S.No. : 05 **LS1_EC_E+F_100819**

Topic Name

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CLASS TEST 2019-2020

ELECTRONICS ENGINEERING

Date of Test : 10/08/2019

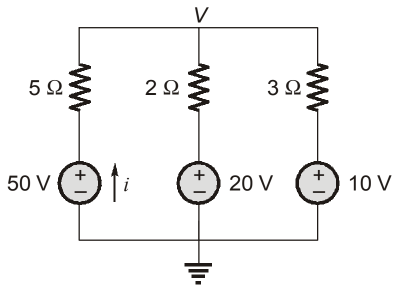
ANSWER KEY ➤ Network Theory

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

DETAILED EXPLANATIONS

1. (c)

using source transformation



applying KCL at V

$$\frac{V-50}{5}+\frac{V-20}{2}+\frac{V-10}{3} = 0$$

$$\frac{6V-300+15V-300+10V-100}{30} = 0$$

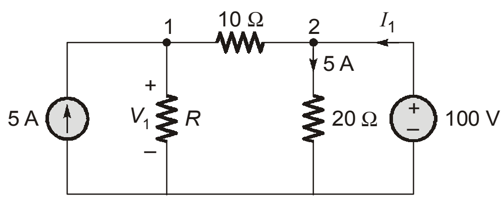
$$31V-700 = 0$$

or $$V = \frac{700}{31} = 22.58\text{ V}$$

$$i = \frac{50-V}{5}$$

$$= \frac{50-22.58}{5} = 5.48\text{ A}$$

2. (d)



At node 1, using KCL, we have:

$$5 = \frac{V_1}{R}+\frac{V_1-100}{10} \quad \text{...(i)}$$

At node 2, using KCL, we have:

$$\frac{V_1-100}{10}+I_1 = \frac{100}{20} = 5$$

or, $$\frac{V_1-100}{10}+I_1 = 5 \quad \text{...(ii)}$$

For equal power; $100\,I_1 = 5\,V_1$ ...(iii)

From equation (i) we obtain,

$$\frac{V_1}{R} + \frac{V_1}{10} = 15 \quad \text{...(iv)}$$

From equation (ii) we obtain,

$$I_1 + \frac{V_1}{10} = 15 \quad \text{...(v)}$$

Equating equation (iv) and (v) we can write,

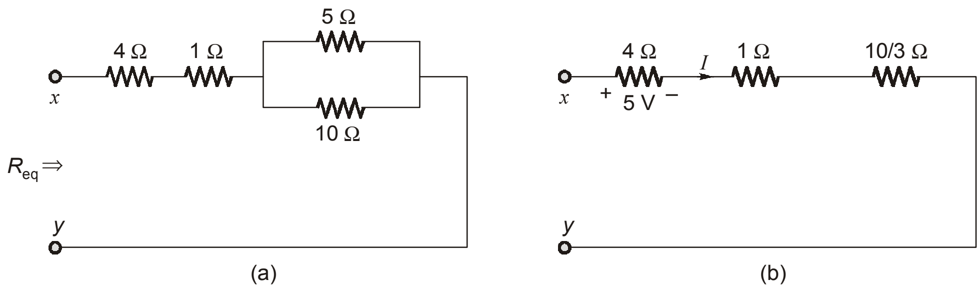
$$I_1 = \frac{V_1}{R} \quad \text{...(vi)}$$

Finally equation (iii) and (vi) yield,

$$\frac{100V_1}{R} = 5\,V_1$$

or, $R = 20\ \Omega$

3. (b)



$$R_{eq} = 4\ \Omega + 1\ \Omega + (5\,||\,10)\Omega$$

$$= 5\ \Omega + \left(\frac{5\times 10}{15}\right)\Omega$$

$$= 5 + \frac{10}{3} = \frac{25}{3}\ \Omega$$

Also from (b) $\quad I = \frac{5}{4}\ \text{A} \quad$ (in series circuit current remains same)

