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# ESE-2017 : Prelims Exam

UPSC Engineering Services Examination

# ELECTRICAL ENGINEERING

## Answer Key & Solutions

Test 1: Part Syllabus Technical

## Electrical Circuits

| | | | | | | | | | |
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| 1. | (b) | 16. | (b) | 31. | (b) | 46. | (a) | 61. | (c) |
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| 5. | (a) | 20. | (a) | 35. | (b) | 50. | (b) | 65. | (a) |
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| 11. | (b) | 26. | (d) | 41. | (c) | 56. | (d) | 71. | (d) |
| 12. | (d) | 27. | (c) | 42. | (a) | 57. | (b) | 72. | (a) |
| 13. | (c) | 28. | (c) | 43. | (c) | 58. | (d) | 73. | (a) |
| 14. | (c) | 29. | (b) | 44. | (b) | 59. | (b) | 74. | (c) |
| 15. | (d) | 30. | (a) | 45. | (a) | 60. | (b) | 75. | (b) |

## DETAILED EXPLANATIONS

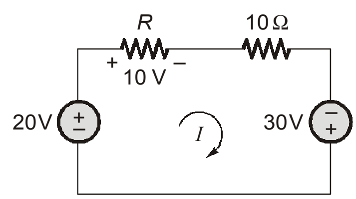
1. (b)

Total charge passed through the point is

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

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

2. (b)




Applying KVL in the given loop;

$$-20 + 10 + 10\,I - 30 = 0$$

then current in loop, $I = 4$ A

$\therefore$ $10 = RI$

$\Rightarrow$ $R = \dfrac{10}{4} = 2.5\ \Omega$

3. (b)

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

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

$$= -90\ e^{-4t}\text{ W}$$

4. (b)

From Tellegen's theorem,

$$\Sigma P = 0;$$

$$= -205 + 60 + 45 + 30 + P_3 = 0$$

then: $P_3 = 205 - 135 = 70$ W

5. (a)

From the given circuit,

$$C_{ab} = [C\,||\,80\,\mu] + 14\,\mu = 30\,\mu F$$

or $$\frac{C \times 80\,\mu}{C + 80\,\mu} + 14\,\mu = 30\,\mu$$

$$\frac{C \times 80\,\mu}{C + 80\,\mu} = 16\,\mu$$

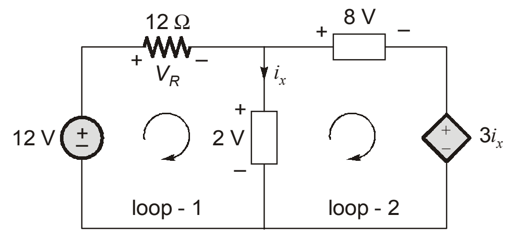
or $$80\,C = 16\,C + 16 \times 80$$

$$C = \frac{16 \times 80}{64} = 20\ \mu F$$

6. (c)

All current sources are open circuited and voltage sources are short circuited while making graph of given network, where dark circles represent nodes.

7. (a)




Apply KVL in loop-1;

$$-12 + V_R + 2 = 0$$

then $V_R = 10\text{ V}$

Apply KVL in loop-2;

$$-2 + 8 + 3\,i_x = 0;$$

$$i_x = -2\text{ A}$$

8. (c)

If $I_{16\,\Omega} = i_0 = 2\text{ A}$

then $v_{16} = 16 \times 2 = 32\text{ V}$

Now, $i_{8\,\Omega} = \dfrac{32}{8} = 4\text{ A};$

and $i_{4\,\Omega} = \dfrac{32}{4} = 8\text{ A}$

and $i_{2\,\Omega} = \dfrac{32}{2} = 16\text{ A}$

$\therefore$ $i_x = i_2 + i_4 + i_8 + i_{16}$

$= 16 + 8 + 4 + 2 = 30\text{ A}$

9. (b)

Orthogonal relationship between fundamental cut-set matrix $B$ and the fundamental tie-set matrix A is represented by the following relation:

$$[A]\,[B^t] = 0$$

10. (a)

$\therefore$ Total charge released $= q = i \times t$

$= 85 \times 10^{-3} \times 12 \times 60 \times 60$

$q = 3672\text{ C}$

Total energy delivered by battery

$= qV = 3672 \times 1.2 = 4.4 \times 10^3\text{ J}$

11. (b)

