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NETWORK THEORY

EC-EE

Date of Test : 04/04/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

$$R_L = \left|Z_s^*\right| = |5 - j10| = \sqrt{5^2 + 10^2} = 11.18\,\Omega$$

2. (b)

At $t = \infty$, capacitor is open circuited

$$V = 2 \times \frac{3}{2} = 3\text{ V}$$

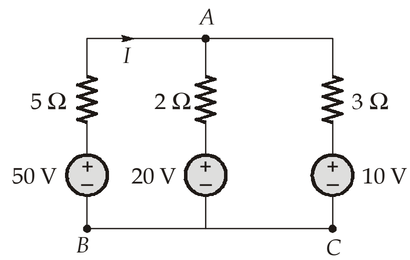
3. (a)

$$V_5 = 20 \times 5 = 100\text{ V}$$

$$\text{Voltage across } 10\,\Omega = 20\text{ V} = V_{10}$$

$$V_{Th} = V_5 - V_{10}$$
$$= 100 - 20 = 80\text{ V}$$

4. (a)



Using nodal analysis,
KCL at node 'A'

$$\frac{50 - V_A}{5} = \frac{V_A - 20}{2} + \frac{V_A - 10}{3}$$

$$V_A = 22.580\text{ V}$$

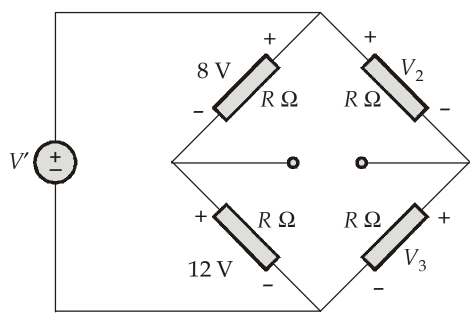
So,
$$I = \frac{50 - 22.580}{5} = 5.483\text{ A}$$

So, power delivered by 50 V is,

$$50 \times I = 50 \times 5.483 = 274.2\text{ Watts}$$

5. (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.

6. (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.

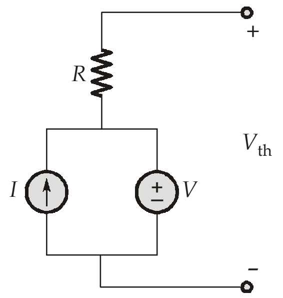
$$Z = \frac{V\angle\theta_V}{I\angle\theta_I} = \frac{V}{I}\angle\theta_V - \theta_I$$

$$\theta_V > \theta_I$$

Hence, an inductive load has lagging power factor.

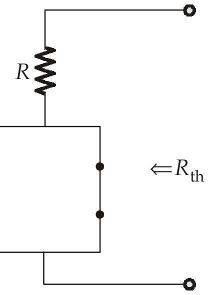
7. (d)

Given, circuit,



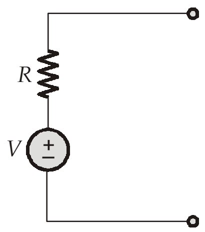
The open circuit voltage (Thevenin voltage V_{th}) is equal to V.

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.



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

The equivalent circuit is



8. (c)