$\therefore \quad V_{xy} = \frac{5}{4} \times \frac{25}{3} = 10.417\ \text{V}$

4. (b)

$$R = \frac{V^2}{P} = \frac{110^2}{10} = 1210\ \Omega$$

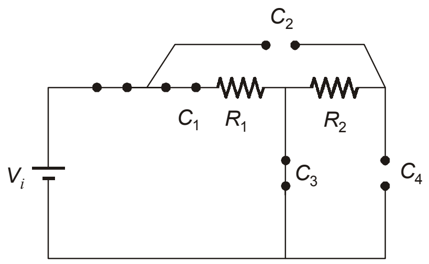
Also $\quad I_R = \frac{V}{R} = \frac{110\angle 0^\circ}{1210\angle 0^\circ} = 0.091\ \text{A}$

$$I = \sqrt{I_R^2 + I_C^2}$$

$\therefore \quad I_C = \sqrt{I^2 - I_R^2} = \sqrt{0.5^2 - 0.091^2} = 0.492\ \text{A}$

5. (b)

At $t = 0^+$



Series combination of C_2 and C_4 is connected across V_i directly. So C_2 and C_4 will charge instantly.

6. (c)

For the given circuit the transient free condition can be obtained as

$$\omega t_0 = \tan^{-1}\left(\frac{1}{\omega RC}\right) + \frac{\pi}{2}$$

$\because$ $\quad \omega = 2$ rad/sec, $\quad R = 1\ \Omega$ and $C = \frac{1}{2}F$

$$2t_0 = \tan^{-1}\left(\frac{1}{2\times 1\times \frac{1}{2}}\right) + \frac{\pi}{2} = \frac{\pi}{4} + \frac{\pi}{2}$$

or $\quad t_0 = \frac{3\pi}{2\times 4} = 1.178$ sec.

7. (d)

$$V_L = L\frac{di}{dt}$$

$$V_L(s) = L[sI_L(s) - i_L(0^+)]$$

where $\quad i_L(0^+) = \lim_{s\to\infty} sI_L(s)$

$$= \lim_{s\to\infty} s\cdot\frac{10}{s(s+2)} = 0$$

and $\quad V_L(s) = s\times L\times I_L(s)$

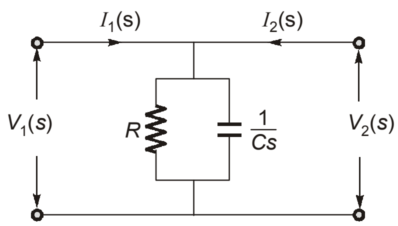
$$= s\times 4\times\frac{10}{s(s+2)} = \frac{40}{(s+2)}$$

$\therefore$ Initial voltage across the inductor is

$$\lim_{s\to\infty} sV_L(s) = \lim_{s\to\infty}\frac{s\times 40}{(s+2)} = 40\text{ V}$$

8. (d)

Converting the network into s-domain



$$V_2(s) = I_1(s)\left(\frac{R \times \frac{1}{Cs}}{R + \frac{1}{Cs}}\right)$$

or
$$\frac{V_2(s)}{I_1(s)} = \frac{R}{RCs + 1} = \frac{1}{\left(s + \frac{1}{RC}\right)}$$

∴
$$Z_{21}(s) = \frac{V_2(s)}{I_1(s)} = \frac{1}{\left(s + \frac{1}{RC}\right)} = \frac{1}{1(s+1)}$$

$$Z_{21}(s) = \frac{1}{(s+1)}$$

9. (c)

At node-1

$$i + 49i = \frac{V_1}{25}$$

$$50i = \frac{V_1}{25}$$

$$50\left(\frac{10 - V_1}{100 \times 10^3}\right) = \frac{V_1}{25}$$

$$V_1 = 0.123$$

at node-2
$$49i = \frac{10 - V_2}{1 \times 10^3}$$

$$49\left(\frac{10 - V_1}{100 \times 10^3}\right) = \frac{10 - V_2}{1 \times 10^3}$$

$$49\left(\frac{10 - 0.123}{100 \times 10^3}\right) = \frac{10 - V_2}{1 \times 10^3}$$

$$V_2 = 5.16 \text{ V}$$

10. (c)

$$P = P_0 + P_1 + P_2$$

$$= 4^2 \times 20 + \left(\frac{5}{\sqrt{2}}\right)^2 \times 20 + \left(\frac{3}{\sqrt{2}}\right)^2 \times 20 \qquad \left[\because I_{rms} = \frac{I_{max}}{\sqrt{2}}\right]$$

$$= (16 + 12.5 + 4.5) \times 20 = 660 \text{ W}$$

11. (a)

