CLASS TEST

S.No.: 01SK_ECEE_ABCD_280324

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NETWORK THEORY

EC-EE

Date of Test : 28/03/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

The circuit will act as an ideal current source if impedance is infinite

$$\therefore \quad Z = \frac{(j\omega L)\left(\frac{1}{j\omega C}\right)}{j\omega L + \frac{1}{j\omega C}} = \frac{j\omega L}{-\omega^2 LC + 1}$$

Now, put Z = ∞

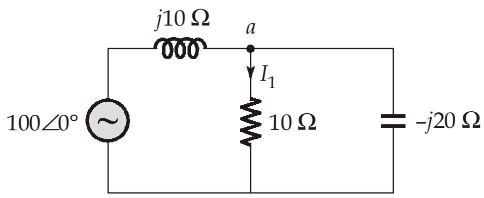
$$\Rightarrow \quad 1 - \omega^2 LC = 0$$

$$\therefore \quad \omega = \frac{1}{\sqrt{LC}}$$

$$\omega = \frac{1}{\sqrt{10\times10^{-3}\times25\times10^{-6}}} = \frac{1}{5\times10^{-4}}$$

$$\omega = 2 \text{ k rad/sec}$$

2. (c)



Applying nodal analysis at node a,

$$\frac{V_a}{10} + \frac{V_a}{-j20} + \frac{V_a - 100\angle 0^\circ}{j10} = 0$$

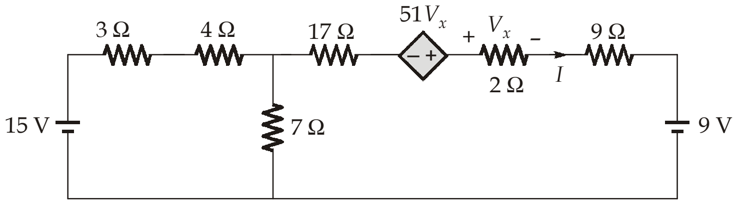
$$\Rightarrow \quad V_a = \frac{200}{1+2j}$$

$$I_1 = \frac{V_a}{10} = \frac{20}{1+2j} = 8.94\angle -63.44^\circ \text{ A}$$

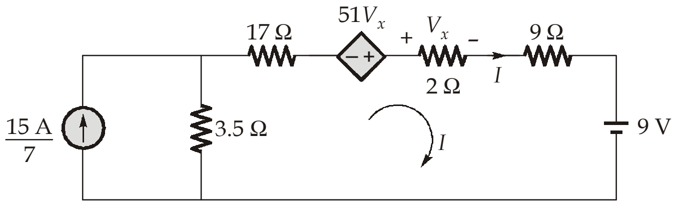
3. (c)

Applying source transformation:

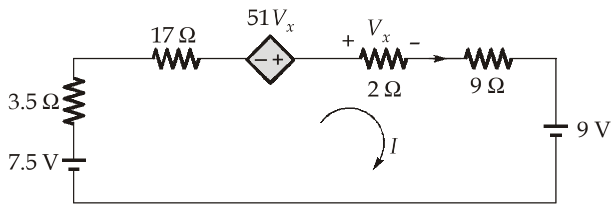
Step 1:



Step 2:



Step 3:



Applying KVL in the loop, we get:

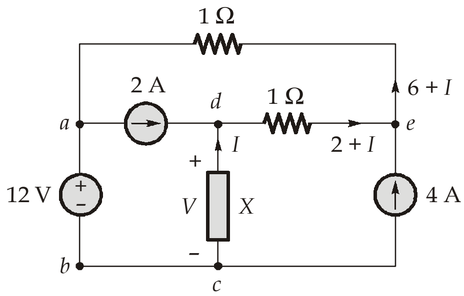
$$7.5 + 51V_x - 9 - 31.5I = 0$$

$$7.5 - 9 = 31.5\,I - 102\,I \qquad \{\because\ V_x = 2I\}$$

$$-1.5 = -70.5\,I$$

$$I = 21.28 \text{ mA}$$

4. (c)



Applying KVL in loop *abcde*,

$$-12 + V - (2 + I) - (6 + I) = 0$$

$$-12 + V - 2 - I - 6 - I = 0$$

$$V = 2I + 20$$

$$\Rightarrow \qquad A = 2\ \Omega \quad ; \quad B = 20 \text{ V}$$

5. (a)

$$X_L = \omega L = 2500 \times 16 \times 10^{-3} = 40\ \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2500 \times 10 \times 10^{-6}} = 40\ \Omega$$

$\because$ $X_L = X_C$

$\therefore$ The tank circuit will be open circuited.