From the given fully connected graph,

$n$ = no. of nodes = 4 and $b$ = no. of branches = 6

No. of trees = $n^{(n-2)}$ (for fully connected graph)

No. of trees = $4^2 = 16$

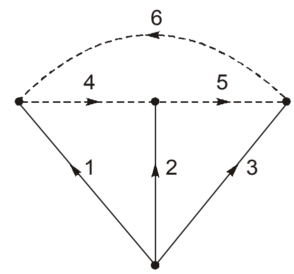
No. of fundamental cut set = $n - 1$

$= 4 - 1 = 3$

No. of twigs/tree branches = $n - 1 = 3$

$$\text{No. of fundamental tie-set} = \text{No. of links/chords}$$
$$= b - (n - 1) = 6 - (4 - 1) = 6 - 3 = 3$$

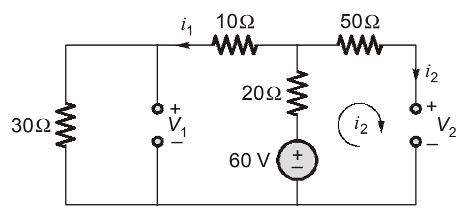
A possible tree and co-tree from the given graph can be drawn as shown below.




Here, Twigs (dark lines): [1, 2, 3] and links/chords (dotted lines) : [4, 5, 6]

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. (c)

From the given circuit, we note that $\omega = 1$ rad/sec

i.e. the phasor for the voltage source is $\frac{1}{\sqrt{2}}\angle 0°$ V.

As the capacitor is disconnected since, $i_2 = 0$,
Hence $i_2$ induces no component in $V_1$ and equation for $V_1$ is,

$$V_1 = j1 \times i_1,$$

or $$\frac{1}{\sqrt{2}}\angle 0° = j\,1 \times i_1$$

From which it follows that,

$$i_1 = \frac{1}{\sqrt{2}}\angle -90° \text{ A}$$

Now we can state that,

$$V_2 = j\omega\ M i_1$$

or $$V_2 = j \times 1 \times 2 \times \frac{1}{\sqrt{2}} \angle -90° \text{ A}$$

$$V_2 = \sqrt{2} \angle 0° \text{ V}$$

or $$V_2(t) = 2 \cos t \text{ V}$$

14. (c)

$$\text{Current, } i = 20 \ \mu\text{A}$$

$$\text{Total charge, } q = 15 \text{ C}$$

$$\text{time taken, } t = \frac{q}{i} = \frac{15}{20 \times 10^{-6}} = 750 \times 10^3 \text{ sec}$$

15. (d)

Let us apply KCL at all the nodes,

At node $A$ ;

$$8 = 12 + I_1$$

i.e. $$I_1 = -4 \text{ A}$$

At node $C$ ;

$$9 = 8 + I_2$$

or $$I_2 = 1 \text{ A}$$

At node $D$ ;

$$9 = 12 + I_3$$

$$I_3 = -3 \text{ A}$$

16. (b)

From circuit diagram,

equivalent capacitance across current source,

$$C_{eq} = 12 \,||\, (20 + 40)$$

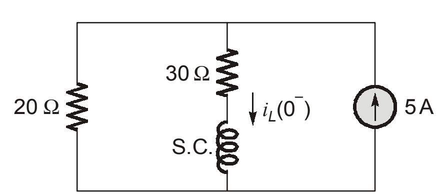
$$= \frac{12 \times 60}{72} = 10 \ \mu\text{F}$$

Now, $$V_1(t) = \frac{1}{C}\int_0^t i_s dt + V_1(0) = \frac{1}{12 \times 10^{-6}}\int_0^t 30e^{-2t} dt + V_1(0)$$

$$= \left[-1250e^{-2t}\right]_0^t + 50$$

$$V_1(t) = (-1250\, e^{-2t} + 1300) \text{ V}$$

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

18. (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 $$0.1 = 0.05 + \frac{10 - v_a}{50}$$

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

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

19. (b)

Any element connected in parallel with a voltage source is redundant because a voltage source have a constant value of voltage across it and similarly any element connected in series with a current source is redundant because a current source supply a constant current to a network.