The impedance Z will be

$$Z = 4j + \frac{4j \times 4}{4j + 4} - \frac{j}{\omega C}$$

$$= -\frac{j}{\omega C} + 4j + \frac{j16(4 - 4j)}{32}$$

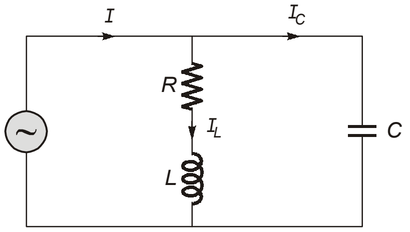
$$= -\frac{j}{\omega C} + 4j + 2j + 2 = -\frac{j}{\omega C} + 6j + 2$$

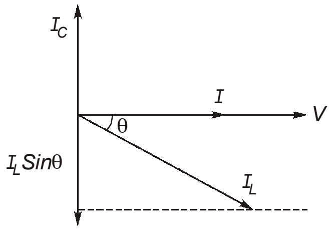
For the power factor to be unity, reactive part of impedance must be zero

$$\frac{1}{\omega C} = 6$$

$$C = \frac{1}{6\omega} = \frac{1}{6 \times 314} = 530.78\ \mu\text{F}$$

12. (b)





where $\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$

$$I_c = \omega C \cdot V$$

$$I_L = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + \omega L^2}}$$

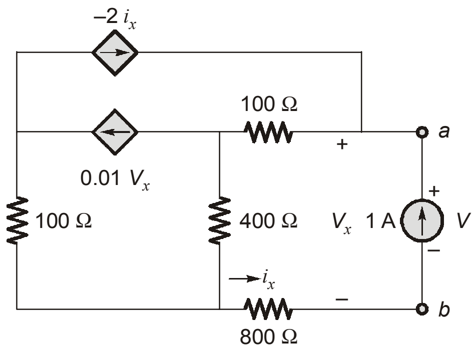
For power factor to be unity

$$I_C = I_L \sin\theta$$

$$\omega CV = \frac{V}{\sqrt{R^2 + (\omega L)^2}} \times \frac{\omega L}{\sqrt{R^2 + (\omega L)^2}}$$

$$C = \frac{L}{R^2 + (\omega L)^2}$$

13. (d)



$$V = 100\,(1 - 2i_x) + 400\,(1 - 2i_x - 0.01\,V_x) + 800\,i_x$$

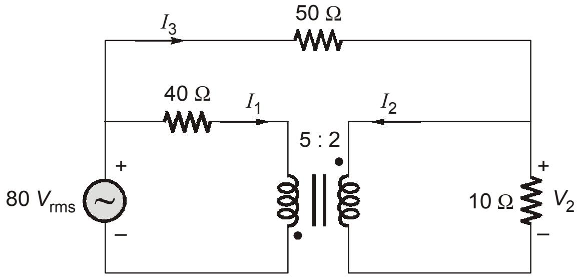
$$i_x = 1\text{ A and } V_x = V$$

$$5V = 1300 - 1000 = 300$$

∴ $V = 60\text{ V}$

and $R_{TH} = 60\ \Omega$

14. (c)



$$V_1 = 2.5\ V_2$$

$$I_1 = 0.4\ I_2, \qquad I_3 = I_2 + \frac{V_2}{10}$$

$$80 = 40\,(0.4 I_2) - 2.5\ V_2 \qquad \text{... (i)}$$

$$80 = 50\ I_3 + V_2$$

$\Rightarrow$
$$80 = 50\ (I_2 + 0.1\ V_2) + V_2 \qquad \text{... (ii)}$$

From (i) and (ii)

$$V_2 = -\,12.31\ \text{V}$$

15. (d)

