S.No. : 04 LS1_EE_T_210919

Network Theory

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CLASS TEST 2019-2020

ELECTRICAL ENGINEERING

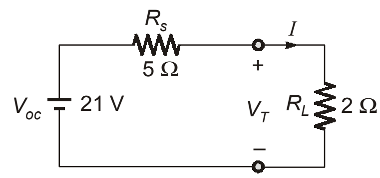
Date of Test : 21/09/2019

ANSWER KEY ➤ Network Theory

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

DETAILED EXPLANATIONS

1. (b)
The internal resistance will be in series with the load.



∴ Circuit current will be

$$I = \frac{21}{7} = 3\text{ A}$$

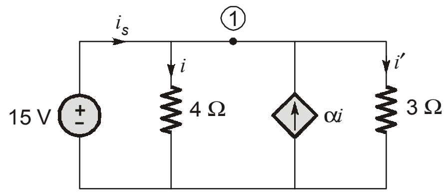
∴ Terminal voltage $= I \times R_L = 3 \times 2 = 6$ V

2. (d)

By inspection, $$i = \frac{15}{4} = 3.75\text{ A}$$

and the current through 3 Ω resistor is,

$$i' = \frac{15}{3} = 5\text{ A}$$



Applying KCL at node (1), we get,

$$i_s + \alpha i = i + i'$$

$$\alpha = 1 + \frac{i'}{i} - \frac{i_s}{i}$$

As i_s can't be determined with the given data, α also can't be determined.

3. (b)

$$\omega_0 = \frac{1}{\sqrt{L_{eq}C}}$$

Here, $$L_{eq} = L_1 + L_2 - 2M = 1 + 5 - 4 = 2\text{ H}$$
$$C = 2\text{ F}$$

∴ $$\omega_0 = \frac{1}{\sqrt{2 \times 2}} = \frac{1}{2} = 0.5\text{ rad/sec}$$

4. (d)

$$\text{Bandwidth} = \frac{\text{Resonant frequency}}{\text{Quality factor}}$$

For parallel RLC circuit, $$Q = R\sqrt{\frac{C}{L}}$$

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

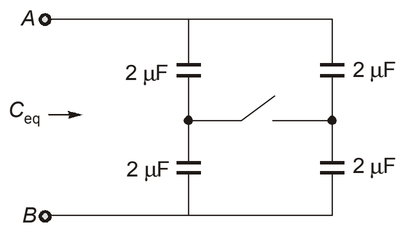
$$\therefore \qquad \text{BW} = \frac{1\sqrt{L}}{R\sqrt{LC}\times\sqrt{C}}$$

$$\text{BW} = \frac{1}{RC} \Rightarrow \text{BW is independent of } L$$

5. (d)
Given graph is a complete graph
$\therefore$ the maximum number of possible trees = n^{n-2}
where n = total number of nodes
$\because$ $n = 4$

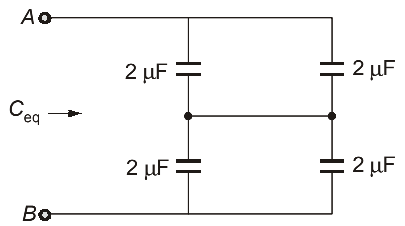
$$\text{Total number of trees} = 4^{(4-2)} = 4^2 = 16$$

6. (a)
When the switch was opened



$$C_{eq} = 2\left[\frac{2\times 2}{2+2}\right] = \frac{8}{4} = 2\,\mu\text{F}$$

When the switch get closed



$$C'_{eq} = \frac{4\,\mu\text{F}\times 4\,\mu\text{F}}{8\,\mu\text{F}} = \frac{16}{8} = 2\,\mu\text{F}$$

7. (c)
Net equivalent resistance

$$R_{eq} = 20 + \left[40 \,\|\, \{20 + 40 \,\|\, 40\}\right] = 20 + 20 = 40\ \Omega$$

$$\text{Current} = \frac{V}{R_{eq}} = \frac{12}{40}\ \text{A}$$

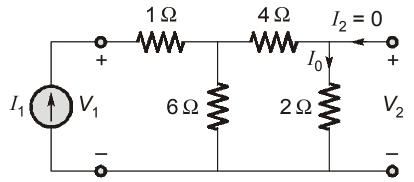
$$\text{Power, } P = VI = \frac{V^2}{R_{eq}} = \frac{12^2}{40} = 3.6\ \text{W}$$