20. (a)

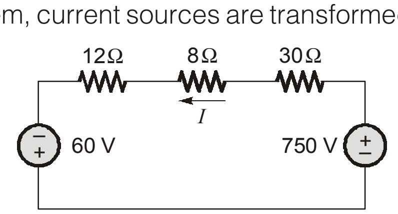
Voltage across inductor is given by;

$$v_L(t) = L\frac{di}{dt} = 0.5\frac{d}{dt}(e^{-t^2})$$

$$= (0.5)(-2t)e^{-t^2} = -te^{-t^2} \text{ V}$$

21. (d)

Using source transformation theorem, current sources are transformed into voltage sources.




Now, using KVL in the loop,

We get, $$750 + 60 = 50\,I$$

$$I = \frac{810}{50} = 16.2 \text{ A}$$

22. (c)

Given; $V_R = 31.6$ V

and $R = 5\ \Omega$

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

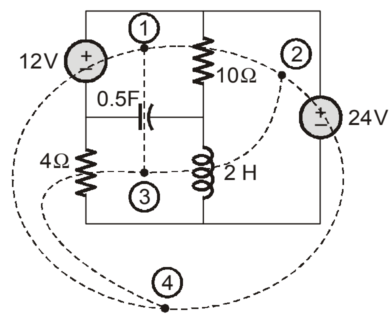
Now, $P = I^2_{eff} \times R = (6.32)^2 \times 5 \approx 200$ W

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

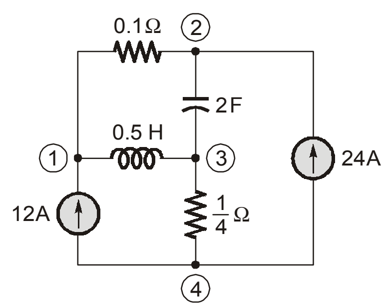
Therefore; $S = (200 + j600)$ VA

23. (d)

For the dual network, the capacitors are replaced by inductor, resistors by conductances, inductors by capacitors, current source by voltage sources, voltage sources by current sources and the elements are connected as in the dual network shown below




The dual network is,




24. (a)

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

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

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

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

25. (a)

At supply frequency below resonant frequency ($f_r$) the inductive reactance is smaller than the capacitive reactance. Thus, inductive current is greater than the capacitive current and the total supply current lags the supply voltage.

Similarly for supply frequency above $f_r$, the capacitive reactance becomes smaller than the inductive reactance. Thus, capacitor current is larger than inductor current and total supply current leads the supply voltage.

A parallel RLC circuit has a maximum impedance at the resonant frequency. Therefore the supply current is minimum at resonance.

26. (d)

From the circuit diagram;

as 3 μF is in series with 6 μF, therefore

equivalent capacitance of 3 μF and 6 μF

$$= \frac{3\times 6}{9} = 2\ \mu\text{F}$$

Now 2 μF and 2 μF are in parallel. Hence, equivalent capacitance of these two

$$= 2 + 2 = 4\ \mu\text{F}$$

Now; voltage across 4 μF $= V_{4\mu\text{F}} = \frac{1}{2}\times 120 = 60\text{ V}$

Now, $V_{6\ \mu\text{F}} = \frac{3}{6+3}(60) = 20\text{ V}$

$\because$ $V_{3\ \mu\text{F}} = 60 - 20 = 40\text{ V}$

27. (c)

Determinant of the incidence matrix of a closed loop is always zero. So statement 2 is incorrect.

28. (c)

Net equivalent resistance

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

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

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

29. (b)

Applying KCL to the top node;

We get,

$$\frac{30 - V_0}{2k} + \frac{20 - V_0}{5k} = \frac{V_0}{4k}$$

or $$15 - \frac{V_0}{2} + 4 - \frac{V_0}{5} = \frac{V_0}{4}$$

$$19 = \frac{10+5+4}{20}V_0$$

$$V_0 = 20\text{ V}$$

30. (a)
Phasor analysis can be performed on single frequency circuits only. So statement 2 is correct and statement-3 is not correct.

31. (b)

- Time constant of a series R-L circuit is $\tau = \frac{L}{R}$.

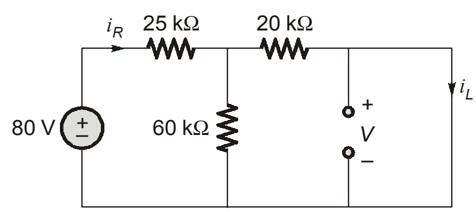
  According to the rate of decay from the given graph, $\tau_3 < \tau_2 < \tau_1$

  $\therefore \quad R_3 > R_2 > R_1$
- The response time is independent of the voltage source.
- Since $Q = \frac{\omega L}{R}$, therefore, for higher $Q$, $L$ will be high and $R$ will be small so that $\tau$ will be higher.