The h-parameter

$$V_1 = 2I_1 + 4V_2$$
$$I_2 = -5I_1 + 2V_2$$

Power dissipated in R_L

$$P_L = \frac{V_2^2}{R_L} = 25\ \text{W}$$

$\therefore$ $V_2 = \sqrt{25 \times 4} = 10\ \text{V}$

$\because$ $V_2 = -I_2 R_L$

$\therefore$ $I_2 = -2.5\ \text{A}$

substituting the values

we get $V_1 = 2I_1 + 40$

$$-2.5 = -5I_1 + 20$$

$\therefore$ $I_1 = 4.5\ \text{A}$ and $V_1 = 49\ \text{V}$

$\because$ $I_1 = \dfrac{V_s - V_1}{2} = 4.5$

$\Rightarrow$ $V_s = 58\ \text{V}$

16. (c)

$$P_x = \frac{1}{T}\int_{<T>} |x(t)|^2\, dt$$

$$= \frac{1}{T}\int_0^{\alpha T}\left(\frac{3}{\alpha T}t\right)^2 dt$$

$$= \frac{1}{T}\int_0^{\alpha T}\frac{9t^2}{\alpha^2 T^2}\,dt$$

$$= \frac{9}{\alpha^2 T^3}\left(\frac{t^3}{3}\right)_0^{\alpha T} = \frac{3}{\alpha^2 T^3}\left(\alpha^3 \cdot T^3\right)$$

$$P_x = 3\alpha = 3\left(\frac{2}{3}\right) = 2 \text{ Watt}$$

17. (b)

Given,

$$f_0 = 5 \text{ kHz}$$
$$Z = Z_{source} + Z_{load}$$
$$= 2 + j4 + 10 - jX_C$$
$$= [12 + j(4 - X_C)]\ \Omega$$

at resonance, imaginary part of Z is zero.

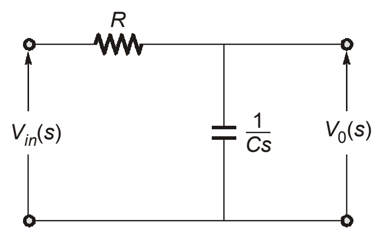
$\because$ $$X_L = X_C$$

$\therefore$ $$X_C = \frac{1}{\omega_0 C} = 4$$

or $$C = 7.95\ \mu\text{F}$$

As at resonance current is maximum and thus, maximum power transferred to R.

18. (b)



$$\frac{V_0}{V_i} = \frac{1}{1 + j\omega CR}$$

$$\tan\theta = \omega RC$$
$$\tan(30^\circ) = \omega RC$$

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

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

$$Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

$$Z = \sqrt{R^2 + \left(\sqrt{3}R\right)^2} = 2R$$

$$R = \frac{Z}{2} = \frac{250}{2} = 125\ \Omega$$

$$C = \frac{1}{\sqrt{3}\,\omega R} = 14.7\ \mu\text{F}$$

19. (c)

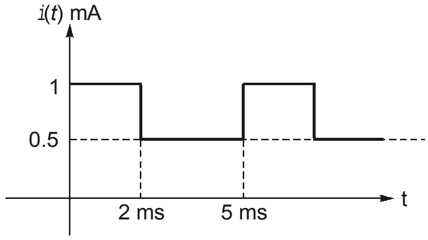
When switch is at position 'A'

$$i_1(t) = \frac{10}{10\text{k}} = 1 \text{ mA}$$

when switch is at position 'B'

$$i_2(t) = \frac{10}{20} = 0.5 \text{ mA}$$

∴

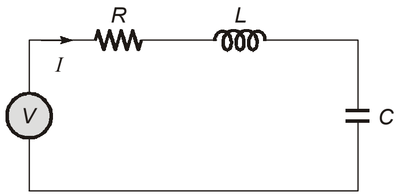


Average value

$$i_{av}(t) = \frac{1}{5}\int_0^5 i(t)dt = \frac{1}{5}\left\{\int_0^2 1dt + \int_2^5 0.5dt\right\}$$

$$= \frac{1}{5}(1 \times 2 + 0.5 \times 3) = 0.7 \text{ mA}$$

20. (c)



For series RLC circuit,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

The circuit current

$$I = \frac{V}{Z}$$

∴ The drop across the capacitor C

$$V_C = IX_C = \frac{V}{Z}X_C$$

i.e.

