CLASS TEST

Sl. : 01_JP_EE_02072023

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ELECTRICAL ENGINEERING

NETWORK THEORY

Duration : 1:00 hr. **Maximum Marks : 50**

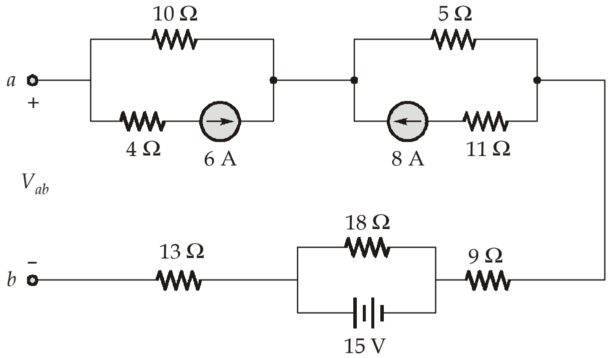
Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

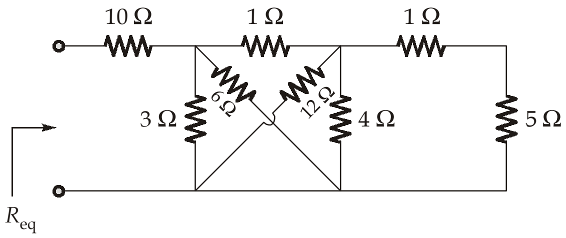
Q.1 Consider the circuit shown in the figure below:



the value of voltage V_{ab} is equal to

(a) V_{ab} = 25 V (b) V_{ab} = –85 V
(c) V_{ab} = –35 V (d) V_{ab} = 105 V

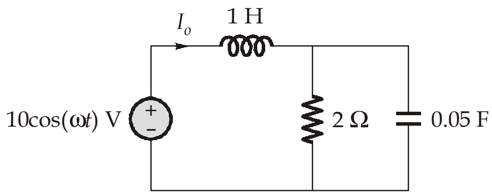
Q.2 Consider the circuit shown in the figure below:



the equivalent resistance (R_{eq}) is

(a) 10.5 Ω (b) 11.2 Ω
(c) 22.4 Ω (d) 36.5 Ω

Q.3 Consider the circuit shown in the figure below:

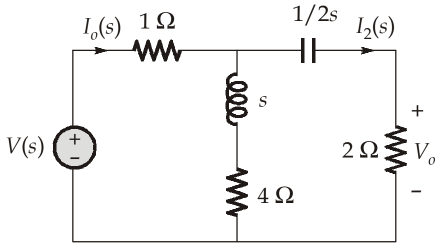


If the $I_o(j\omega)$ is current flowing in the circuit for particular value of angular frequency ω,

then the value of $\left|\dfrac{I_o(j)}{I_o(5j)}\right|$ is equal to

(a) 2.1 (b) 3.6
(c) 4.2 (d) 8.8

Q.4 Consider the circuit shown in the figure below:

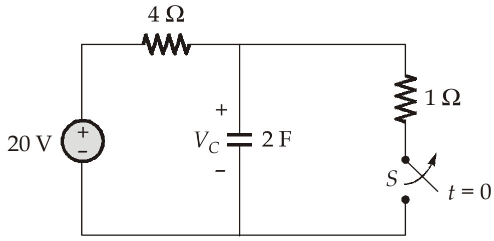


The transfer function $H(s) = \dfrac{V_o(s)}{I_o(s)}$ is equal to

(a) $\dfrac{4s(s+4)}{2s^2+12s+1}$ (b) $\dfrac{4(s+2)}{2s^2+12s+3}$

(c) $\dfrac{4(s+4)}{s^2+12s+2}$ (d) $\dfrac{4s(s+4)}{2s^2+2s+1}$

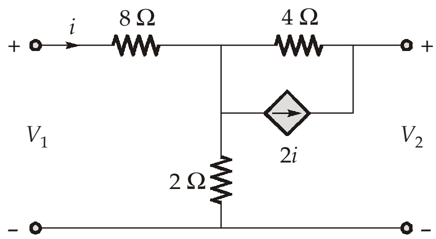
Q.5 Consider the circuit shown in the figure below:



The switch 'S' was closed for long time and then it was opened at t = 0, then the value of voltage V_C across the capacitor for $t > 0$ is equal to

(a) $16 - 20\,e^{-t/8}$ V (b) $4 - 6\,e^{-t/8}$ V
(c) $20 - 16\,e^{-t/8}$ V (d) $16 - 16\,e^{-t/8}$ V