Hence, the current flowing in the circuit will be zero.

6. (c)

Bandwidth, $B = \omega_2 - \omega_1 = 101 - 99 = 2$ k rad/sec

$$B = \frac{1}{RC} = 2 \times 10^3$$

$$C = \frac{1}{100 \times 10^3 \times 2 \times 10^3} = 5 \text{ nF}$$

$$\omega_1 = \omega_0 - \frac{B}{2}$$

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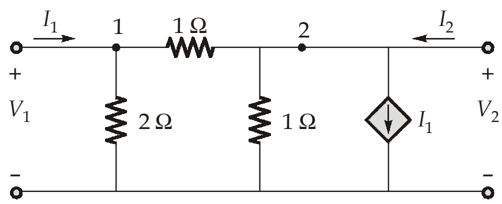
$$\Rightarrow \qquad \omega_0 = \omega_1 + \frac{B}{2} = 99 + 1 = 100 \text{ k rad/sec}$$

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

$$\Rightarrow \qquad LC = \frac{1}{\omega_0^2} \quad \Rightarrow \quad L = \frac{1}{10^{10} \times 5 \times 10^{-9}} = 20 \text{ mH}$$

7. (c)



Applying nodal analysis at node 1:

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

$$I_1 = \frac{3}{2}V_1 - V_2 \qquad \text{...(i)}$$

Applying nodal analysis at node 2:

$$\frac{V_2}{1} + \frac{V_2 - V_1}{1} = -I_1 + I_2$$

$$\Rightarrow \qquad I_2 = \frac{1}{2}V_1 + V_2 \qquad \text{...(ii)}$$

Comparing equation (i) and (ii) with general equations of Y-parameter, we get

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

8. (a)

$$I(s) = \frac{I_0}{s^2}; \quad I_L(s) = \left[\frac{5}{s^2} - \frac{1}{s}\right] + \frac{1}{s+5}$$

$$I_L(s) = I(s)\left[\frac{1}{1+sL}\right]$$

$$\left[\frac{5}{s^2} - \frac{1}{s}\right] + \frac{1}{s+5} = \frac{I_0}{s^2(1+sL)}$$

$$\frac{5-s}{s^2}+\frac{1}{s+5} = \frac{I_0}{s^2[1+sL]}$$

$$\frac{(25)}{s^2(s+5)} = \frac{I_0/L}{s^2\left(s+\frac{1}{L}\right)}$$

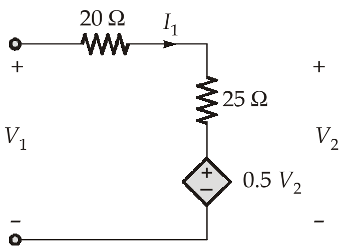
$\Rightarrow$ $$L = \frac{1}{5} = 0.2\text{ H}; \quad \frac{I_0}{L} = 25$$

$$\Rightarrow \quad I_0 = 25L = 5\text{A}$$

9. (b)

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

If $I_2 = 0$, then the circuit becomes:



Applying KVL:

$$V_1 - 20I_1 - 25I_1 - 0.5V_2 = 0$$

$$V_1 = 45I_1 + 0.5V_2 \qquad \text{...(1)}$$

$$V_2 = 25I_1 + 0.5V_2$$

$$V_2 = 50I_1 \qquad \text{...(2)}$$

solving (1) and (2): $$Z_{11} = \frac{V_1}{I_1} = 70\ \Omega$$

10. (c)

$$V_c(j\omega) = V_i(j\omega)\left[\frac{\frac{-j}{\omega C}}{2\times10^3+\frac{-j}{\omega C}}\right]$$

$$V_c(j\omega) = V_i(j\omega)\left[\frac{1}{1+j2\times10^3\times\omega\times C}\right]$$

Also, $$V_0(j\omega) = \left[\frac{30\text{k}}{15k+30k}\right]AV_c(j\omega)$$

$$V_0(j\omega) = \frac{2A}{3}V_c(j\omega)$$

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$$\therefore \quad \frac{V_0(j\omega)}{V_i(j\omega)} = \frac{2A/3}{1 + j2\times 10^3 \times C \times \omega}$$

On comparing, $A = 6$ and $C = 5\ \mu F$.