8. (c)
For series RLC circuit,
Q-factor is given by

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{25}\sqrt{\frac{100\times 10^{-6}}{100\times 10^{-12}}} = \frac{1000}{25} = 40$$

9. (c)

To get z_{11} and z_{21}, consider circuit as shown below



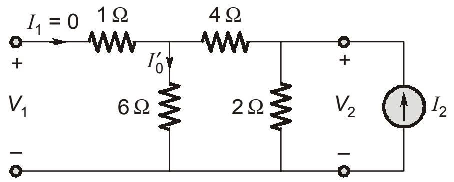
$$z_{11} = \frac{V_1}{I_1} = 1 + (6 \parallel 6) = 1 + 3 = 4\ \Omega$$

$\because$
$$I_0 = \frac{1}{2} I_1$$

$$V_2 = 2\,I_0 = 2 \times \frac{1}{2} I_1 = I_1$$

$$z_{21} = \frac{V_2}{I_1} = 1\ \Omega$$

To get z_{22} and z_{21} , consider the circuit as below,



$$z_{22} = \frac{V_2}{I_2} = 2 \parallel 10 = 1.67\ \Omega$$

$$I_0' = \frac{2}{2+10} I_2 = \frac{1}{6} I_2$$

$\because$
$$V_1 = 6 I_0' = 6 \times \frac{1}{6} I_2 = I_2\ ;$$

Therefore
$$z_{12} = \frac{V_1}{I_2} = 1\ \Omega$$

Hence,
$$z = \begin{bmatrix} 4 & 1 \\ 1 & 1.67 \end{bmatrix} \Omega$$

10. (b)

Total charge passed through the point is

$$q = \int_0^t i\,dt = \int_0^1 10t\,dt + \int_1^2 10\,dt$$

$$= 10\left[\frac{t^2}{2}\right]_0^1 + 10[t]_1^2 = 10\left[\frac{1}{2}\right] + 10[2-1] = 15\ \mu\text{C}$$

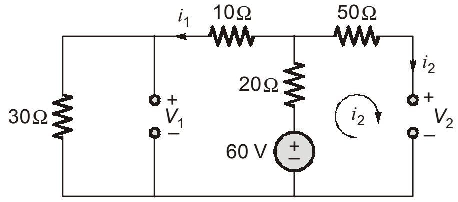
11. (b)

$$V(t) = \frac{5di}{dt} = \frac{5d}{dt}[3e^{-2t}] = -30\ e^{-2t} \text{ Volts}$$

$$\text{Power, } P = Vi = (-30\ e^{-2t}) \times 3e^{-2t}$$
$$= -90\ e^{-4t}\ \text{W}$$

12. (d)

Under dc conditions, the circuit becomes as shown below,



From circuit;

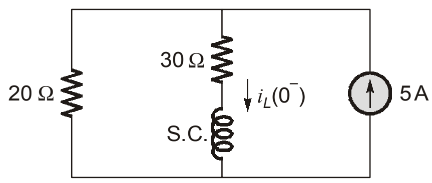
$$i_2 = 0$$

and
$$i_1 = \frac{60}{10+20+30}$$
$$i_1 = 1\ \text{A}$$

∵
$$V_1 = 30\ i_1 = 30\ \text{V}$$

and
$$V_2 = 60 - 20\ i_1 = 40\ \text{V}$$

13. (a)



for $t < 0$

For $t < 0$; 50 $u(t)$ source gives 0(i_L) current, but 5 A current source gives;

$$i_L(0^-) = \frac{5 \times 20}{20+30}$$
$$i_L(0^-) = 2\ \text{A}$$

At $t = 0^+$,
$$i_L(0^+) = i_L(0^-)$$

Hence,
$$i_L(0^+) = 2\ \text{A}$$

14. (d)