In series RLC circuit at resonance,

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

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

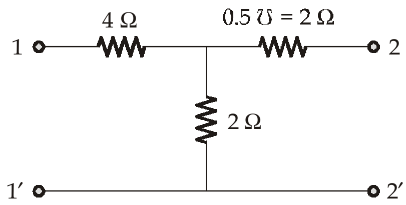
$$V_L = jQV_s$$

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

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

9. **(b)**

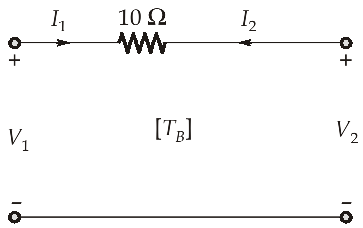
Given, two port network



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

10. **(b)**

When 2 Ω is replaced by 10 Ω,



From the above figure, we get,

$$V_1 - V_2 = 10I_1 \quad \text{...(i)}$$

and $$V_2 - V_1 = 10I_2 \quad \text{...(ii)}$$

From T parameter model,

$$V_1 = AV_2 - BI_2$$

and $$I_1 = CV_2 - DI_2$$

from equation (ii), we get,

$$V_1 = V_2 - 10I_2 \qquad \Rightarrow A = 1 \text{ and } B = 10$$

from equation (i), we get,

$$V_2 - 10I_2 - V_2 = 10I_1$$

$$-I_2 = I_1 \qquad \Rightarrow C = 0 \text{ and } D = 1$$

$$\therefore \qquad T_B = \begin{bmatrix} 1 & 10 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 0 & 1 \end{bmatrix}^5 = [T_A]^5$$

11. **(b)**

$$Z_{AB} = \left(\frac{23}{6}\right) + \left[(3+j4) \| (3-j4)\right]$$

$$= \frac{23}{6} + \frac{(3+j4)(3-j4)}{6} = \frac{23+25}{6} = \frac{48}{6}\Omega = 8\,\Omega$$

$$\therefore \qquad Z_{AB} = 8\ \Omega$$

12. (a)

$$L_{eq} = L_1 + L_2 - 2M = 4 + 4 - 2 \times 2 = 4 \text{ mH}$$

Resonant frequency,
$$f_o = \frac{1}{2\pi\sqrt{L_{eq}C}}$$

$$f_o = \frac{1}{2\pi\sqrt{4\times 0.1\times 10^{-9}}} = 7.96 \text{ kHz}$$

13. (b)

Impedance matrix for 'N' $= \frac{1}{[Y]} = \frac{1}{5}\begin{bmatrix} 3 & -2 \\ -2 & 3 \end{bmatrix} = \begin{bmatrix} 3/5 & -2/5 \\ -2/5 & 3/5 \end{bmatrix}$

In series connection: individual impedance parameters are added

$\therefore$ For individual network $= \frac{1}{2}\begin{bmatrix} 3/5 & -2/5 \\ -2/5 & 3/5 \end{bmatrix} = \begin{bmatrix} 0.3 & -0.2 \\ -0.2 & 0.3 \end{bmatrix}$

14. (c)

$$v(t) = 2[u(t) - u(t-2)] \text{ V}$$

$$i(t) = [r(t) - r(t-2)] \text{ A}$$

$$v(t) = 2\frac{di(t)}{dt}$$

For inductor,
$$v(t) = L\frac{di(t)}{dt}$$

$\therefore$ The element is inductor of 2 H

15. (b)

From the given data:

$$V = 20\sin(2000t + 40°)$$
$$i = 5\sin(2000t + 10° + 90°) = 5\sin(2000t + 100°)$$

The current leads the voltage by 60°,

Now,
$$\tan\theta = \frac{1}{\omega CR}$$

$$\tan 60° = \frac{1}{\omega CR}$$

$$\frac{1}{\omega C} = \sqrt{3}R$$

Since,
$$\frac{V_m}{I_m} = \frac{20}{5} = 4 = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

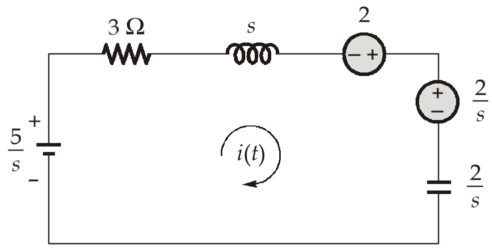
$$\sqrt{R^2 + 3R^2} = 4 \quad \Rightarrow 2R = 4$$

$\therefore$
$$R = 2\ \Omega$$

16. (c)

At t = 0, switch is closed

For $t > 0$, the circuit in s-domain becomes,



Applying KVL, we get,

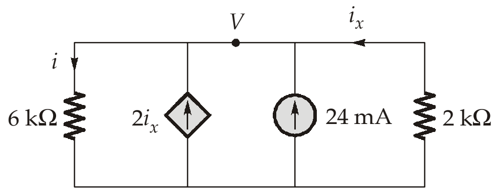
$$\frac{5}{s} - \frac{2}{s} + 2 = \left(3 + s + \frac{2}{s}\right) I(s)$$