32. (b)
For all linear circuits system should be homogenous in nature and superposition is strictly followed.

33. (c)
At frequency below resonant frequency, series RLC network shows capacitive nature.

34. (c)
At $t = 0^-$, the equivalent circuit is shown below,



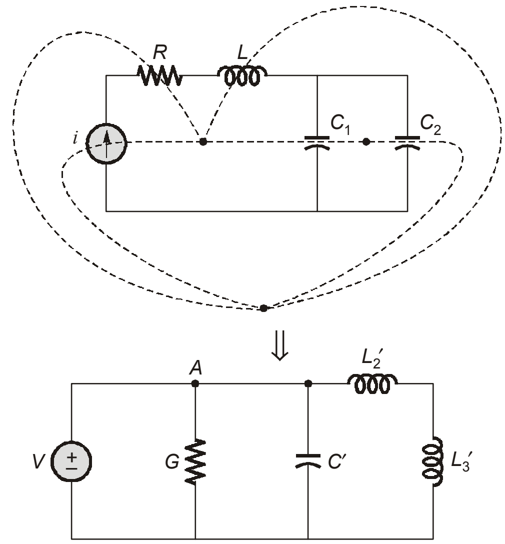

Here $\quad i_R(0^-) = \frac{80}{[25 + 20 \,||\, 60]}\text{mA} = \frac{80}{40} = 2 \text{ mA}$

Now, $\quad i_L(0^-) = \frac{60 \times 2}{(60 + 20)}\text{ mA} = 1.5 \text{ mA}$

$\because \quad i_L(0^+) = i_L(0^-) = 1.5 \text{ mA}$

35. (b)

Dual network of the given network will be,




Therefore,

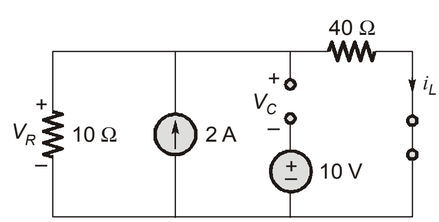
no. of nodes = 3, (including reference)

No. of branches in between nodes 5

Hence option '*b*' is correct.

36. (a)

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




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

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

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

37. (a)

For series RLC network;

$$\text{damping ratio, } \xi = \frac{R}{2}\sqrt{\frac{C}{L}}$$

$$\xi = \frac{10\times10^3}{2}\sqrt{\frac{10\times10^{-6}}{0.1\times10^{-3}}} = 5\times10^3\sqrt{10^{-1}} = 1581.13 > 1$$

Hence, the circuit is overdamped.

38. (b)

$$[z] = [y]^{-1}$$

$$\therefore \quad \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \frac{1}{\Delta y}\begin{bmatrix} y_{22} & -y_{12} \\ -y_{21} & y_{11} \end{bmatrix}$$

$$\because \quad z_{11} = \frac{y_{22}}{\Delta y}$$

$$\because \quad \Delta y = y_{11}\, y_{22} - y_{12}\, y_{21}$$
$$= 0.5 \times 0.4 - 0.2 \times 0.2 = 0.16$$

$$z_{11} = \frac{0.4}{0.16} = 2.5\Omega$$

and $$z_{12} = \frac{-y_{12}}{\Delta y} = \frac{0.2}{0.16} = 1.25\Omega$$

39. (a)

Comparing the given characteristic equation with the standard characteristic equation of a series RLC circuit, we have:

$$s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$$

Given, $$s^2 + 100s + 10^6 = 6$$

Here, $$\frac{R}{L} = 100$$

or, $$L = \frac{R}{100}$$

or $$L = \frac{2000}{100} = 20 \text{ H}$$

and $$\frac{1}{LC} = 10^6$$

$$\Rightarrow \quad C = \frac{1}{10^6 \times L}$$

or $$C = \frac{1}{20 \times 10^6} = 50 \text{ nF}$$

40. (b)

For a parallel RLC circuit, the characteristic equation is

$$s^2 + \frac{1}{RC}s + \frac{1}{LC} = 0$$

Comparing with the standard characteristic equation,

$$s^2 + 2\xi\,\omega_n s + \omega_n^2 = 0,$$

We have:

$$\text{Damping factor, } \alpha = \frac{1}{2RC} = \xi\omega_n = 1 \text{ (Given)}$$

$$\therefore \quad 1 = \frac{1}{2 \times 10 \times C}$$

$$C = \frac{1}{20} = 50 \text{ mF}$$

41. (c)