$$V_C^2 = \frac{V^2 X_C^2}{Z^2} = \frac{V^2}{(\omega C)^2\left[R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2\right]}$$

For maximum voltage drop

$$V_{C\max} = \frac{dV_C}{d\omega} = 0$$

$$= \sqrt{\frac{1}{LC} - \frac{R^2}{2L^2}} \text{ rad/sec}$$

21. (d)

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

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

For Lattice network

$$Z_{11} = \frac{Z_1 + Z_2}{2} = Z_{22}$$

and $$Z_{21} = Z_{12} = \frac{Z_1 - Z_2}{2}$$

from h parameters

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

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

from Z-parameter model

$$h_{12} = \frac{V_1}{V_2} = \frac{Z_{12}}{Z_{22}} = \frac{Z_1 - Z_2}{Z_1 + Z_2}$$

Hence option (d) is the correct answer.

22. (c)

Condition for Transient free response is given by

$$\omega t_0 = \tan^{-1}\left(\frac{\omega L}{R}\right) - \theta + \frac{\pi}{2}$$

here, $$\omega = \frac{1}{2}, \qquad \theta = 45°$$

$$\frac{t_0}{2} = \tan^{-1}\left(\frac{\frac{1}{2}\times 2}{1}\right) - \frac{\pi}{4} + \frac{\pi}{2}$$

$$\frac{t_0}{2} = \frac{\pi}{2}$$

$$t_0 = \pi = 3.1416 \text{ sec}$$

23. (a)

Using KCL

$$100 = R\frac{dQ}{dt} + \frac{Q}{C}$$

$$100\,C = RC\frac{dQ}{dt} + Q$$

$$\int_{Q_0}^{Q} \frac{dQ}{100C - Q} = \frac{1}{RC}\int_0^t dt$$

$$(-ln(100C - Q))_{Q_0}^{Q} = \frac{t}{RC}$$

$$ln\frac{(100C - Q)}{(100C - Q_0)} = -\frac{t}{RC}$$

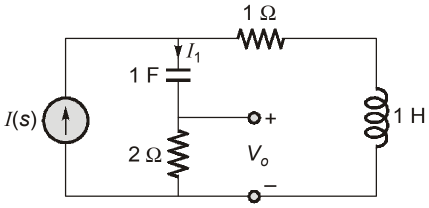
$$100\,C - Q = (100\,C - Q_0)\,e^{-t/RC}$$

$$i = \frac{dQ}{dt} = \left(\frac{100C - Q_0}{RC}\right)e^{-t/RC} = \left(\frac{50 - 10}{1}\right)e^{-t/RC}$$

$$i = 40\,e^{-t/RC}$$

at $t = 2$ sec $$i = 40\,e^{-2} = 5.413 \text{ A}$$

24. (a)



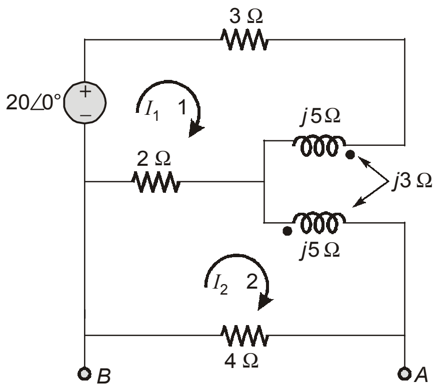
$$I_1(s) = \frac{I(s)(1+s)}{\frac{1}{s}+2+1+s} = \frac{I(s)(s+1)\,s}{s^2+3s+1}$$

$$V_o(s) = 2I_1(s) = \frac{I(s)\,2s(s+1)}{s^2+3s+1}$$

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

25. (b)

