S.No. : 02 **LS1_EC_B_140519**

Networks Theory

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CLASS TEST 2019-2020

ELECTRONICS ENGINEERING

Networks Theory

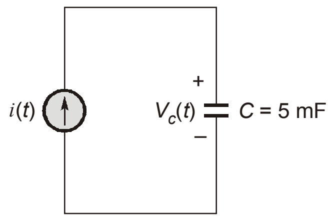
Date of Test : 14/05/2019

Answer Key

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

DETAILED EXPLANATIONS

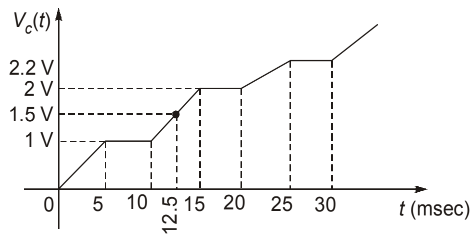
1. (a)



$$i = C\frac{dv}{dt}$$

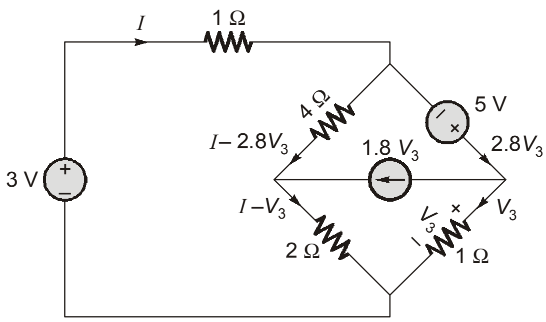
$$V_C = \frac{1}{C}\int_{-\infty}^{t} i\,dt$$

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,



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

3. (b)
Showing the corresponding currents in all the branches, the circuit is shown as below



Now we apply KVL in outer loop

$$-3 + I(1) - 5 + V_3 = 0$$

$$I + V_3 = 8 \quad \text{...(i)}$$

Applying KVL in bridge,

$$-5 + V_3 - 2(I - V_3) - 4(I - 2.8V_3) = 0$$

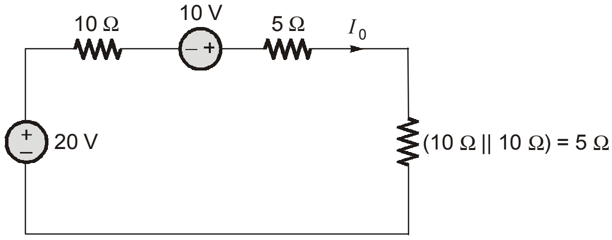
$$14.2\,V_3 - 6\,I = 5$$

$$I = 5.37 \text{ A}$$

$$V_3 = 2.62 \text{ V}$$

4. (b)

Using the source transformation technique, the given circuit can be reduced as shown below:

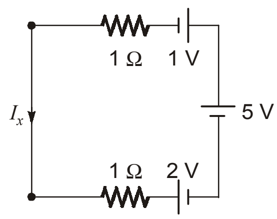


$$I_0 = \frac{20\text{V}+10\text{V}}{10\Omega+5\Omega+5\Omega} = 1.5\text{ A}$$

$$I_x = \frac{I_0}{2} = 0.75\text{ A}$$

5. (a)

Using the source transformation technique, the given circuit can be reduced as shown:



$$I_x = \frac{-1\text{V}+5\text{V}-2\text{V}}{1\Omega+1\Omega} = \frac{2\text{V}}{2\Omega} = 1\text{ A}$$

6. (b)

Resonance frequency, $f_0 = \dfrac{1}{2\pi\sqrt{LC}} = \dfrac{1}{2\pi\sqrt{(10\times10^{-3})(10^{-6})}}\text{ Hz} = \dfrac{10}{2\pi}\text{ kHz} = 1.6\text{ kHz}$

7. (c)