11. (b)

$$P = I_{rms} V_{rms} \cos\theta$$

$$\Rightarrow \quad 1000\text{ W} = I_{rms} V_{rms} \times 0.8$$

$$\Rightarrow \quad I_{rms} V_{rms} = \frac{1000}{0.8} = 1250$$

$$\Rightarrow \quad \frac{V_{rms}^2}{I_{rms}\times V_{rms}} = \frac{(200)^2}{1250} = |Z|$$

$$\therefore \quad |Z| = 32\ \Omega$$

$\because$ Power factor is leading, $\theta < 0°$

$$\angle Z = \theta = -\cos^{-1} 0.8 = -36.86°$$

$$\therefore \quad Z = |Z|\angle Z = 32\angle -36.86° = 25.6 - j19.2\ \Omega$$

12. (d)

$$I_{rms} = \frac{V_{rms}}{Z}$$

$$= \frac{100\angle 0°}{6 + j15 - j7} = \frac{100}{6 + j8} = 6 - j8$$

Complex power supplied by the source,

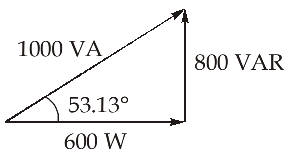
$$S = V_{rms}\ I_{rms}^{*} = 100(6 + j8)$$

$$S = 600 + j800\text{ VA} = 1000\angle 53.13°$$

As we know that, $S = P + jQ$

$\therefore$ $P = 600$ W, $Q = 800$ VAR

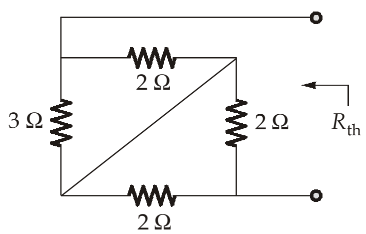
and power factor angle, $\theta = 53.13°$



13. (c)

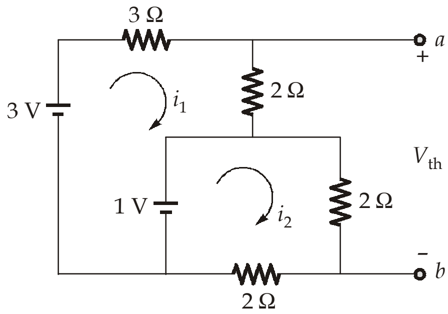
Using Thevenin's theorem taking 1 Ω as load:

- **Thevenin's equivalent resistance, R_{th}:**



$$R_{th} = (3 \parallel 2) + (2 \parallel 2) = 1.2 + 1 = 2.2\ \Omega$$

- **Thevenin's Equivalent Voltage, V_{th}:**
  Using source transformation, we get



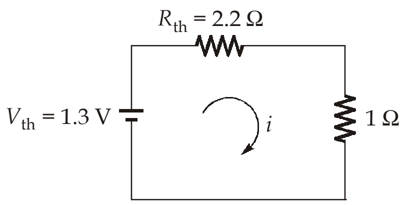
$$i_1 = \frac{3-1}{5} = 0.4 \text{ A}; \quad i_2 = \frac{1}{4} = 0.25 \text{ A}$$