Redrawing the circuit



Applying Mesh Law

Mesh I

$$3I_1 + j5I_1 + j3I_2 + 2I_1 - 2I_2 = 20\angle 0^\circ$$

$$(5 + j5)I_1 + (-2 + j3)I_2 = 20\angle 0^\circ \qquad ...(i)$$

Mesh II

$$2I_2 + j5I_2 + j3I_1 + 4I_2 - 2I_1 = 0$$

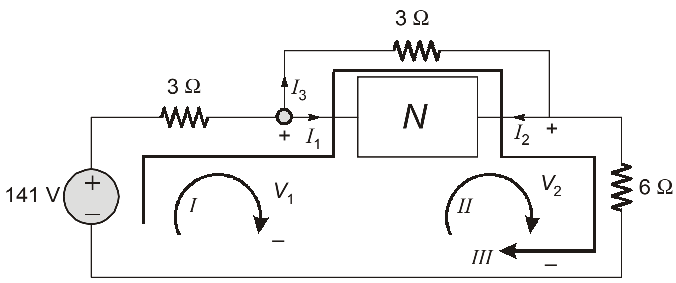
$$(6 + j5)I_2 + (-2 + 3j)I_1 = 0 \qquad ...(ii)$$

From equations (i) and (ii)

$$I_1 = 2.30\angle{-41.70^\circ} \qquad I_2 = 1.064\angle{-137.8^\circ}$$

$$V_{Th} = V_{AB} = I_2 \times (4) = 4.256\angle{-137.8^\circ}$$

26. (c)



$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 1 & 4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \Rightarrow \begin{aligned} V_1 &= 2I_1 + I_2 \\ V_2 &= I_1 + 4I_2 \end{aligned}$$

Applying KVL

Loop I

$$\begin{aligned} 3(I_1 + I_3) + V_1 &= 141 \\ 3I_1 + 3I_3 + 2I_1 + I_2 &= 141 \\ 5I_1 + I_2 + 3I_3 &= 141 \qquad \ldots(i) \end{aligned}$$

Loop II

$$\begin{aligned} V_2 &= (I_3 - I_2) \cdot 6 \\ V_2 &= I_1 + 4I_2 \\ I_1 + 4I_2 &= 6I_3 - 6I_2 \\ I_1 + 10I_2 - 6I_3 &= 0 \qquad \ldots(ii) \end{aligned}$$

Loop III

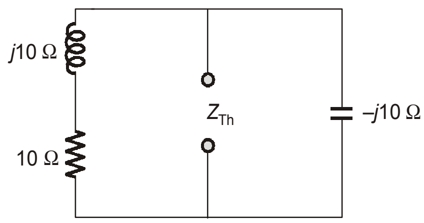
$$\begin{aligned} 3(I_1 + I_3) + 3I_3 + 6(I_3 - I_2) &= 141 \\ 3I_1 - 6I_2 + 12I_3 &= 141 \qquad \ldots(iii) \end{aligned}$$

By equation (i), (ii) and (iii)

$I_1 = 24$ A $\quad I_2 = 1.5$ A $\quad I_3 = 6.5$ A

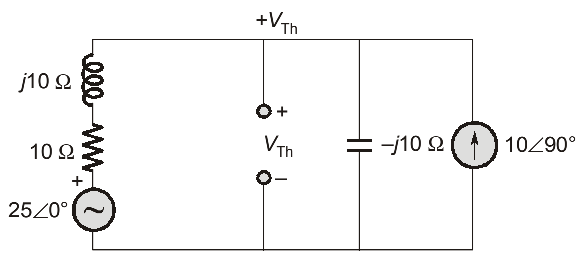
27. (a)

Z_{Th} :



$$Z_{Th} = \frac{(10 + j10)(-j10)}{10 + j10 - j10} = 10 - j10$$

V_{Th} :



$$\frac{V_{Th} - 25}{10 + j10} + \frac{V_{Th}}{-j10} = 10\angle 90^\circ$$

$$\frac{V_{Th}}{10 + j10} - \frac{25}{10 + j10} - \frac{V_{Th}}{j10} = 10j$$

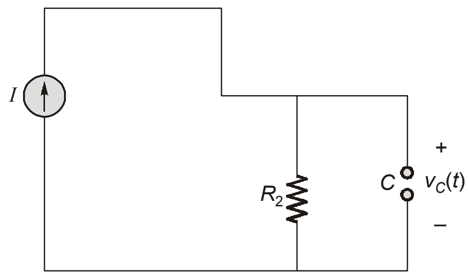
$$\begin{aligned} (V_{Th})j10 - 250j - 10V_{Th} - 10j\,V_{Th} &= -100(10 + 10j) \\ j10\,V_{Th} - 250j - 10V_{Th} - 10j\,V_{Th} &= -1000(1 + j) \\ -10V_{Th} &= -1000 - 1000j + 250j \\ -10V_{Th} &= -1000 - 750j \\ V_{Th} &= 100 + j75 \\ Z_L &= Z_{Th}^{*} = 10 + j10 \end{aligned}$$