Q.6 Consider the circuit shown in the figure below:



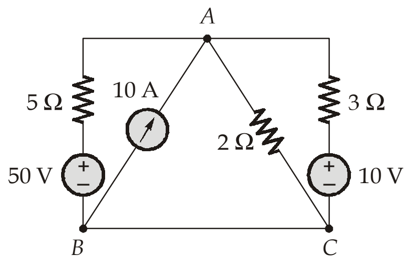
the value of Y_{21} is equal to

(a) –0.25 s (b) – 0.5 s
(c) – 0.75 s (d) – 1 s

Q.7 If the combined generator and line impedance is $(5 + j10)\ \Omega$, then for the maximum power transfer to a resistive load from a generator of constant generated voltage, the load resistance is given by which one of the following

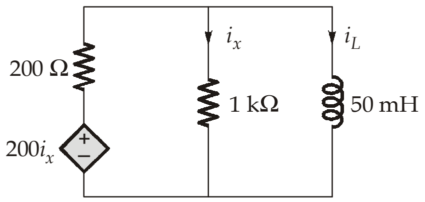
(a) 10 Ω (b) 15 Ω
(c) 11.18 Ω (d) 5 Ω

Q.8 The power delivered by the 50 V voltage source in the circuit shown below is



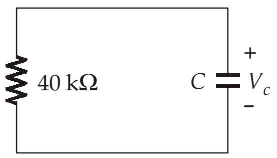
(a) 274.2 W (b) 100 W
(c) 125.5 W (d) 375.5 W

Q.9 In the circuit given below, the equivalent resistance seen by the inductor is



(a) 100 Ω (b) 200 Ω
(c) 400 Ω (d) 600 Ω

Q.10 Consider the circuit shown in figure below:

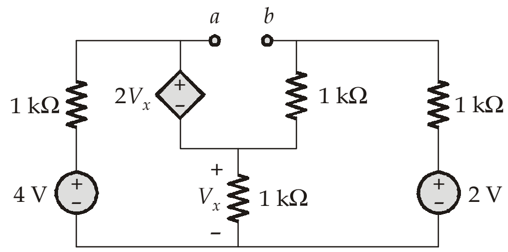


Assume $V_c(0^-) = 5$ V. If $v_c(t) = \frac{5}{e} V$ at $t = 0.1$ sec, then the value of C is

(a) 1.2 μF (b) 1.5 μF
(c) 2.5 μF (d) 5 μF

Q. No. 11 to Q. No. 30 carry 2 marks each

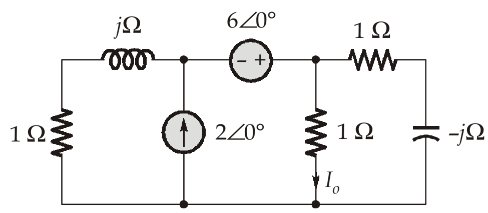
Q.11 Consider the circuit shown in the figure below:



The value of resistance as seen from terminal ab i.e. R_{ab} is equal to

(a) $R_{ab} = 555\ \Omega$ (b) $R_{ab} = 777\ \Omega$
(c) $R_{ab} = 252\ \Omega$ (d) $R_{ab} = 111\ \Omega$

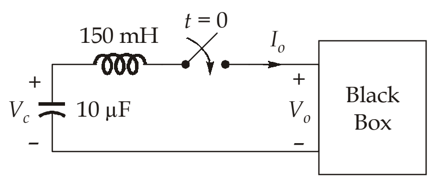
Q.12 Consider the circuit shown in the figure below:



The value of I_o is equal to

(a) $5.831\angle 149.03°$ (b) $2\angle 180°$
(c) $6.913\angle 132.1°$ (d) $2.915\angle -30.96°$

Q.13 At $t = 0$, a series-connected capacitor and inductor are placed across the terminal of a black box as shown in the figure below:



For $t > 0$, $I_o = (200e^{-800t} - 40e^{-200t})$ mA. If $V_c(0) = 5$ V, then the value of V_o for $t > 0$ is equal to