For series RLC circuit,
$Q$-factor is given by

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

$$= \frac{1000}{25} = 40$$

42. (a)

$$x(t) = 11.26 \cos 2t + 6.5 \sin 2t$$

$$= 11.26 \cos 2t + 6.5 \cos (2t - 90°)$$

$$= \frac{1}{\sqrt{2}}[11.26 \angle 0° + 6.5 \angle{-90°}]$$

$$x(t) = \frac{13}{\sqrt{2}}\angle{-30°}$$

and $\quad y(t) = 15 \cos (2t - 15°) = \frac{15}{\sqrt{2}}\angle{-15°}$

Phase difference $= -15° - (-30°) = +15°$

Thus, $y(t)$ leads $x(t)$ by 15°.

43. (c)

Capacitance reactance

$$X_C = \frac{1}{j\omega C} = \frac{1}{j(10^6)(2 \times 10^{-6})}$$

$$X_C = -j\,0.5\ \Omega$$

Voltage across capacitor $= V = IZ$

$$V = \left(\frac{4}{\sqrt{2}}\angle 25°\right)(0.5\angle{-90°})$$

$$V = \sqrt{2}\angle -65° \text{ Volt}$$

Therefore $\quad V(t) = 2 \sin (10^6 t - 65°)$ V

44. (b)

For forced response $V_0$ to be zero the circuit must be working in resonance. Therefore, the circuit behaves as purely resistive.

$$\therefore \quad V_0 = 0$$

$$\text{if} \quad \omega = \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(5\times 10^{-3})(20\times 10^{-3})}}$$

$$\omega_0 = 100 \text{ rad/sec}$$

45. (a)

For a two port network to be symmetric, the following conditions must be held true.

(i) $z_{11} = z_{22}$

(ii) $y_{11} = y_{22}$

(iii) $A = D$

(iv) $(h_{11}h_{22} - h_{12}h_{21}) = 1$

46. (a)

$$\text{Phase shift, } \theta = 45° = \tan^{-1}\left(\frac{X_c}{R}\right)$$

$$\tan 45° = \frac{X_c}{R} \text{ or } X_c = R$$

$$\frac{1}{\omega C} = R;$$

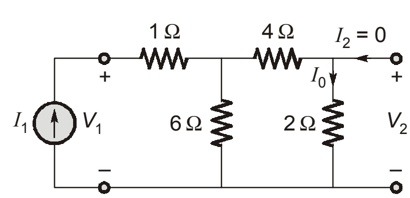
$$\omega = \frac{1}{RC}$$

$$\omega = \frac{1}{5\times 20\times 10^{-9}} = 10\times 10^6 \text{ rad/sec}$$

$$\omega = 10 \text{ M rad/sec}$$

47. (c)

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



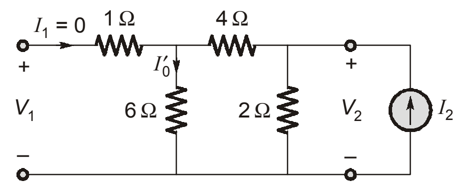

$$z_{11} = \frac{V_1}{I_1} = 1 + (6 \,\|\, 6) = 1 + 3 = 4\ \Omega$$

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

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

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

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




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

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

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

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

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

48. (d)

For a series RLC circuit,

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.01 \times 4}} = 5 \text{ rad/sec}$$

For critical damping ($\xi = 1$),

$$\omega_0 \xi = \frac{R_0}{2L} = 5 \qquad (\therefore \xi = 1)$$

or $$R_0 = 10\,L = 40$$

Where, $$R_0 = R \,||\, 60 = \frac{60\,R}{60 + R}$$

Hence, $$\frac{60\,R}{60 + R} = 40$$

or, $$20\,R = 60 \times 40$$

or, $$R = 120\ \Omega$$

50. (b)

In a series RLC circuit at resonant frequency, current is maximum, impedance is minimum and the net reactance is zero. Thus, we can easily find the curves for $i$, $z$ and $x$ from given curves.