Since total power absorbed or delivered in the circuit

$\Rightarrow \quad \Sigma P = 0;$

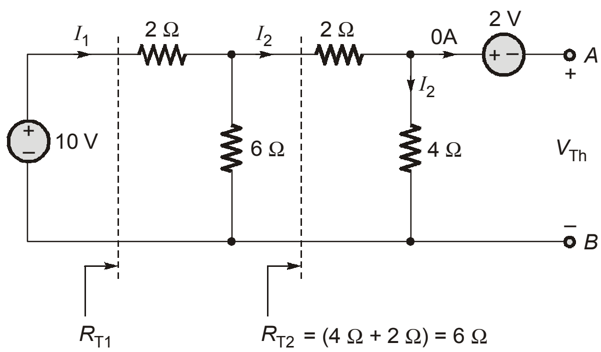
then $\quad -30\times6+6\times12+3V_0+28+28\times2-3\times10=0$

$72+84+3V_0 = 210;$

or $\quad 3V_0 = 54$

$\Rightarrow \quad V_0 = 18\text{ V}$

8. (a)



$$R_{T1} = 2\,\Omega + (6\,\Omega \parallel R_{T2}) = 5\,\Omega$$

$$I_1 = \frac{10}{R_{T1}} = 2\text{ A}$$

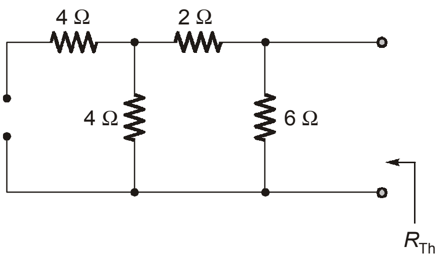
$$I_2 = I_1\times\frac{6\Omega}{R_{T2}+6\Omega} = \frac{I_1}{2} = 1\text{A}$$

$$V_{Th} = (4\,\Omega)\,I_2 - 2\text{ V} = 4\text{ V} - 2\text{ V} = 2\text{ V}$$

9. (b)

Maximum power will be transferred to R_L in the given circuit, when $R_L = R_{Th}$.

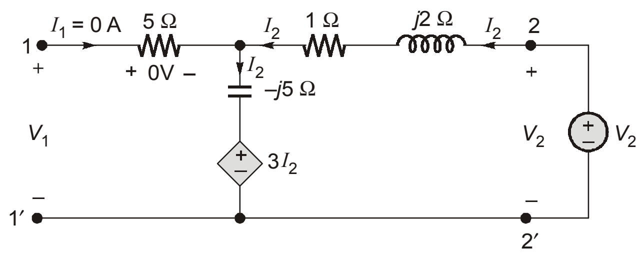
To determine R_{Th} :



$$R_{Th} = (4\ \Omega + 2\ \Omega) \parallel 6\ \Omega = 6\ \Omega + 6\ \Omega = 3\ \Omega$$

10. (a)

$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0 \Rightarrow \text{port} - 1 \text{ is open circuited}}$$



When port-1 is open circuited, i.e. $I_1 = 0$,

$$V_1 = (-j5\ \Omega)I_2 + 3I_2 = (3 - j5)I_2$$

$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0} = (3 - j5)\Omega$$

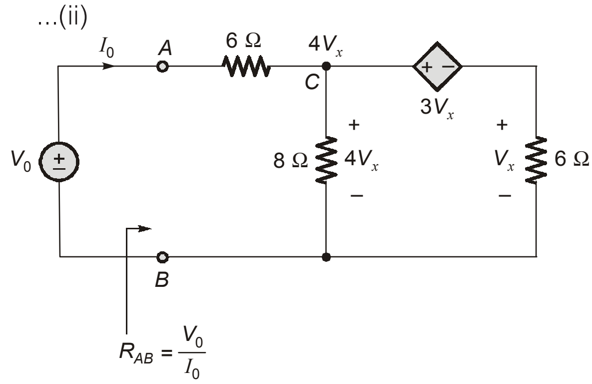
11. (c)

$$R_{AB} = \frac{V_0}{I_0}$$

By applying KCL at node C, we get,

$$I_0 = \frac{4V_x}{8\Omega} + \frac{V_x}{6\Omega} = \frac{4V_x}{6\Omega} \qquad \text{...(i)}$$