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

Using partial fractions, $$I(s) = \frac{1}{(s+1)} + \frac{1}{(s+2)}$$

or $$i(t) = L^{-1}[I(s)] = (e^{-t} + e^{-2t})\text{ A} \;;\; \text{for } t > 0$$

17. (a)



Applying KCL, $$i = 2i_x + 24\text{ mA} + i_x \quad \text{...(i)}$$

where, $$i = \frac{V}{6000} \text{ and } i_x = \frac{-V}{2000} \quad \text{...(ii)}$$

Therefore, from equations (i) and (ii)

$$\frac{V}{6000} + \frac{V}{2000} - 2\left(-\frac{V}{2000}\right) = 24\text{ mA}$$

$\Rightarrow$ $$V = (600)(24 \times 10^{-3}) = 14.4\text{ V}$$

Hence, power supplied by independent current source

$$P = V \times 24\text{ mA} = 14.4 \times 24 \times 10^{-3} = 345.6\text{ mW}$$

18. (a)

$$\frac{1}{2} v_p I_p \cos\theta = 200$$

$\Rightarrow$ $$v_p I_p = \frac{400}{0.6}$$

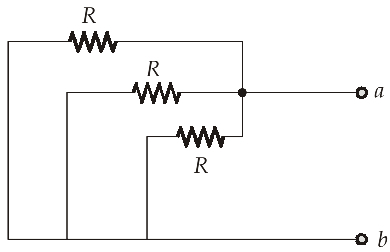
$$\cos\theta = 0.6 \quad \Rightarrow \sin\theta = 0.8$$

$$\text{Now reactive power} = \frac{1}{2} v_p I_p \sin\theta = \frac{1}{2} \times \frac{400}{0.6} \times 0.8$$

$$= 266.67\text{ VAR}$$

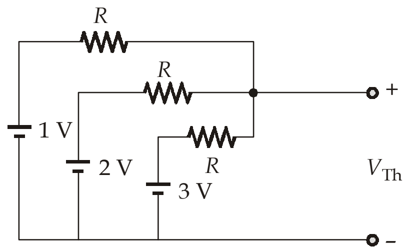
19. **(c)**

For finding R_{Th} across terminal a and b:



$$R_{Th} = \frac{R}{3}\ \Omega$$

For finding V_{Th}:



Using KCL, we get,

$$\frac{V_{Th}-1}{R}+\frac{V_{Th}-2}{R}+\frac{V_{Th}-3}{R} = 0$$

$$3V_{Th} = 6$$

$$V_{Th} = 2\text{ V}$$

∴ Maximum power transferred will be given by

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}}$$

$$5 \times 10^{-3} = \frac{2\times 2}{4\times\frac{R}{3}}$$

$$\frac{R}{3} = \frac{10^3}{5}$$

or $$R = \frac{3}{5}\times 10^3 = 600\ \Omega$$

20. **(b)**

The total admittance of the network

$$Y_{eq} = j\omega C+\frac{1}{R_1}+\frac{1}{R_2+j\omega L} = j\omega(0.5)+\frac{1}{5}+\frac{1}{1+j\omega(1)}$$

$$= j0.5\omega+0.2+\frac{1}{1+j\omega}\times\frac{(1-j\omega)}{(1-j\omega)} = j0.5\omega+0.2+\frac{1-j\omega}{1+\omega^2}$$

$$= \left\{0.2+\frac{1}{1+\omega^2}\right\}+j\left\{0.5\omega-\frac{\omega}{1+\omega^2}\right\}$$

For unity power factor imaginary part of admittance is zero.

$$\text{Im}\{Y_{eq}\} = 0$$

$$0.5\omega_o - \frac{\omega_o}{1+\omega_o^2} = 0$$

$$\frac{1}{2}\omega_o = \frac{\omega_o}{1+\omega_o^2}$$

$$1+\omega_o^2 = 2$$

$$\omega_o = 1 \text{ rad/sec}$$

21. (a)