For maximum power transfer from the circuit of N to N_L , R_{Th} across the terminals should be 100 Ω . Hence the voltage v should be

$$v = \frac{1}{2} \times 20 = 10\ \text{V}$$

Now,
$$i = \frac{v}{R_{th}} = \frac{10}{100} = 0.1\ \text{A}$$

Applying KCL at top terminal of N_L we get,

$$0.1 = \frac{10}{200} + \frac{10 - v_a}{50}$$

or $$0.1 = 0.05 + \frac{10 - v_a}{50}$$

$$10 - v_a = 0.05 \times 50$$

$$v_a = 10 - 2.5 = 7.5 \text{ V}$$

15. (c)

Given; $V_R = 31.6$ V

and $R = 5\ \Omega$

$\because$ $$I_{eff} = \frac{V_R}{R} = \frac{31.6}{5} = 6.32 \text{ A}$$

Now, $P = I^2_{eff} \times R = (6.32)^2 \times 5 \approx 200$ W

Similarly: $Q = I^2_{eff} \times X_L = (6.32)^2 \times 15 \approx 600$ W

Therefore; $S = (200 + j600)$ VA

16. (a)

For the given circuit, the impedance at resonance is given by

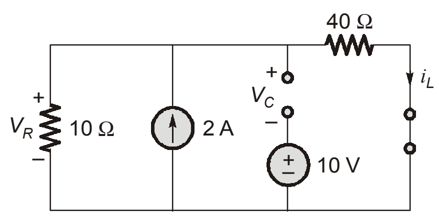
$$Z = \frac{L}{RC}$$

Therefore, $$Z = \frac{150 \times 10^{-6}}{15 \times 750 \times 10^{-12}} = \frac{10^6}{75}$$

$$Z|_{\text{at resonance}} = 13.3 \text{ k}\Omega$$

17. (a)

As $t \to \infty$, we end up with the equivalent circuit shown below



$$i_L(\infty) = \frac{10(2)}{(40+10)} = 400\text{mA}$$

$$V_c(\infty) = 2[10 \,||\, 40] - 10$$

$$= 16 - 10 = 6 \text{ V}$$

18. (c)

Using the dot polarities given in figure,

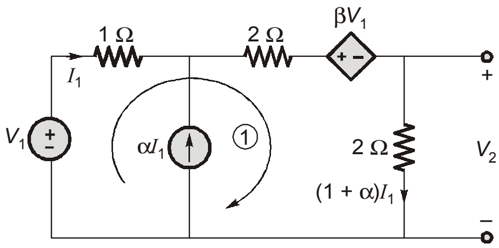
For coil 1 : $L_1 - M_{12} - M_{13} = 4 - 1 - 3 = 0 = L_{eq1}$

For coil 2 : $L_2 - M_{12} + M_{23} = 5 - 1 + 2 = 6 = L_{eq2}$

For coil 3 : $L_3 - M_{13} + M_{23} = 6 - 3 + 2 = 5 = L_{eq3}$

Effective inductance = $L_{eq1} + L_{eq2} + L_{eq3} = 0 + 6 + 5 = 11$ H

20. (c)



In loop (1), by applying KVL, we get,

$$V_1 = I_1 + 2(1+\alpha)I_1 + \beta V_1 + 2(1+\alpha)I_1$$

or $$(1-\beta)V_1 = (5+4\alpha)I_1$$

or $$V_1 = \frac{(5+4\alpha)}{(1-\beta)} I_1$$

Also, $$V_2 = (1+\alpha)I_1 \times 2 = 2(1+\alpha)I_1$$

$\because$ $$\frac{V_2}{V_1} = \frac{2(1+\alpha)(1-\beta)}{(5+4\alpha)}$$

$\alpha = -\frac{3}{2} \Rightarrow 4\alpha = -6$

So, $$\frac{V_2}{V_1} = \frac{2\left(1-\frac{3}{2}\right)}{(5-6)}(1-\beta) = (1-\beta)$$