Also, $4V_x$ can be written as, $4V_x = V_0 - I_0\,(6\ \Omega)$ ...(ii)

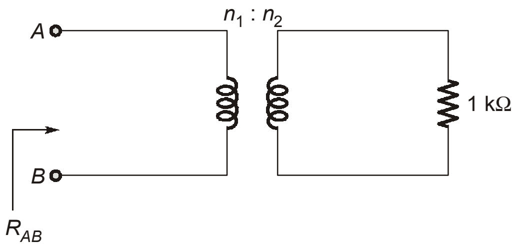


From the equation (i) and (ii), $I_0 = \frac{V_0 - I_0(6\Omega)}{6\Omega}$

$$2I_0 = \frac{V_0}{6\Omega}$$

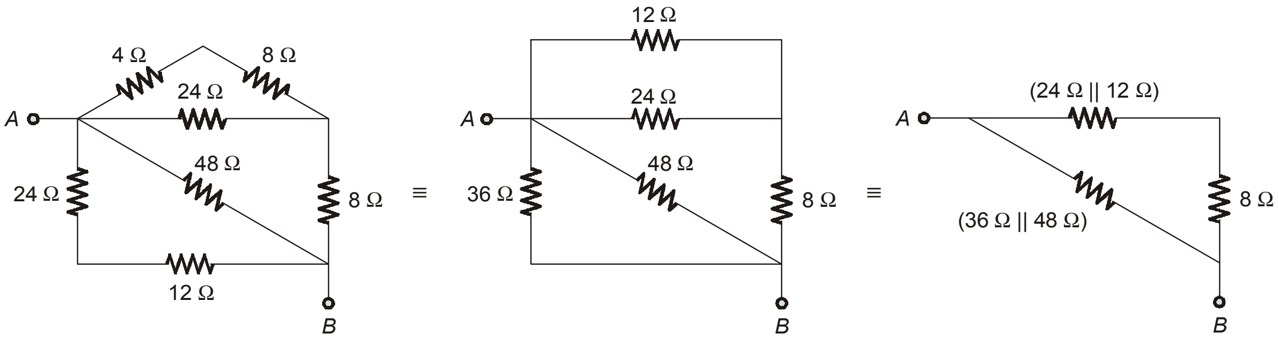
$$R_{AB} = \frac{V_0}{I_0} = 12\ \Omega$$

12 (a)



$$R_{AB} = \left(\frac{n_1}{n_2}\right)^2 (1\,\text{k}\Omega) = \left(\frac{1}{5}\right)^2 (1000)\Omega = 40\ \Omega$$

13. (a)



$$\begin{aligned} R_{AB} &= [(24\ \Omega \parallel 12\ \Omega) + 8\ \Omega] \parallel (36\ \Omega \parallel 48\ \Omega) \\ &= (8\ \Omega + 8\ \Omega) \parallel (36\ \Omega \parallel 48\ \Omega) \\ &= 16\ \Omega \parallel 36\ \Omega \parallel 48\ \Omega = 12\ \Omega \parallel 36\ \Omega = 9\ \Omega \end{aligned}$$

14. (d)

Let the current be shown in the figure

$$i = 0.6\ V_0 + 12$$
$$i = i_1 + i_2$$

Since branches *ab* and *ac* have idential resistance,

Hence, $i_1 = i_2$

and $i = 12 + 0.6\ V_0 = 2i_1 = 2i_2$

$$V_0 = (i_1 \times 2)\ \text{V}$$
$$i = 2i_1, \text{ we write}$$

$$i_1 = \frac{i}{2} = \frac{1}{2}(12 + 0.6V_0)$$

and $V_0 = i_1 \times 2 = i_1 + 0.6\ V_0$

$$V_0 = i_1 \times 2 = 12 + 0.6\ V_0$$

Equation resistance across xe node is:

$$R_{xe} = (5 \parallel 5) + 4 + 1 = 7.5\ \Omega$$

$$\begin{aligned} V_{xe} &= 0.6\ V_0 \times 7.5 + 12 \times 7.5 \\ &= 18 \times 7.5 + 12 \times 7.5 \\ &= 225\ \text{V} \end{aligned}$$