For t < 0, source $2\,u(t) = 0$

Therefore, $i_L(0^-) = i_L(0^+) = 0$ A

$v_c(0^-) = v_c(0^+) = 0$ V

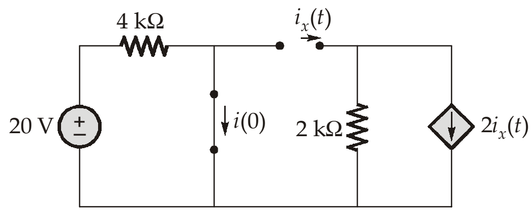
For $t > 0$, $i_c(0^+) = 2$ mA

$$i_c(0^+) = c\frac{dv_c(0^+)}{dt}$$

$$\frac{dv_c(0^+)}{dt} = \frac{i_c(0^+)}{C} = \frac{2\times10^{-3}}{4\times10^{-3}} = 0.5 \text{ V/sec}$$

22. (d)

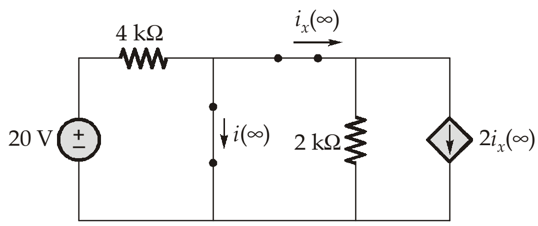
For $t < 0$: The switch was open, the circuit is said to be in steady state.



Since, the inductor acts as short circuit in steady state, the current through it is

$$i(0) = \frac{20}{4\text{ k}\Omega} = 5 \text{ mA}$$

For $t > 0$; at $t = \infty$, the circuit again reaches steady state.



$\therefore$ $$i_x(\infty) = 0,\ i(\infty) = \frac{20}{4\text{ k}\Omega} = 5 \text{ mA}$$

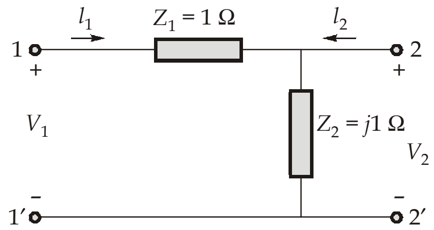
$\therefore$ $$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau},\ t > 0$$

$$= 5\text{ mA} + [(5\text{ mA} - 5\text{ mA})]e^{-t/\tau};\ t > 0$$

$\therefore$ $i(t) = 5$ mA, $t > 0$ which is a constant current.

23. (a)

Given, two port circuit is,



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

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

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

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

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

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

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

24. (c)

Given, $\qquad \omega_o = 1000$ rad/s

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

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

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

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

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

$$Q = \omega_o RC$$

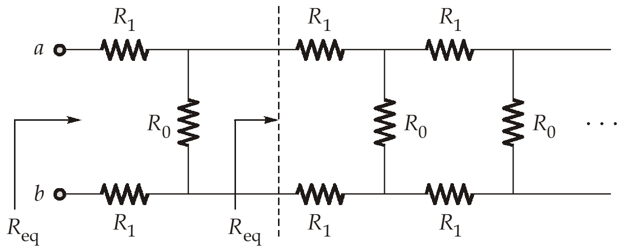
$$\Rightarrow \qquad R = \frac{Q}{\omega_o C}$$

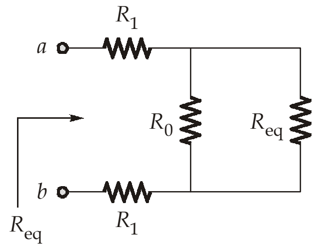
$$\therefore \qquad R = \frac{80}{10^3 \times 0.2 \times 10^{-6}} = \frac{80}{0.2 \times 10^{-3}} = 400\ \text{k}\Omega$$

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

25. (a)