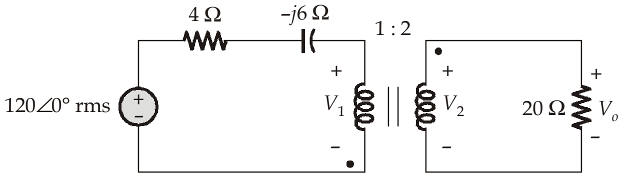
(a) $49e^{-800t} - 21.2e^{-200t}$

(b) $21.2e^{-800t} + 49e^{-200t}$

(c) $21.2e^{-800t} - 21.2e^{-200t}$

(d) $49e^{-200t} - 21.2e^{-800t}$

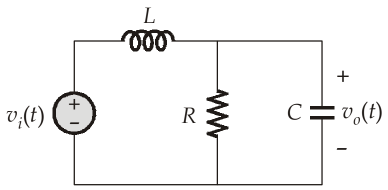
Q.14 Consider the circuit shown in the figure below:



The value of output voltage $|V_o|$ is equal to (Assume the transformer to be ideal)

(a) 100.2 (b) 110.9
(c) 211.4 (d) 92.6

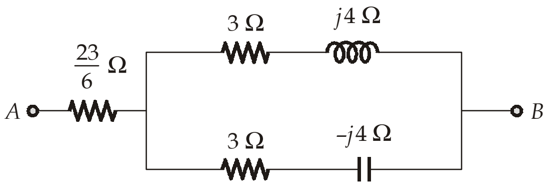
Q.15 Consider the circuit shown in the figure below:



If R = 2 kΩ, L = 2 H and C = 2 μF, then the corner cut-off frequency for the circuit is equal to

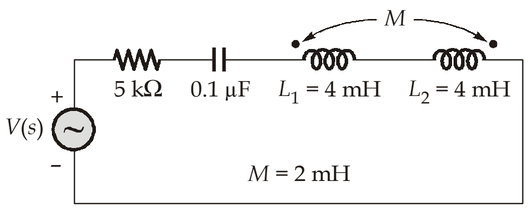
(a) 638 rad/s (b) 742 rad/s
(c) 845 rad/s (d) 931 rad/s

Q.16 For the circuit shown below the equivalent impedance seen across the terminals A and B is



(a) 5 Ω (b) 8 Ω
(c) j8Ω (d) (7 + j10) Ω

Q.17 The resonant frequency of the circuit shown in the figure below is



(a) 7.96 kHz (b) 11.58 kHz
(c) 14.76 kHz (d) 17.86 kHz

Q.18 Two identical two port networks are connected in series to form a composite network 'N'. The admittance parameter of 'N' is given by $\begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}$. The impedance matrix for individual network is

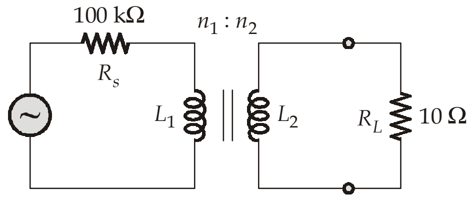
(a) $\begin{bmatrix} 1.5 & -1 \\ -1 & 1.5 \end{bmatrix}$

(b) $\begin{bmatrix} 0.3 & -0.2 \\ -0.2 & 0.3 \end{bmatrix}$

(c) $\begin{bmatrix} 0.2 & 0.3 \\ 0.3 & 0.2 \end{bmatrix}$

(d) $\begin{bmatrix} 3/5 & -2/5 \\ -2/5 & 3/5 \end{bmatrix}$

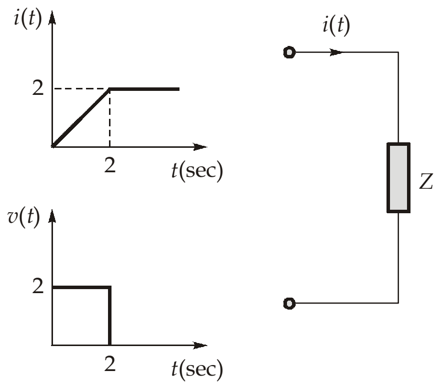
Q.19 Consider the circuit shown in figure below:



For maximum power delivered to load, the required transformer turns ratio $\left(\frac{n_1}{n_2}\right)$ is

(a) 10 (b) 100
(c) 120 (d) 10000

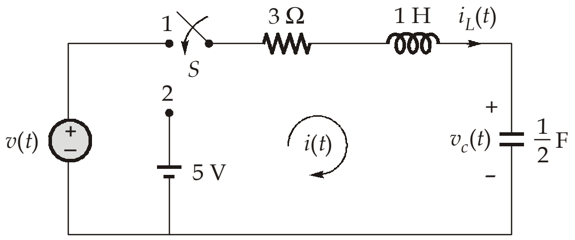
Q.20 The voltage and current waveforms for an element are shown in the figure below:



The circuit element and its values are

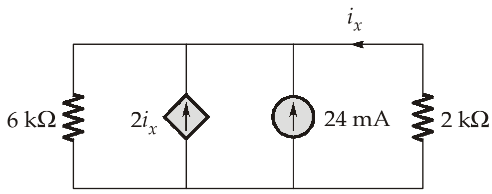
(a) capacitor and 2F
(b) inductor and 1 H
(c) inductor and 2 H
(d) capacitor and 1 F

Q.21 In the figure shown below, the switch S is moved from position 1 to 2 at time $t = 0$. Just before the switch is thrown, the initial conditions are $i_L(0^-) = 2$ A and $V_c(0^-) = 2$ V. Then the current $i(t)$ for $t > 0$ is



(a) $(e^t - e^{-2t})$ A (b) $(e^{-t} - e^{-2t})$ A
(c) $(e^{-t} + e^{-2t})$ A (d) $(e^t + e^{2t})$ A

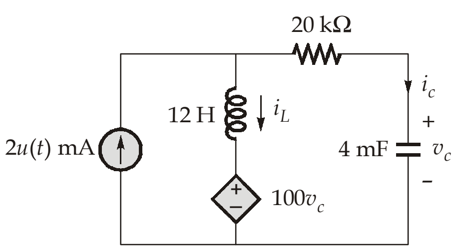
Q.22 In the circuit shown below:



The power supplied by independent current source is
(a) 345.6 mW (b) 425.9 mW
(c) 520.6 mW (d) 700 mW

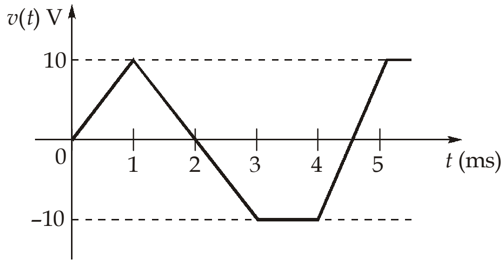
Q.23 The resonant frequency of a series RLC circuit is 1.5 MHz with the resonating capacitor set at 150 pF. If the bandwidth is 10 kHz, then the effective resistance of the circuit would be (approximately)
(a) 1.25 Ω (b) 2.25 Ω
(c) 3.25 Ω (d) 4.71 Ω

Q.24 Consider the circuit shown below:

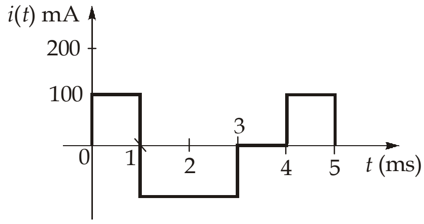


Then the value of $\frac{dv_c(0^+)}{dt}$ will be
(a) 0.25 V/sec (b) 0.5 V/sec
(c) 1 V/sec (d) 2 V/sec

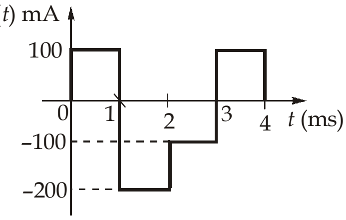
Q.25 A voltage signal $v(t)$ is applied to a capacitor with capacitance equal to 10 μF. The voltage wave is shown in the figure below. Which of the following plot is correct for the current $i(t)$ through the capacitor?



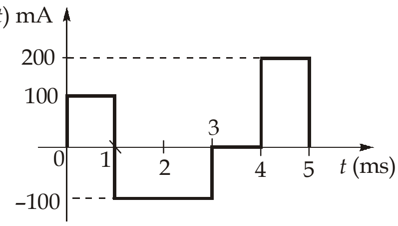
(a)



(b)

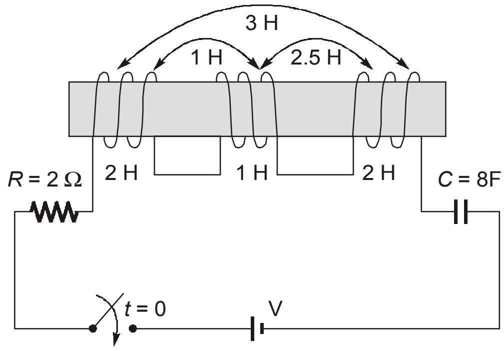


(c)