15. (d)

$$I_0 = \frac{I_m}{\sqrt{2}}$$

$$I_m = \frac{V_0}{\omega_0 L}$$

When,
$$v(t) = -V_0 \sin(\omega_0 t) + 4V_0 \sin(4\omega_0 t)$$

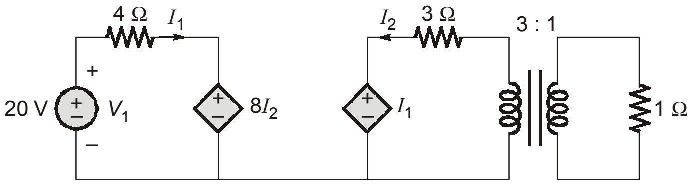
$$i(t) = -\frac{V_0 \sin(\omega_0 t)}{j\omega_0 L} + \frac{4V_0 \sin(4\omega_0 t)}{j4\omega_0 L} = j[I_m \sin(\omega_0 t) - I_m \sin(4\omega_0 t)]$$

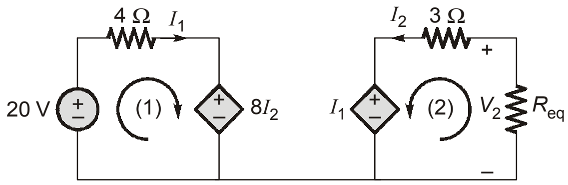
Reading of meter = overall RMS value of $i(t)$

$$= \sqrt{\left(\frac{I_m}{\sqrt{2}}\right)^2 + \left(\frac{I_m}{\sqrt{2}}\right)^2} = I_m = \sqrt{2}\, I_0$$

16. (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
$$V_2 = -9I_2 = I_1 + 3I_2$$

$\Rightarrow$
$$I_1 = -12I_2$$

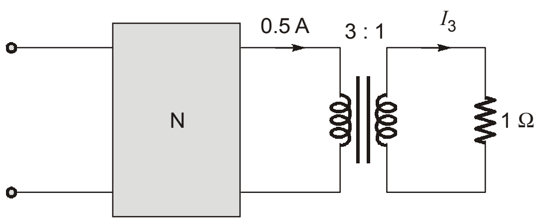
$$20 = 4(-12I_2) + 8I_2$$

$$20 = -40I_2$$

$\Rightarrow$
$$I_2 = -0.5 \text{ A}$$

$$I_1 = -12(-0.5) = 6 \text{ A}$$

Now,

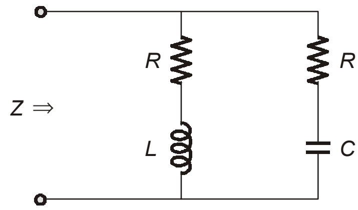


$$\frac{I_{\text{primary}}}{I_{\text{secondary}}} = \frac{1}{3}$$

$\Rightarrow$
$$3I_{\text{primary}} = I_{\text{secondary}}$$

$$3(-I_2) = I_3$$
$$\Rightarrow \quad I_3 = 1.5 \text{ A}$$
$$\text{Power delivered to } 1\ \Omega = (I_3)^2 \times R_L = (1.5)^2 \times 1$$
$$= 2.25 \text{ Watts}$$