Given, infinite resistive network,





$$\therefore \quad R_{eq} = R_1 + R_0 \| R_{eq} + R_1$$

$$R_{eq} = 2R_1 + R_0 \| R_{eq} = 2R_1 + \frac{R_0 \times R_{eq}}{R_0 + R_{eq}}$$

$$R_{eq}(R_{eq} + R_0) = 2R_1(R_0 + R_{eq}) + R_0 R_{eq}$$

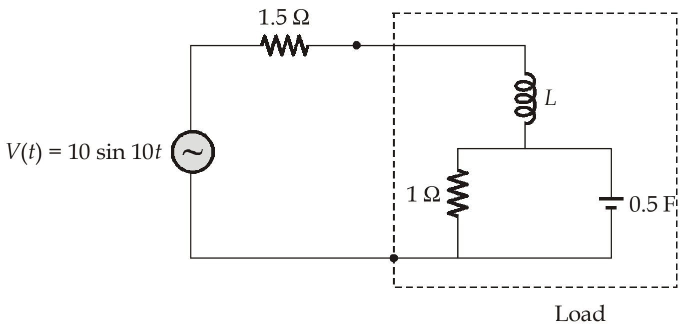
$$R_0 R_{eq} + R_{eq}^2 = 2R_1 R_0 + 2R_1 R_{eq} + R_0 R_{eq}$$

$$\therefore \quad R_{eq}^2 - 2R_{eq}R_1 - 2R_1R_o = 0$$

$$\therefore \quad R_{eq} = \frac{2R_1 \pm \sqrt{4R_1^2 + 8R_1R_0}}{2}$$

$$= R_1 + \sqrt{R_1^2 + 2R_1R_o} \qquad (R_{eq} > 0)$$

26. (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.

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

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

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.

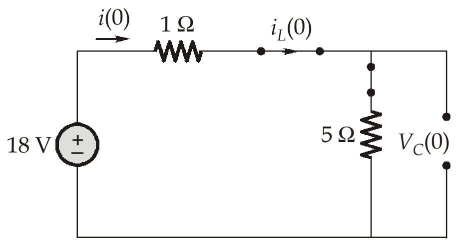
$$10L = \frac{20}{104}$$

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

27. **(b)**

At t = 0, the switch is closed, hence the circuit is in steady state.

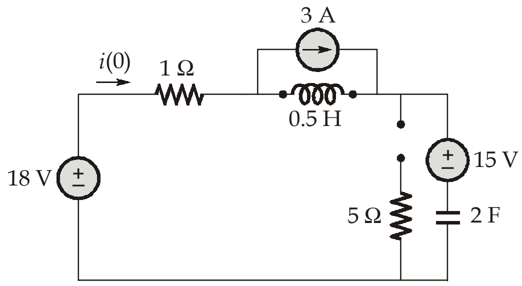
The inductor and capacitor are in steady state i.e., they are replaced as short circuit and open circuit.



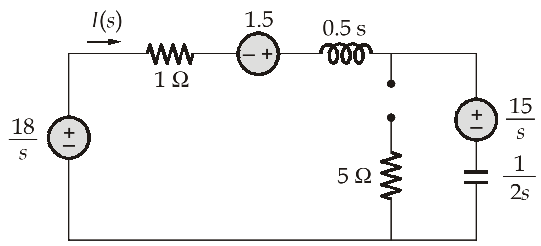
$$\therefore \qquad i_L(0) = i(0) = \frac{18}{6} = 3 \text{ A}$$

$$V_c(0) = \frac{18 \times 5}{6} = 15 \text{ V}$$

For t > 0; the switch is in open state,



by taking Laplace transform,



$$\therefore \qquad I(s) = \frac{\frac{18}{s} - \frac{15}{s} + 1.5}{1 + 0.5s + \frac{1}{2s}} = \frac{2s\left[\frac{3}{s} + 1.5\right]}{2s + s^2 + 1}$$

$$\therefore \quad I(s) = \frac{6+3s}{s^2+2s+1}$$

$$I(s) = \frac{6}{(s+1)^2} + \frac{3s}{(s+1)^2}$$

$$= \frac{6}{(s+1)^2} + \frac{3s+3-3}{(s+1)^2} = \frac{6}{(s+1)^2} + \frac{3(s+1)}{(s+1)^2} - \frac{3}{(s+1)^2}$$

$$I(s) = \frac{3}{(s+1)^2} + \frac{3}{s+1}$$

$$\therefore \quad i(t) = 3te^{-t}u(t) + 3e^{-t}u(t);\ t > 0$$

$$= (3 + 3t)e^{-t}\, u(t);\ t > 0$$

at $t = 1$ sec

$$i(1) = (3 + 3)e^{-1}\, u(1) = 2.20 \text{ A}$$

28. (c)