$\therefore$ $$(1-\beta) = -\frac{1}{2}$$

or $$\beta = \frac{1}{2}+1 = \frac{3}{2}$$

21. (c)

Energy, $$E = \int_{-\infty}^{t} v(t)\cdot i(t)\,dt$$

But, $$i(t) = \frac{dq}{dt} \quad \text{or} \quad i(t)\,dt = dq$$

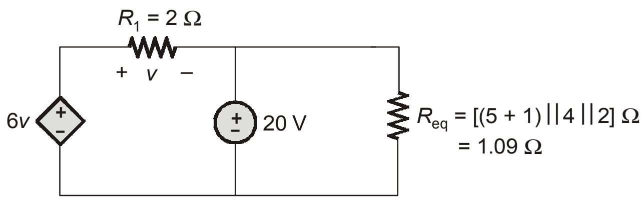
$\therefore$ $$E = \int_{-\infty}^{t} v(t)\,dq = \int_{1}^{3}(1+2q+3q^2)\,dq = \left[q + \frac{2q^2}{2} + \frac{3q^3}{3}\right]_1^3$$

$$= [(3-1) + (3^2-1^2) + (3^3-1^3)]$$

$$= 2 + (9-1) + (27-1) = 2 + 8 + 26 = 36 \text{ J}$$

22. (b)

The given circuit can be reduced as



By applying KVL, we get,

$$-6v + v + 20 = 0$$

or, $$-5v = -20$$

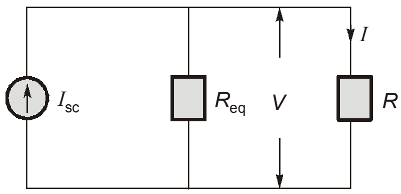
or, $$v = 4\text{ V}$$

∴ Power loss in 2 Ω resistance is

$$P_{R_1} = \frac{v^2}{R_1} = \frac{4^2}{2}\text{ W} = 8\text{ W}$$

23. (d)

Given,
$$I = 25\text{ mA}$$
$$I_{sc} = 50\text{ mA}$$
$$V = 0.5\text{ V}$$



∴ $$I = \frac{R_{eq}}{R+R_{eq}} \times I_{sc}$$

$$25 = \frac{R_{eq}}{R+R_{eq}} \times 50$$

or $$\frac{50}{25} - 1 = \frac{R}{R_{eq}}$$

or $$R_{eq} = R$$

∵ $$V = I \times R$$

$$0.5\text{ V} = 25\text{ mA} \times R$$

or $$R = \frac{0.5}{25}\text{ k}\Omega = 20\ \Omega$$

∴ $$R_{eq} = 20\ \Omega$$

24. (d)

Let $$\phi_1 = \text{primary coil flux}$$

$$\phi_{12} = \text{mutual flux}$$

where $$\phi_{12} = K\phi_1 = 0.5 \times \phi_1 = 0.7$$

∴ $$\phi_1 = \frac{0.7}{0.5} = \frac{7}{5} = 1.4\text{ Wb}$$

∴ The primary coil inductance,

$$L_1 = \frac{N\phi_1}{I_1} = \frac{250\times\frac{7}{5}}{70} = \frac{25}{5} = 5\text{ H}$$

25. (c)

Under resonance, $X_L = X_C$

$\therefore$ The current flowing through the inductor is equal to the current flowing through the capacitor.

$$\therefore \quad I = \frac{V}{X_L} = \frac{V}{2\pi fL}$$

where, $$f = \frac{1}{2\pi\sqrt{LC}}$$

$$\therefore \quad I = \frac{V\times 2\pi\sqrt{LC}}{2\pi L} = V\cdot\sqrt{\frac{C}{L}}$$

26. (a)

Let, v be the reference vector, it is clearly observed from the question that, i lags v by 30°.