17. (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

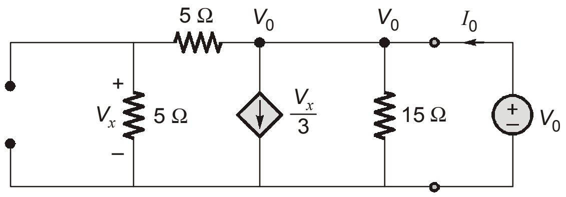
also $\text{Im}(Y) = 0$

$$\Rightarrow \quad X_L(R^2 + X_C^2) = X_C(R^2 + X_L^2)$$
$$R^2 X_L + X_C^2 X_L = R^2 X_C + X_L^2 X_C$$
$$R^2(X_L - X_C) = X_L X_C(X_L - X_C)$$
$$R^2 = X_L X_C = \omega L \times \frac{1}{\omega C} = \frac{L}{C}$$

18. (a)

Maximum power will be delivered to R_L, when $R_L = R_{Th}$.

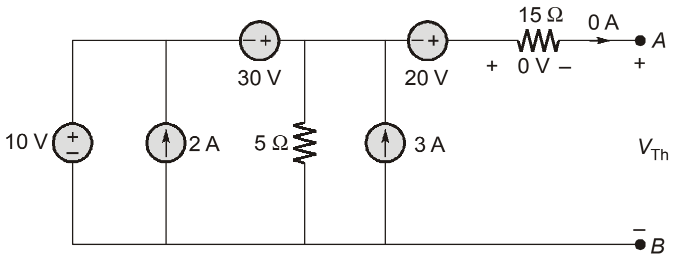
To determine R_{Th} :



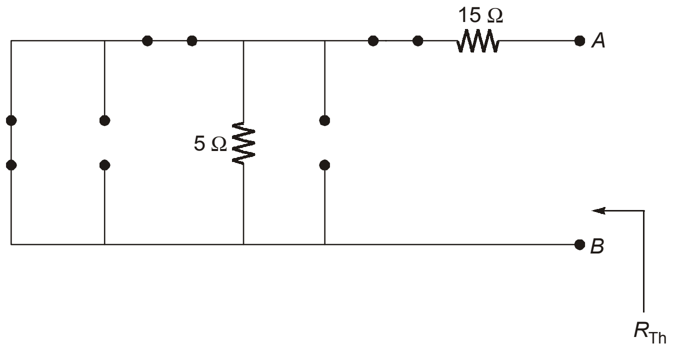
$$I_0 = \frac{V_0}{15\Omega} + \frac{V_x}{3} + \frac{V_0}{10\Omega}$$
$$V_x = \frac{V_0}{2}$$
So,
$$I_0 = \frac{V_0}{15\Omega} + \frac{V_0}{6\Omega} + \frac{V_0}{10\Omega}$$
$$R_{Th} = \frac{V_0}{I_0} = (15\ \Omega \parallel 6\ \Omega \parallel 10\ \Omega) = 3\ \Omega$$

19. (a)

It is very easy to calculate Thevenin's equivalent rather than Norton's equivalent for the given circuit.



$$V_{Th} = 0\text{ V} + 20\text{ V} + 30\text{ V} + 10\text{ V} = 60\text{ V}$$



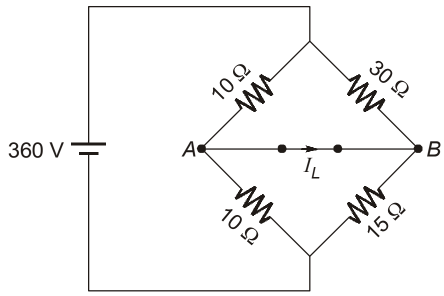
$$R_{Th} = 15\ \Omega + (5\ \Omega \parallel 0\ \Omega) = 15\ \Omega$$

So, $$I_N = \frac{V_{Th}}{R_{Th}} = \frac{60V}{15\Omega} = 4\text{ A}$$

$$R_N = R_{Th} = 15\ \Omega$$

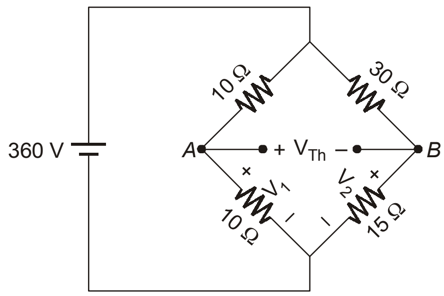
20. (b)

In the steady state condition, for DC excitation , Inductor acts as short circuit.