Applying KVL in outer loop:

$$V_{th} + 3i_1 - 3 + 2i_2 = 0$$

$$\therefore \quad V_{th} = 1.3 \text{ V}$$

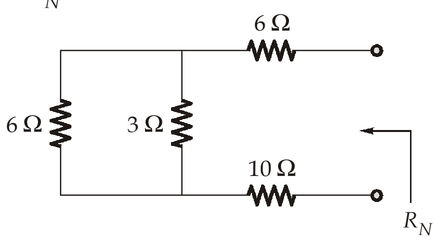
Now,



$$i = \frac{1.3}{2.2+1} = 0.406 \text{ A}$$

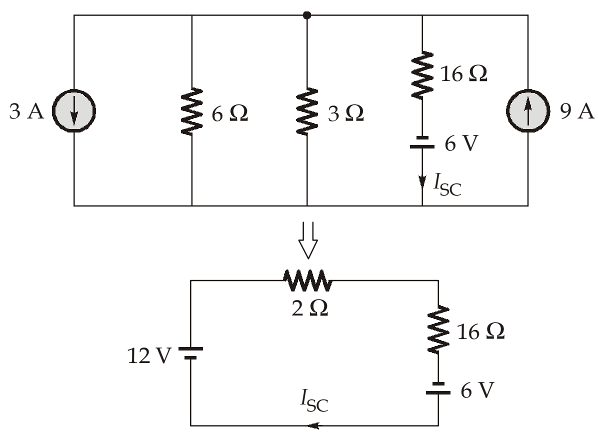
14. (d)

Norton equivalent resistance R_N :



$$\therefore \quad R_N = 18 \ \Omega$$

Norton current, I_{SC} :



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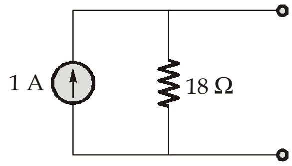
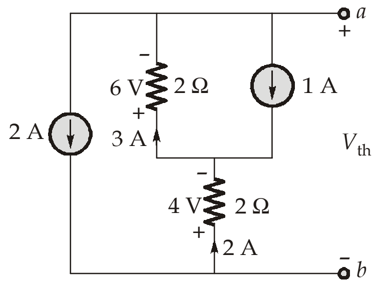
$$I_{SC} = \frac{12+6}{18} = 1\text{ A}$$

∴ Norton equivalent circuit will be



15. **(c)**

The Thevenin's voltage across *ab* is

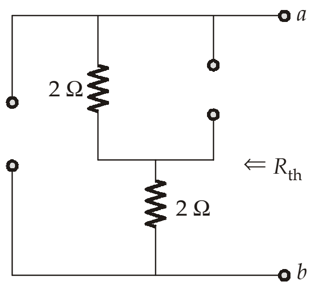


$$+V_{th} + 6\text{ V} + 4\text{ V} = 0$$

∴ $$V_{th} = -10\text{ V}$$

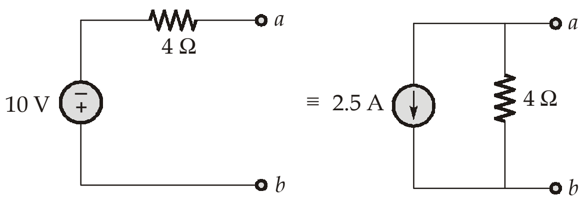
Thevenin's resistance, R_{th}:

by open circuiting all independent current sources,



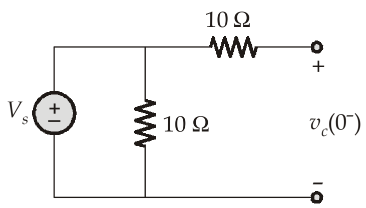
∴ $R_{th} = 4\ \Omega$

∴ The Norton's equivalent circuit is



16. **(c)**

At $t = 0^-$

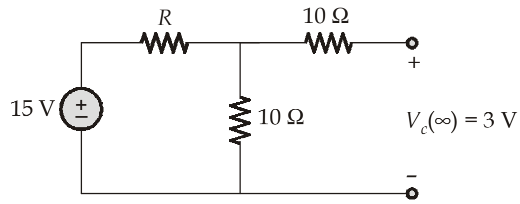


$$v_c(0^-) = 3 + 12e^0 = 15 \text{ V}$$

$\therefore$ $$V_s = 15 \text{ V}$$

At $t = \infty$

$$v_c(\infty) = 3 \text{ V}$$



$\therefore$ $$3 = \frac{15\times 10}{10+R}$$

$\Rightarrow$ $$R = 40\ \Omega$$

$$R_{eq} = (40 \| 10) + 10 = 18\ \Omega$$

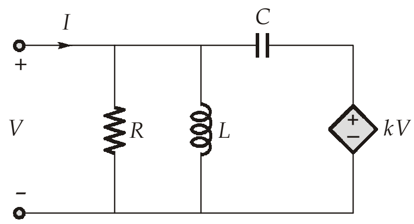
$$\text{Time constant, } \tau = R_{eq}C = 18C = \frac{1}{5.56}$$

