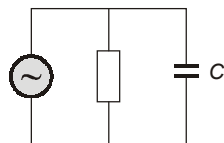
⇒

$$Q = P \tan 60^\circ = 10\sqrt{3} \text{ kVAR}$$

$$S = \sqrt{P^2 + Q^2} = 20 \text{ kVA}$$



Now,



As per question

$$S' = 14.14 = 10\sqrt{2} \text{ kVA}$$

$$P' = 10 \text{ kW}$$

$$\cos \theta' = \frac{p}{s} = \frac{10}{10\sqrt{2}} = \frac{1}{\sqrt{2}}$$

$$\theta' = 45^\circ$$

$$Q' = 10 \text{ kVAR}$$

Reduction in reactive power

$$\begin{aligned} &= (10\sqrt{3} - 10) \text{ kVAR} \\ &= 10(\sqrt{3} - 1) = 10(0.732) \\ &= 7.32 \text{ kVAR} \end{aligned}$$

25. (d)

Let $v_{in}(t)$ be the input voltage while $v_{out}(t)$ be the output voltage

$$h(t) = (e^{-2t} + e^{-3t}) u(t) \text{ V}$$

$$\therefore H(s) = \frac{V_{out}(s)}{V_{in}(s)} = \frac{1}{s+2} + \frac{1}{s+3} = \frac{2s+5}{(s+2)(s+3)}$$

if $v_{out}(t) = te^{-2t} u(t) \text{ V}$

$$V_{out}(s) = \frac{1}{(s+2)^2}$$

However,

$$H(s) = \frac{2s+5}{(s+2)(s+3)} = \frac{V_{out}(s)}{V_{in}(s)}$$

$$\therefore V_{in}(s) = \frac{V_{out}(s)}{H(s)}$$

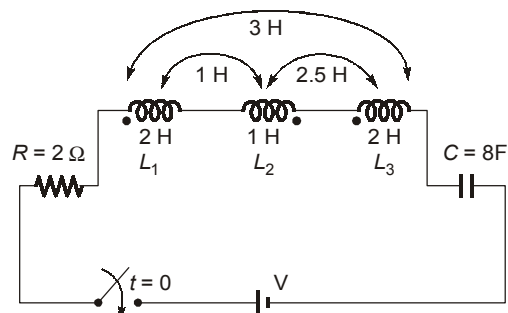
or
$$V_{in}(s) = \frac{1}{(s+2)^2} \times \frac{(s+2)(s+3)}{(2s+5)} = \frac{1}{2} \left[\frac{2}{s+2} - \frac{1}{s+2.5} \right]$$

Taking inverse of Laplace

$$v_{in}(t) = \left(e^{-2t} - \frac{1}{2} e^{-2.5t} \right) u(t) \text{ volts}$$

26.(a)

For the circuit



$$L_{eq} = L_1 + L_2 + L_3 - 2M_{12} - 2M_{23} + 2M_{13}$$

$$L_1 = 2 \text{ H}$$

$$L_2 = 1 \text{ H}$$

$$L_3 = 2 \text{ H}$$

$$M_{12} = 1 \text{ H}$$

$$M_{23} = 2.5 \text{ H}$$

$$\begin{aligned}
 M_{13} &= 3 \text{ H} \\
 L_{eq} &= 2 + 1 + 2 - 2 - 5 + 6 \\
 &= 11 - 7 \\
 &= 4 \text{ H} \\
 C &= 8 \text{ F} \\
 R &= 2 \Omega
 \end{aligned}$$

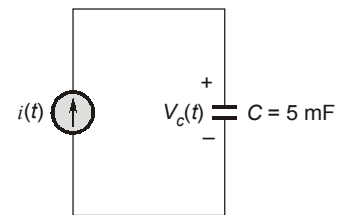
Note : M_{12}, M_{23} is negative, because both L_1, L_2 and L_2, L_3 opposes the flux of respective loops.

$$\xi = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{2}{2} \sqrt{\frac{8}{4}} = \sqrt{2} = 1.414$$

Thus, the given circuit is overdamped.

27.(b)

$$\begin{aligned}
 i &= C \frac{dv}{dt} \\
 V_C &= \frac{1}{C} \int_{-\infty}^t i dt
 \end{aligned}$$

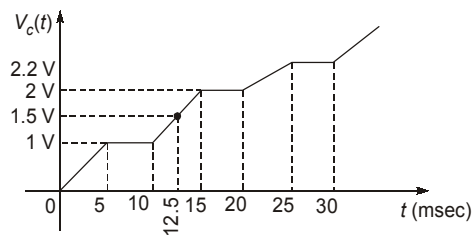


For $0 < t < 5$; Unit step current is applied ; voltage will increase linearly.

For $5 < t < 10$; No current is applied, hence open circuit, the capacitor will hold the charge.