It is easy to calculate I_L by calculating Thevening equivalent across the terminals *A* and *B*.

To determine V_{Th}:



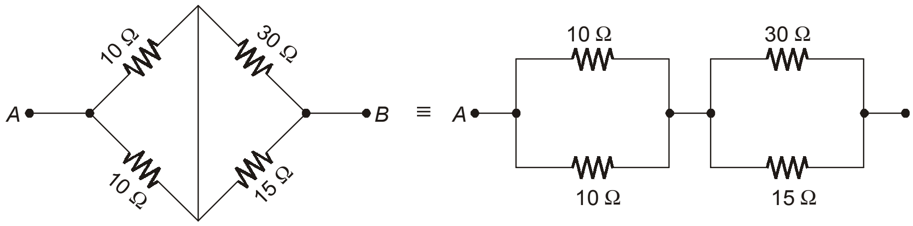
$$V_{Th} = V_1 - V_2$$

$$V_1 = \frac{10}{10+10}\times 360\text{ V} = 180\text{ V}$$

$$V_2 = \frac{15}{15+30}\times 360\text{ V} = 120\text{ V}$$

So, $$V_{Th} = 180\text{ V} - 120\text{ V} = 60\text{ V}$$

To determine R_{Th}:



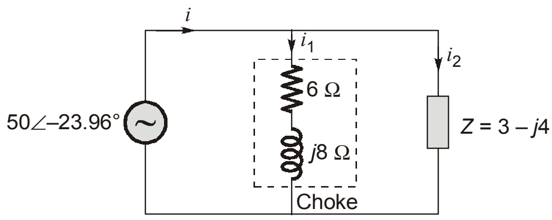
$$R_{Th} = (10\ \Omega \parallel 10\ \Omega) + (30\ \Omega \parallel 15\ \Omega) = 15\ \Omega$$

So, $$I_L = \frac{V_{Th}}{R_{Th}} = 4\,A$$

Steady state energy stored in the inductor is,

$$W_L = \frac{1}{2}LI_L^2 = \frac{1}{2}(2)(4)^2\text{ J} = 16\text{ J}$$

21. (a)



Here, applying KCL

$$i(t) = i_1(t) + i_2(t)$$

$$= \frac{V_1}{6+j8} + \frac{V_1}{3-j4} \Rightarrow \qquad V_1\left(\frac{3-j4+6+j8}{2(3+j4)(3-j4)}\right)$$

$$= \frac{V_1(9+j4)}{2\times 25} \Rightarrow \qquad \frac{50\angle -23.96^\circ \times \sqrt{97}\angle 23.96^\circ}{50}\text{ A}$$

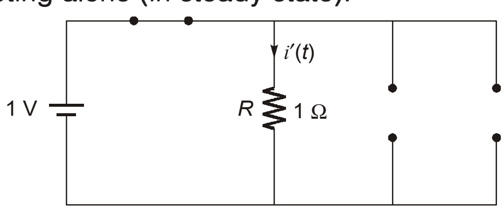
$$= \sqrt{97}\text{ A}$$

$$= 9.85\text{ A}$$

22. (a)

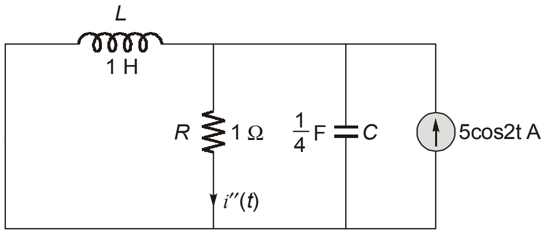
The given circuit has two sources with different frequencies, hence we have to use superposition theorem.