From the given circuit,

$$\text{Current, } i = \frac{V_s}{Z} \quad \text{where } V_s : \text{Supply voltage}$$

$$\therefore \quad i = \frac{V_s}{1 + j\omega L + \dfrac{1}{j\omega 10^{-5}}} = \frac{V_s}{1 + j10^3 L + \dfrac{1}{j10^3 \times 10^{-5}}}$$

$$= \frac{V_s}{1 + j10^3 L - j10^2}$$

$$i = \frac{V_s}{1 + j(10^3 L - 10^2)}$$

$$\therefore \quad \frac{V_s}{i} = Z = 1 + j(10^3 L - 10^2)$$

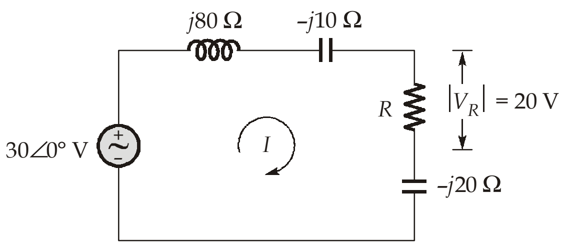
given, V_s and i are in phase,

hence, $10^3 L - 10^2 = 0$

$$\Rightarrow \quad L = \frac{10^2}{10^3} = 0.1$$

$$L = 100 \text{ mH}$$

29. (a)



Let I be the current flowing in the circuit,

$$\therefore \quad I = \frac{30\angle 0^\circ}{j80 - j10 + R - j20} = \frac{30\angle 0^\circ}{R + j50}$$

$$|V_R| = |I|R = 20$$

$$\Rightarrow \quad \frac{30 \times R}{\sqrt{R^2 + 50^2}} = 20$$

$$\frac{900 \times R^2}{R^2 + 2500} = 400$$

$$\Rightarrow \quad R^2 + 2500 = \frac{9R^2}{4}$$

$$4R^2 + 10000 = 9R^2$$

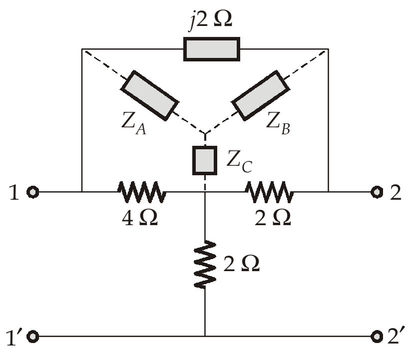
$$\Rightarrow \quad 5R^2 = 10000$$

$$\Rightarrow \quad R^2 = 2000$$

$$\Rightarrow \quad R = \sqrt{2000} = 44.72\ \Omega$$

30. (a)

By redrawing the given two-port network,

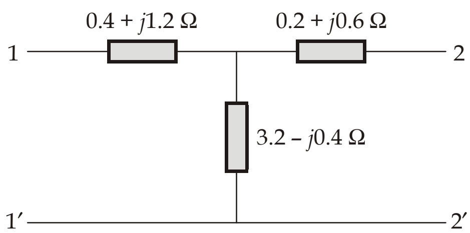


where,
$$Z_A = \frac{4 \times j2}{6 + j2} = 0.4 + j1.2\ \Omega$$

$$Z_B = \frac{2 \times j2}{6 + j2} = 0.2 + j0.6\ \Omega$$

$$Z_C = \frac{4 \times 2}{6 + j2} = 1.2 - j0.4\ \Omega$$

After rearrangement, consider the network,



$$\therefore \quad Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2 = 0} = 3.2 - j0.4\ \Omega$$

$$\therefore \quad |Z_{21}| = 3.22\ \Omega$$

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