$\Rightarrow$ $$C = \frac{1}{18\times 5.56}$$

$$C \simeq 10 \text{ mF}$$

17. **(a)**

The equivalent impedance of the network can be found as:



$$R_{eq} = \frac{V}{I}$$

$\therefore$ $$\frac{V}{R} + \frac{V}{jX_L} + \frac{V-kV}{-jX_C} = I$$

$$\frac{I}{V} = \left[\frac{1}{R} + \frac{1}{j\omega L} + j\omega C(1-k)\right]$$

$$Y(j\omega) = \frac{1}{R} + j\left[\omega C(1-k) - \frac{1}{\omega L}\right]$$

At resonance, imaginary part of input admittance becomes zero.

$\therefore$ $$\omega_0 = \frac{1}{\sqrt{LC(1-k)}}$$

For a parallel RLC circuits, quality factor is

$$Q = \frac{R}{\omega_0 L} = \frac{R\sqrt{LC(1-k)}}{L} = R\sqrt{\frac{C(1-k)}{L}}$$

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18. **(b)**

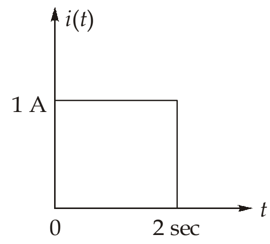
$$v_0(t) = 2e^{-t}$$

Taking Laplace transform, $V_0(s) = \dfrac{2}{s+1}$

$$V_0(s) = Z(s)\ I(s)$$

$\therefore$ $Z(s) = V_0(s)$ $\{\because i(t) = \delta(t)\}$

When $i(t)$ is a pulse i.e. $i(t) = u(t) - u(t-2)$



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

$\Rightarrow$ $$V_0(s) = \frac{2}{s+1}\left[\frac{1}{s} - \frac{e^{-2s}}{s}\right]$$

$$V_0(s) = \frac{2}{s(s+1)} - \frac{2e^{-2s}}{s(s+1)}$$

Taking inverse Laplace transform:

$$v_0(t) = 2[u(t) - e^{-t}u(t)] - 2[u(t-2) - e^{-(t-2)}\ u(t-2)]$$

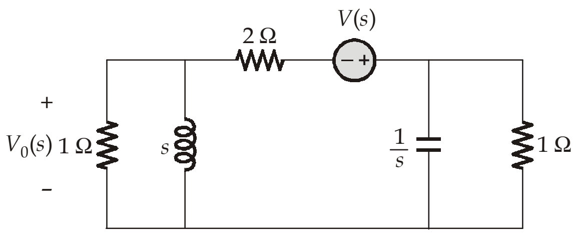
At $t = 3$ sec, $v_0(t) = 2[1 - e^{-3} - 1 + e^{-1}]$

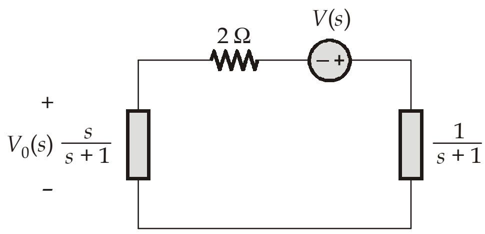
$$= 2[e^{-1} - e^{-3}]$$

$$= 0.636 \text{ V}$$

19. **(b)**

Applying source transformation and transforming the circuit into s-domain.