When 1 V DC source is acting alone (in steady state):



$$i'(t) = \frac{1\text{V}}{1\Omega} = 1\text{A}$$

When 5cos 2*t* A AC source is acting alone (in steady state):



The circuit looking like a parallel RLC circuit.

$$\omega_0 = \frac{1}{\sqrt{LC}} = 2 \text{ rad/sec}$$

And the source is also working with 2 rad/sec. So, the circuit will be in resonance.

When the parallel RLC circuit is in resonance, the total source current flows through the resistor.

So, $$i''(t) = 5\cos 2t \text{ A}$$

When both the sources are acting simultaneously,

$$i(t) = i'(t) + i''(t) = (1 + 5\cos 2t) \text{ A}$$

23. (d)

It is clear from the given circuit that, the current flowing through 1 Ω resistor due to either 5 V source alone or 30 A source alone is in the same direction.

So, $$I_{1\Omega} = I'_{1\Omega} + I''_{1\Omega}$$

$$I'_{1\Omega} = \sqrt{\frac{1\text{W}}{1\Omega}} = 1\text{A}$$

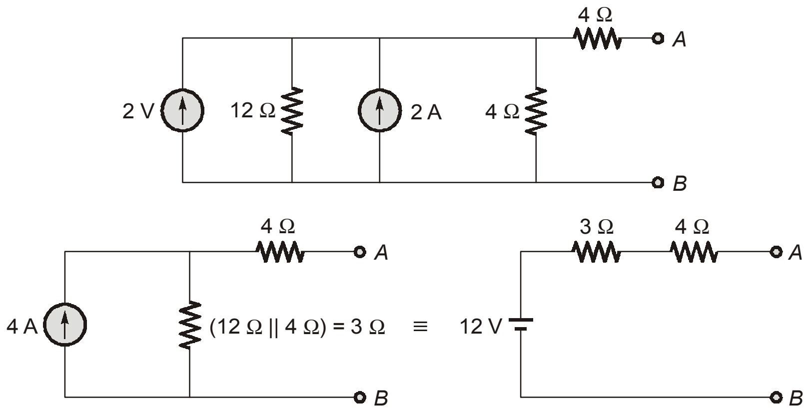
$$I''_{1\Omega} = \sqrt{\frac{576\text{W}}{1\Omega}} = 24\text{A}$$

$$I_{1\Omega} = 24 \text{ A} + 1 \text{ A} = 25 \text{ A}$$

$$P_{1\Omega} = (25 \text{ A})^2 (1 \text{ }\Omega) = 625 \text{ W}$$

24. (b)

By applying source transformation technique, we get,



So, $$V_x = 12 \text{ V}$$

and $$R_x = 7 \text{ }\Omega$$

25. (d)

The voltage across inductor is,

$$v_L = L\frac{di_L}{dt} = L\frac{di_s(t)}{dt}$$

Current across capacitor is given by,

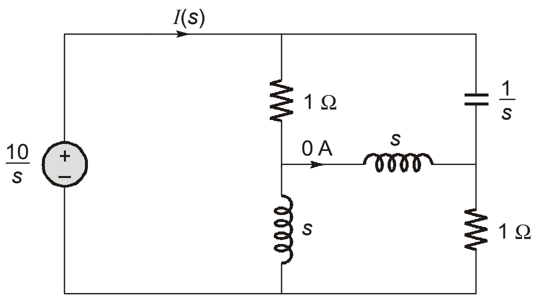
$$i_c = C\frac{dv_c}{dt}$$

$$v_c = 3v_L$$

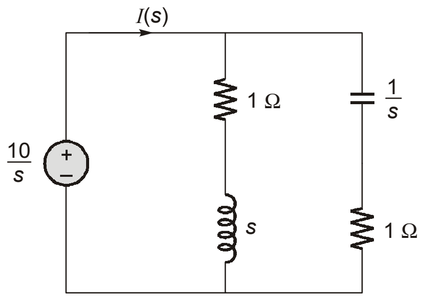
$$\Rightarrow \qquad i_c = 3C\frac{dV_L}{dt} = 3C.L\frac{d^2 i_s(t)}{dt^2} = -9.6 \sin 4t \text{ A}$$