Also, $$\frac{V_m}{I_m} = \frac{18}{2} = 9\ \Omega$$

$$\therefore \quad Z = \sqrt{R^2+(\omega L)^2}$$

$$9^2 = R^2 + (\omega L)^2 \quad \text{...(i)}$$

$$\because \quad \frac{\omega L}{R} = \tan 30° = \frac{1}{\sqrt{3}}$$

$$\therefore \quad R = \sqrt{3}\,(\omega L) \quad \text{...(ii)}$$

From equation (i) and (ii), $$9^2 = \left(\sqrt{3}\,\omega L\right)^2 + (\omega L)^2$$

$$2(\omega L) = 9$$

$$L = \frac{9}{2\times\omega} = \frac{9}{2\times 9} = 0.5\text{ H} \qquad \because \omega = 9\text{ rad/sec}$$

27. (c)

The internal impedance of the circuit is

$$Z_{in} = 3 + j4 - 8j = (3-4j)\ \Omega$$

The open circuit voltage across R_L

$$V_{oc} = 50\angle 0°\text{ Volts}$$

As per the maximum power transfer theorem, for maximum power transfer,

or, $$R_L = |(3-4j)| = \sqrt{9+16} = 5\ \Omega$$

$$\therefore \quad |I| = \frac{50\angle 0°}{(3-j4+5)} = \left|\frac{50\angle 0°}{8-j4}\right|$$

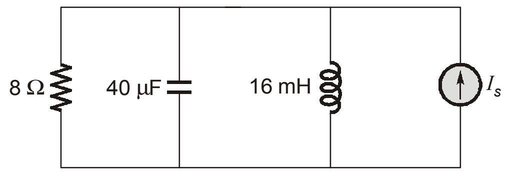
$$|I| = \frac{50\angle 0°}{\sqrt{64+16}} = \frac{50\angle 0°}{4\sqrt{5}} \text{ A}$$

$$P_{max} = |I|^2 \cdot R_L = \left(\frac{50\angle 0°}{4\sqrt{5}}\right)^2 \times 5$$

$$= \frac{50\times 50}{16\times 5}\times 5 = \frac{2500}{16} = 156.25 \text{ W}$$

28. (b)

By applying source transformation, we come to known that the circuit act as a parallel RLC circuit.



$\therefore$ $$Q = R\sqrt{\frac{C}{L}} = 8\sqrt{\frac{40}{16}\times 10^{-3}} = 8\times\frac{1}{20} = \frac{8}{20}$$

The damping factor, $$\xi = \frac{1}{2Q} = \frac{1}{2\times\frac{8}{20}} = \frac{20}{16} = 1.25$$

$\because$ $$\xi > 1 \Rightarrow \text{Overdamped}$$

29. (c)

The charging current equation for RL circuit is

$$i(t) = \frac{V}{R}\left(1-e^{-t/\tau}\right)u(t)$$

where, $$\tau = \frac{L}{R} = \text{time constant}$$

$$= \frac{2}{20} = 0.1 \text{ sec}$$

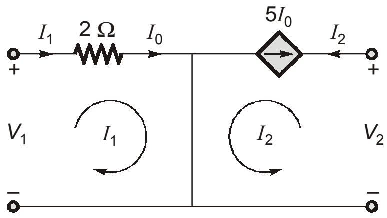
$\therefore$ $$i = \frac{100}{20}(1-e^{-t/0.1})u(t) = 5(1-e^{-10t})u(t) \text{ A}$$

$$\frac{di}{dt} = 50e^{-10t}\, u(t) \text{ A/s}$$

$\therefore$ The rate of change of current at the instant just after closing the switch ($t = 0^+$) is

$$\frac{di}{dt}(t = 0^+) = 50 \text{ A/s}$$

30. (b)



By applying KVL in the first loop, we get,

$$V_1 = I_1 \times 2 + 0(I_1 + I_2)$$

$$V_1 = 2I_1 = 2I_0$$

$$I_1 = \frac{V_1}{2} \quad \text{...(i)}$$

Also, $$I_2 = -5I_0 = -\frac{5}{2}V_1 \quad \text{...(ii)}$$

From equations (i) and (ii),

$$[Y] = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} \frac{1}{2} & 0 \\ -\frac{5}{2} & 0 \end{bmatrix} \mho$$

$$= \frac{1}{2}\begin{bmatrix} 1 & 0 \\ -5 & 0 \end{bmatrix} \mho$$

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