$$V_0(s) = V(s)\frac{s}{3(s+1)}$$

$$V_0(j\omega) = V(j\omega)\frac{j\omega}{3(j\omega+1)}$$

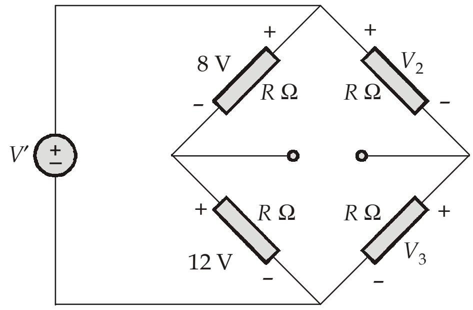
$$= 30\angle 0^\circ \times \frac{1\angle 90^\circ}{3\sqrt{2}\angle 45^\circ}$$ $\{\therefore \omega = 1 \text{ rad/sec}\}$

$$V_0(j\omega) = 5\sqrt{2}\angle 45°$$

$\therefore$
$$v_0(t) = 5\sqrt{2}\cos(t+45°)\ \text{V}$$

20. (d)

Under bridge balance condition, (since current through 6 Ω resistor is zero).

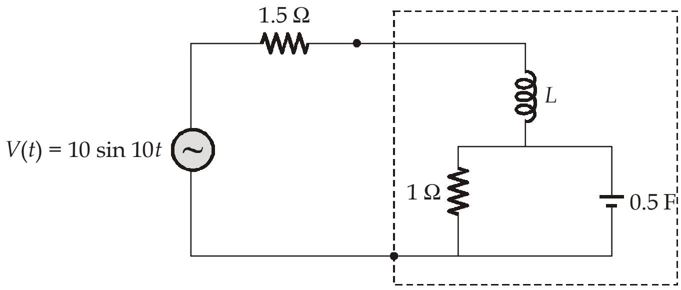


$$V' = 8 + 12 = V_2 + V_3$$

$\Rightarrow$
$$V_2 + V_3 = 20\ \text{V}$$

Option (d) satisfies the above condition.

21. (a)



The maximum power is transferred at the frequency at which the load is resistive and it is equal to 1.5 Ω i.e., the load is resistive means the imaginary part of the load is equal to zero.

$$Z_{\text{load}} = \frac{1\times\frac{2}{s}}{1+\frac{2}{s}} + Ls = \frac{2}{s+2} + Ls$$

$$= \frac{2(s-2)}{s^2-4} + Ls$$

Put $s = j\omega$

$$Z_{\text{load}} = \frac{2(j\omega-2)}{-\omega^2-4} + j\omega L$$

$$= \frac{2(j10-2)}{-104} + j10L$$

$$Z_{\text{load}} = \frac{4}{104} + j\left(10L - \frac{20}{104}\right)$$

equating imaginary part to zero.

$$10L = \frac{20}{104}$$

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$$\therefore \qquad L = \frac{20}{10 \times 104} = 19.23 \text{ mH}$$

22. (b)

The reactive power in the circuit is

$$Q \propto \sin\theta$$

If Q is positive then angle of impedance (θ) is positive which implies that current phasor is lagging voltage phasor i.e., load is inductive.

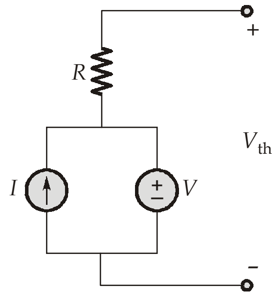
$$Z = \frac{V\angle\theta_V}{I\angle\theta_I} = \frac{V}{I}\angle\theta_V - \theta_I$$

$$\theta_V > \theta_I$$

Hence, an inductive load has lagging power factor.

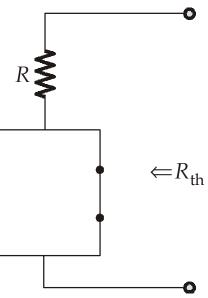
23. (d)

Given, circuit,



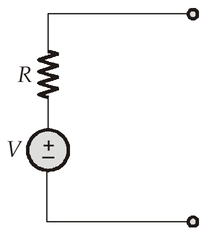
The open circuit voltage (Thevenin voltage V_{th}) is equal to V.