26. (d)

By considering the given circuit in Laplace domain, we get,



Bridge is balanced, hence the circuit can be reduced as,



$$Z(s) = (1+s)\left\|\left(1+\frac{1}{s}\right)\right. = \frac{(1+s)\left(1+\frac{1}{s}\right)}{1+s+1+\frac{1}{s}} = \frac{(s+1)^2}{s^2+2s+1} = 1$$

So, $$I(s) = \frac{10/s}{z(s)} = \frac{10}{s}$$

By taking inverse Laplace transform, we get,

$$i(t) = 10\, u(t) \text{ A}$$

27. (a)

Applying KVL,

$$V_{xy} - j\omega L_2\, i_2 - j\omega\, M\, i_1 = 0$$

as $$i_2 = 0$$

then, $$V_{xy} - j\omega\, M\, i_1 = 0 \qquad \text{...(i)}$$

applying KVL in loop 1

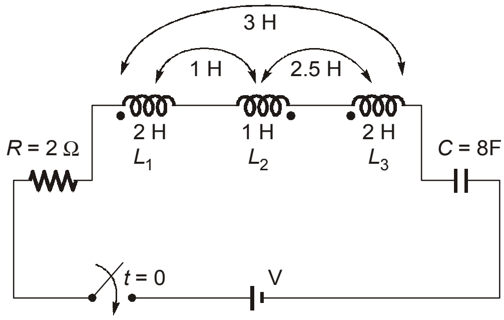
$$V_1 = j\omega L_1\, i_1 \qquad \text{...(ii)}$$

Using value of i_1 from equation (ii) in equation (i)

$$V_{xy} = j\omega M\left[\frac{V_1}{j\omega L_1}\right] = \frac{MV_1}{L_1}$$

28. (a)

For the circuit



$$
\begin{aligned}
L_{eq} &= L_1 + L_2 + L_3 - 2M_{12} - 2M_{23} + 2M_{13} \\
L_1 &= 2\text{ H} \\
L_2 &= 1\text{ H} \\
L_3 &= 2\text{ H} \\
M_{12} &= 1\text{ H} \\
M_{23} &= 2.5\text{ H} \\
M_{13} &= 3\text{ H} \\
L_{eq} &= 2 + 1 + 2 - 2 - 5 + 6 \\
&= 11 - 7 \\
&= 4\text{ H} \\
C &= 8\text{ F} \\
R &= 2\ \Omega
\end{aligned}
$$

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.

29. (b)

For $t > 0$, the given circuit acts like a series RLC circuit,

$$L = 40\text{ H}$$

and $$C = 10\ \mu\text{F}$$

Damping ratio, $$\zeta = \frac{1}{2Q}$$

Quality factor, $$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$ (for series RLC circuit)

So, $$\zeta = \frac{R}{2}\sqrt{\frac{C}{L}}$$

$\zeta \geq 1$ for oscillation free response.

So, $$\frac{R}{2}\sqrt{\frac{C}{L}} \geq 1$$

$$R \geq 2\sqrt{\frac{L}{C}} = 2\sqrt{\frac{40}{10} \times 10^6}$$

$$R \geq 4\ \text{k}\Omega$$
$$R_{min} \geq 4\ \text{k}\Omega$$

30. (c)

In a series *RL* circuit,

$$v_L(t) = V_s e^{-t/\tau}\, u(t)$$
$$v_R(t) = V_s(1 - e^{-t/\tau})\, u(t)$$
$$\tau = \frac{L}{R} = \frac{7\text{H}}{2\Omega} = 3.5 \text{ sec}$$
$$V_s e^{-t/\tau} = V_s(1 - e^{-t/\tau})$$
$$2e^{-t/\tau} = 1$$
$$-\frac{t}{\tau} = \ln(1/2)$$
$$t = \tau \ln(2) = 2.426 \text{ sec}$$

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