51. (a)

Given network represents a low pass filter having transfer function

$$G(s) = \frac{1}{1+RCs}$$

or, $$G(j\omega) = \frac{1}{1+j\omega RC}$$

or, $$G(j\omega) = \frac{1}{\sqrt{1+(\omega RC)^2}} \angle -\tan^{-1}(\omega RC)$$

| $\omega$ | $G(j\omega)$ |
|---|---|
| 0 | $1\angle 0°$ |
| $\frac{1}{RC}$ | $0.707\angle -45°$ |
| $\infty$ | $0\angle -90°$ |

52. (a)

When $N_1$ is replaced by its Thevenin's equivalent, the identity of all elements in $N_1$ are lost and the mutual coupling or dependence on current or voltage is lost and can not be taken into account.

53. (b)

From the circuit we can write,

$$V_1 = \left(R + \frac{1}{sc}\right) I_1 + R.I_2 \quad \text{...(i)}$$

Also, $$V_2 = RI_1 + (R + sL)\, I_2 \quad \text{...(ii)}$$

Therefore, $$Z = \begin{bmatrix} \left(R + \frac{1}{sC}\right) & R \\ R & R + sL \end{bmatrix}$$

54. (a)

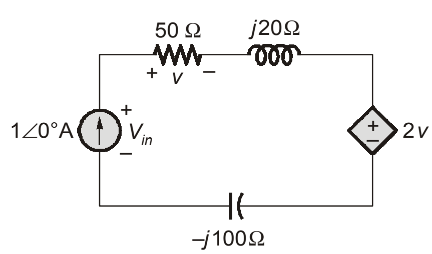
Inductive reactance,

$$X_L = j\omega L = j\,(10 \times 10^3)\,(2 \times 10^{-3}) = j\,20\ \Omega$$

Capacitive reactance, $$X_C = \frac{1}{j\omega C} = \frac{1}{j(10 \times 10^3)(1 \times 10^{-6})}$$

$$X_C = -j\,100\ \Omega$$

We can represent the circuit as shown below,




Here, $$V = 1\angle 0° \times 50 = 50\text{ V}$$

Now, $$V_{in} = 1\angle 0° \times (50 + j20 - j100) + 2 \times 50$$

or, $$V_{in} = 50 - j80 + 100 = (150 - j\,80)\text{ V}$$

Therefore, $$Z_{in} = \frac{V_{in}}{1\angle 0°} = (150 - j80)\,\Omega$$

55. (c)

Charged capacitors are represented in the frequency domain by an impedance $\frac{1}{sC}$ and a voltage source $\frac{v(0^-)}{s}$ in series or a current source $cv(0^-)$ in parallel must be connected to it.

57. (b)

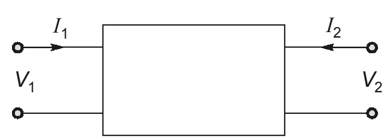
Resistance $\rightarrow$ Conductance

Inductance $\rightarrow$ Capacitance

58. (d)

$$\text{No. of loops} = \text{No. of node pairs}$$
$$\text{No. of loop current} = \text{No. of node pair voltage} = \text{No. of KCL equations}$$
$$\text{Coefficient of coupling, } k = \frac{M}{\sqrt{L_1 L_2}} = \frac{2.5}{\sqrt{20}} \approx 0.56$$

59. (b)

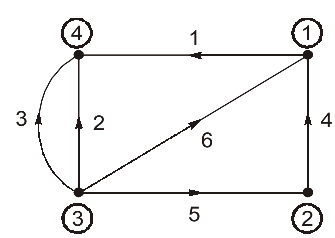



Transmission parameters $A$, $B$, $C$, $D$

$$V_1 = AV_2 - BI_2$$
$$I_1 = CV_2 - DI_2$$
$$h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0} = \text{Open circuit output admittance}$$

60. (b)

The connected graph is




Branches 2 and 3 are not in series so, statement-1 is incorrect.

61. (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

62. (d)

$$V_T = IZ$$

$$= 10\sqrt{3^2 + (2-6)^2}$$

$$V_T = 50 \text{ V}$$

($\because$ for series connection, $V_L$ and $V_C$ are opposite in phase).

64. (c)

- Steady state voltage across $C$ will be same as source voltage. It will be independent of the value of $R$ and $L$.