For Thevenin's resistance : R_{th}, by setting all independent sources to zero, i.e., open circuit the current source and short circuit the voltage source.



$$\therefore \qquad R_{th} = R$$

The equivalent circuit is



24. (c)

In series RLC circuit at resonance,

$$\text{Current, } I_R = \frac{V_s}{R}$$

Voltage across inductor is, $V_L = j\omega_0 L I_R = j\omega_0 L \frac{V_s}{R}$

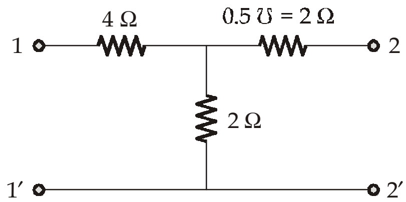
$V_L = jQV_s$

where, $Q = \frac{\omega_0 L}{R}$

Since, $Q > 1 \Rightarrow V_L > V_S$

25. **(b)**

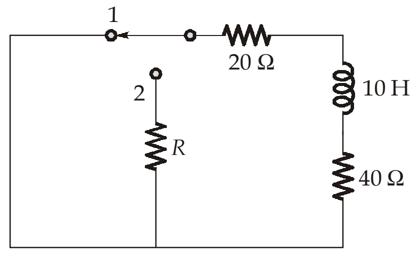
Given, two port network



$\therefore$ $$[z] = \begin{bmatrix} 6 & 2 \\ 2 & 4 \end{bmatrix} \Omega$$

26. **(a)**

After the switch moves to position 1, the circuit can be drawn as below,



$\therefore$ $$\text{time constant, } \tau = \frac{L}{R_{eq}} = \frac{10}{20+40} = 0.167 \text{ sec}$$

27. **(c)**

Given, $\omega_o = 1000 \text{ rad/s}$

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

Resonant frequency, $$\omega_o^2 = \frac{1}{LC}$$

$\Rightarrow$ $$L = \frac{1}{\omega_o^2 \times C}$$

$\therefore$ $$L = \frac{1}{10^6 \times 0.2 \times 10^{-6}} = \frac{1}{0.2} = 5 \text{ H}$$

For parallel *RLC* circuit, *Q*-factor,

$$Q = \omega_o RC$$

$\Rightarrow$ $$R = \frac{Q}{\omega_o C}$$

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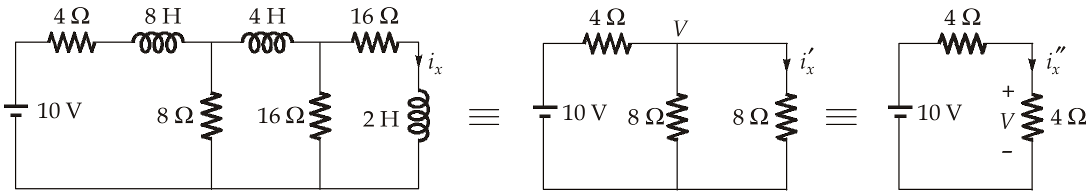
$$\therefore \quad R = \frac{80}{10^3 \times 0.2 \times 10^{-6}} = \frac{80}{0.2 \times 10^{-3}} = 400\text{ k}\Omega$$

$$\therefore \quad \frac{L}{R} = \frac{5}{400 \times 10^3} = 12.5 \times 10^{-6}\text{ s}^{-1}$$

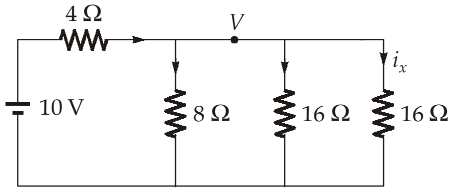
28. (b)

As the circuit has been connected for a long time. Therefore, the inductors behave like a short circuit for the dc voltage source,

∴ The circuit can be redrawn as



$$V = \frac{10}{(4+4)} \times 4 = 5\text{ V}$$



By KCL,

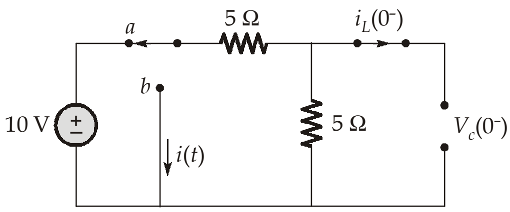
$$i_x = \frac{V}{16} = \frac{5}{16}\text{ A}$$

29. (a)

At $t = 0^+$:

The switch is in position '*a*' and the independent source is connected from a long time to circuit. Hence, the circuit is in steady state.