For $10 < t < 15$; again capacitor's voltage increases linearly.

From above analysis,



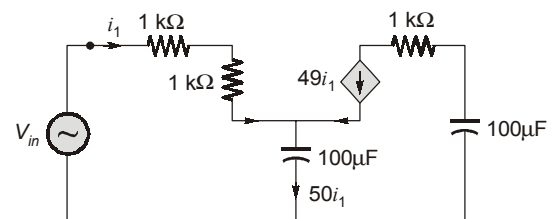
$$V_C(t)|_{12.5 \text{ msec}} = 1.5 \text{ V}$$

28.(b)

Applying KVL,

$$\begin{aligned}
 V_{in} - i_1(1 + 1) - 50 i_1(-jX_C) &= 0 \\
 \Rightarrow V_{in} &= i_1[2 - j50 X_C]
 \end{aligned}$$

$$\text{Input impedance} = \frac{V_{in}}{i_1} = 2 - j50 X_C$$

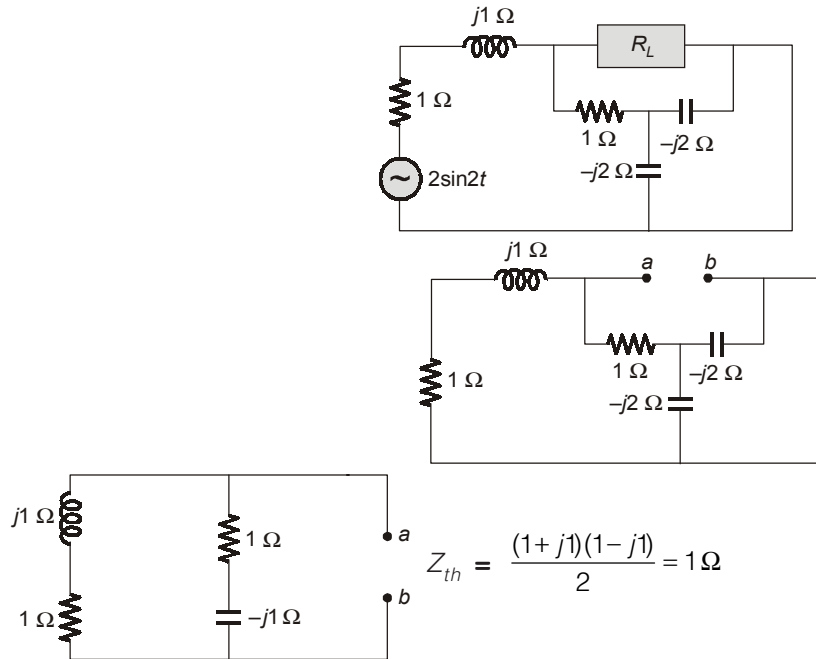


As imaginary part is negative, input impedance has equivalent capacitive reactance X_{Ceq} .

$$\begin{aligned}
 X_{Ceq} &= 50 X_C \\
 \frac{1}{\omega C_{eq}} &= \frac{50}{\omega C} \\
 C_{eq} &= \frac{C}{50} = \frac{100}{50} \mu\text{F} \\
 C_{eq} &= 2 \mu\text{F}
 \end{aligned}$$

29.(b)

Since $(\omega) = 2$ rad/sec, the network is drawn as



$\therefore R_L = |Z_{th}| = 1 \Omega$

Hence, for maximum power to R_L , it should be 1Ω .

30. (d)

$$v(t) = 2\cos(500t + 60^\circ) \text{ V}$$

$$= 2 \angle 60^\circ \text{ V}$$

Using AC phasor

$$i(t) = -\sqrt{3} \cos(500t + 30^\circ) \text{ A}$$

$$v(t) = 2 \angle 60^\circ \text{ V}$$

$$i_1(t) = -i(t) = \sqrt{3} \angle 30^\circ \text{ A}$$

$$\sqrt{3} \angle 30^\circ = \frac{2 \angle 60^\circ}{1 + jX_L} + \frac{2 \angle 60^\circ}{2}$$

$$\sqrt{3} \angle 30^\circ = \frac{2 \left(\frac{1}{2} + j \frac{\sqrt{3}}{2} \right)}{(1 + jX_L)} + \frac{1}{2} + j \frac{\sqrt{3}}{2}$$

By equating real parts on both sides,

$$\frac{3}{2} = \frac{1}{1 + X_L^2} + \frac{1}{2} + \frac{X_L \sqrt{3}}{1 + X_L^2}$$

$$= \frac{1 + X_L \sqrt{3}}{1 + X_L^2} = \frac{3}{2} - \frac{1}{2} = 1 = 1 + X_L \sqrt{3} = 1 + X_L^2$$

$$X_L = \omega L = \sqrt{3} \Omega$$

or $L = \frac{\sqrt{3}}{500} = 3.46 \text{ mH}$