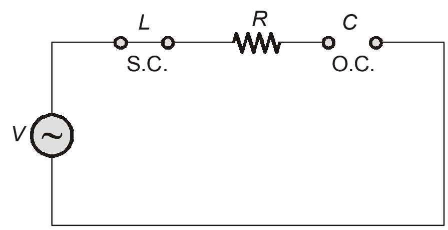



Figure: At steady state

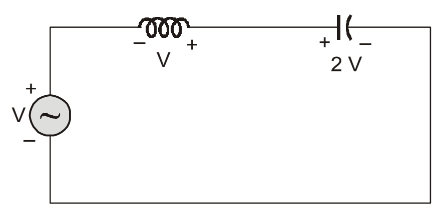
- Frequency of transient oscillations,

$$\omega_d = \omega_o\sqrt{1-\xi^2}$$

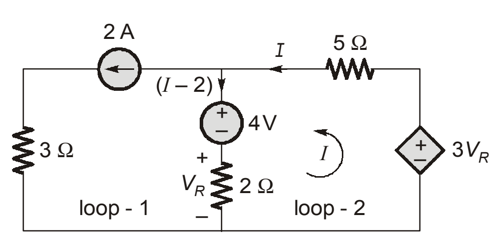
As $R$ increases $\Rightarrow$ $\xi$ increases $\Rightarrow \omega_d$ decreases

- If $R$ decreases $\Rightarrow$ time constant $\tau = \frac{L}{R}$ will increase and hence transient will die down at a slower rate.

- When $R \to 0$,
during the undamped oscillations following case will also be possible.




65. (a)




From the circuit diagram, applying KVL in loop (2), We have:

$$5I - 3V_R + 2(I-2) + 4 = 0$$

$$5I - 3(I-2)\times 2 + 2(I-2) + 4 = 0 \qquad [\text{as } V_R = (I-2)\times 2]$$

$$5I - 6I + 12 + 2I - 4 + 4 = 0$$

$$I + 12 = 0$$

or $$I = -12 \text{ A}$$

66. (b)

$$V = |V|_{rms} = 250 \text{ Volt}$$

Now, $$V_R = \sqrt{V^2 - V_L^2}$$

$$= \sqrt{250^2 - 150^2}$$

$$= 200 \text{ V}$$

Also, $$|I|_{rms} = \frac{V_R}{R} = \frac{200}{100} = 2 \text{ A}$$

and, $$X_L = \frac{V_L}{|I|_{rms}} = \frac{150}{2} = 75\ \Omega$$

or, $$\omega L = 75$$

or, $$L = \frac{75}{300} = 0.25 \text{ H}$$

67. (c)

Using current division rule,

$$\frac{I_1}{I_2} = \frac{10}{\sqrt{3^2 + 4^2}} = 2$$

Given,

$$P_1 + P_2 = 1100$$

$$3I_1^2 + 10I_2^2 = 1100$$

$$\Rightarrow \quad 3(2I_2)^2 + 10I_2^2 = 1100$$

$$\Rightarrow \quad I_2^2 = 50$$

$$\therefore \quad P_2 = 10I_2^2 = 500 \text{ W}$$

$$\Rightarrow \quad P_1 = 1100 - 500 = 600 \text{ W}$$

68. (a)

$$\text{Resonant frequency} = \frac{1}{2\pi\sqrt{L_{eq} \times C}}$$

where, $$L_{eq} = L_1 + L_2 + 2M$$

$$= 10 + 5 + 2 \times 2$$

$$= 19 \text{ mH}$$

$$\therefore \quad \text{Resonant frequency} = \frac{1}{2\pi\sqrt{19 \times 10^{-3} \times 0.01 \times 10^{-6}}} = \frac{10^5}{2\pi\sqrt{1.9}} \text{ Hz}$$

69. (c)

Statement-I is correct as,

$$Q = \frac{\omega_0}{\text{B.W.}}$$

Whereas for statement-II is incorrect.

70. (c)

In a series RLC circuit,

$$V_{\text{supply}} = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$= \sqrt{400^2 + (500 - 200)^2} = 500 \text{ V}$$

Statement-II is incorrect.

71. (d)

Apprant power, $S = VI^*$

$= (50 - j50) \times (4 + j4)$

$\therefore$ $S = (400 + j0)$ VA

74. (c)

In order to avoid infinite voltage and infinite power, an inductor current must not be allowed to jump instantaneously from one value to another as $v = L\frac{di}{dt}$.

75. (b)

Both statements are individually true, but statement (II) is not the correct explanation of statement (I). An electrical network is in resonance when the voltage and current at the network input terminals are in phase because at resonance the network is purely resistive.

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