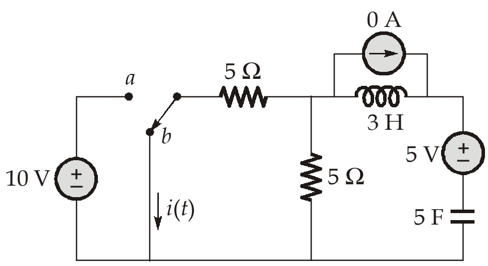
Hence, inductor and capacitor are replaced by short circuit and open circuit respectively.



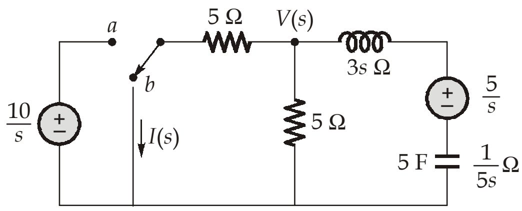
$$i_L(0^-) = 0 = i_L(0^+)$$

$$V_c(0^-) = \frac{10 \times 5}{5+5} = 5\text{ V} = V_c(0^+)$$

At $t > 0$: The switch is moved to position *b*,



By using Laplace transform approach.



Let $V(s)$ be the node voltage.
by nodal analysis:

$$\frac{V(s)}{5} + I(s) + \frac{V(s) - \frac{5}{s}}{3s + \frac{1}{5s}} = 0$$

but, $$V(s) = 5 \times I(s)$$

$$\frac{5I(s)}{5} + I(s) + \frac{5I(s) - \frac{5}{s}}{3s + \frac{1}{5s}} = 0$$

$$2I(s) + \frac{5I(s) - \frac{5}{s}}{3s + \frac{1}{5s}} = 0$$

$$6sI(s) + \frac{2}{5s}I(s) + 5I(s) - \frac{5}{s} = 0$$

$$I(s)\left[5 + 6s + \frac{2}{5s}\right] = \frac{5}{s}$$

$$I(s) = \frac{\frac{5}{s}}{5 + 6s + \frac{2}{5s}}$$

$$= \frac{\frac{5}{s} \times 5s}{25s + 30s^2 + 2}$$

$$\therefore \quad I(s) = \frac{25}{30s^2 + 25s + 2}$$

$$I(s) = \frac{\frac{5}{6}}{s^2 + \frac{5}{6}s + \frac{1}{15}}$$

$$= \frac{\frac{5}{6}}{(s + 0.0896)(s + 0.7436)}$$

$$I(s) = \frac{1.274}{s + 0.0896} - \frac{1.274}{s + 0.7436}$$

$$\therefore \quad i(t) = 1.274(e^{-0.0896t} - e^{-0.7436t})u(t);\ t > 0$$

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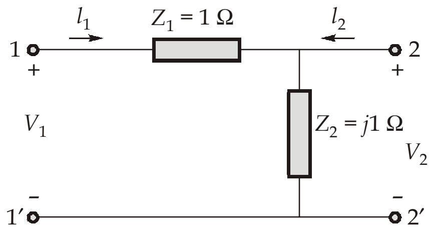
30. (a)

Given, two port circuit is,



We know that, h-parameters for any two port circuit is defined as

$$V_1 = h_{11}I_1 + h_{12}V_2$$
$$I_2 = h_{21}I_1 + h_{22}V_2$$

$\therefore$
$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} \qquad h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$$

$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} \qquad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$$

$\therefore$
$$h_{11} = z_1 = 1\ \Omega \quad h_{21} = \frac{I_2}{I_1} = -1$$

$$h_{12} = \frac{V_1}{V_2} = 1 \qquad h_{22} = -j1\ \mho$$

$$[h] = \begin{bmatrix} 1 & 1 \\ -1 & -j1 \end{bmatrix}$$

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