$$P_{max} = \frac{|V_{Th}|^2}{4\text{Re}\{Z_{Th}\}} = \frac{\left(\sqrt{100^2+75^2}\right)^2}{4\times 10} = 390.625 \text{ W}$$

28. (b)

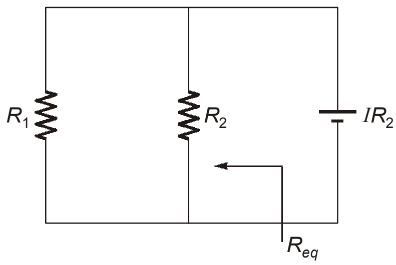
at $t = 0^-$

$$v_C = I \times R_2$$



at $t = 0^+$

$$v_C(0^-) = v_C(0^+) = IR_2$$



$$v_C(\infty) = 0$$

($\because$ capacitor will discharge fully)

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

$$v_C(t) = [v_C(0) - v_C(\infty)]e^{-\frac{t}{\tau}} + v_C(\infty)$$

$$v_C(t) = IR_2 \cdot e^{\frac{-t(R_1+R_2)}{R_1 R_2 \cdot C}} \text{ Volts}$$

29. (c)

$$Y_L = \frac{1}{R_L + jX_L} = \frac{1}{10 + j10} \text{ mho}$$

$$= \frac{10 - j10}{1 + j10} = \frac{10}{200} - j\frac{10}{200}$$

and $$Y_C = \frac{1}{R_C - j2} = \frac{R_C + j2}{R_C^2 + 4} \text{ mho}$$

at resonance, imaginary part of Y_L must be equal to Y_C

i.e. $$-j \times \frac{10}{200} + j\frac{2}{R_C^2 + 4} = 0$$

$$\Rightarrow \quad \frac{10}{200} = \frac{2}{R_C^2 + 4}$$

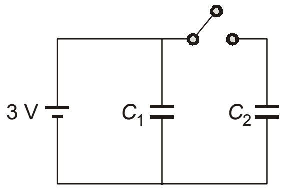
$$10R_C^{\,2} + 40 = 400$$

$$R_C^2 = \frac{360}{10}$$

$$R_C = \sqrt{\frac{360}{10}} = 6\ \Omega$$

30. (b)

At $t = 0^-$ S_1 is closed. S_2 is open



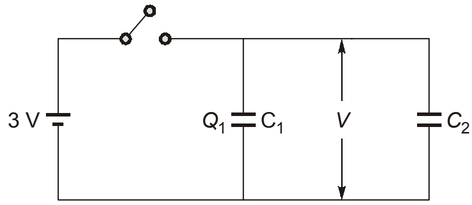
C_1 gets charged upto 3 V charge stored in C_1

$$Q_0 = C_1 V = 1 \times 3 = 3C$$

Voltage across C_2 is zero at $t = 0^-$, so no charge stored in C_2.

At $t > 0$, S_1 is open and S_2 is closed.

charge stored (Q_0) initially in C_1 gets redistributed between C_1 and C_2



Let Charge stored in $C_1 = Q_1$

Charge stored in $C_2 = Q_2$

According to conservation of charge

$$Q_1 + Q_2 = Q_0 = 3 \quad \text{...(1)}$$

Voltage across C_1 = Voltage across C_2

$$\frac{Q_1}{C_1} = \frac{Q_2}{C_2} \Rightarrow \frac{Q_1}{1} = \frac{Q_2}{2}$$

$$Q_2 = 2Q_1 \quad \text{...(2)}$$

from (1) and (2)

$$Q_1 = 1\ C$$

and $$Q_2 = 2\ C$$

$\therefore$ Voltage across the combination $= \dfrac{Q_1}{C_1} = \dfrac{1}{1} = 1\text{ V}$

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