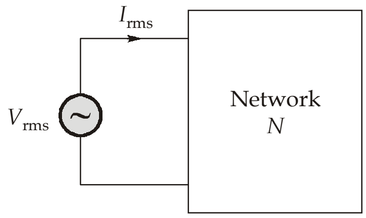
(d) None of these

Q.26 Consider the circuit shown in the figure below,



The value of natural frequency ω_n, for the circuit is equal to
(a) 0.18 rad/sec (b) 0.018 rad/sec
(c) 0.25 rad/sec (d) 0.025 rad/sec

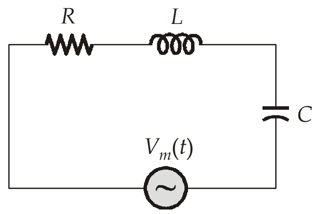
Q.27 For the circuit shown in the figure below, V_{rms} = 100 V, the instantaneous power $p(t)$ dissipated by the network N has a maximum value of 1500 W and minimum value of –1000 W.



The RMS value of current I_{rms} flowing in the circuit is equal to

(a) 1.25 A (b) 12.5 A
(c) 1.625 A (d) 16.25 A

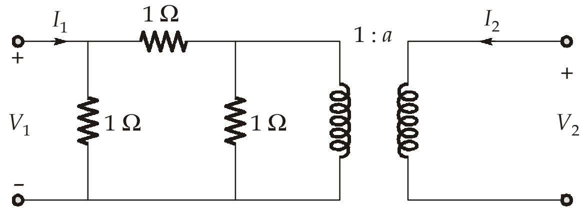
Q.28 Consider the circuit shown in the figure below:



The value of resistance R = 2 Ω, L = 1 mH and capacitance C = 0.4 μF, then which of the following statement is not correct?

(a) The resonant frequency ω_0 for the circuit is equal to 50 krad/sec.
(b) The lower half-power frequency ω_1 is equal to 49 krad/sec.
(c) The upper half-power frequency ω_2 is equal to 59 krad/sec.
(d) The quality factor 'Q' for the circuit is equal to 25.

Q.29 Consider the circuit shown in the figure below:



Assuming 'a' to be a positive non zero number, then which of the following statement is correct?

(a) Z-parameter does not exists for all values of 'a'
(b) Z-parameter does not exists for 'a' = 3
(c) Z-parameter does not exists for 'a' = 8
(d) Z-parameter exists for all positive value of 'a'

Q.30 An RLC circuit along with its phase diagram is shown in figure below,

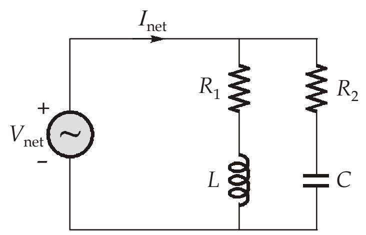


Figure -1

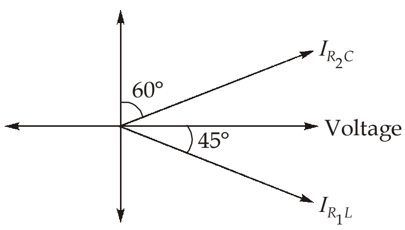


Figure -2

If $L = C$, then the minimum value of $R_1 + R_2$ is

(a) 2.63 Ω (b) 6.33 Ω
(c) 21.4 Ω (d) 19 Ω

■■■■

CLASS TEST

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NETWORK THEORY

ELECTRICAL ENGINEERING

Date of Test : 02/07/2023

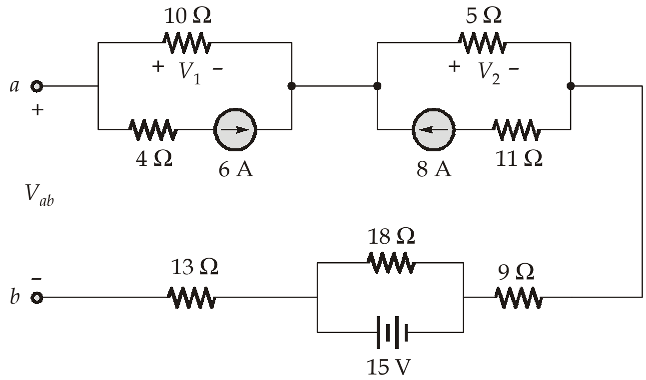
ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Since terminal *a* and *b* forms is open circuit thus, no current flows through circuit is zero, thus the current only flows into the loops.



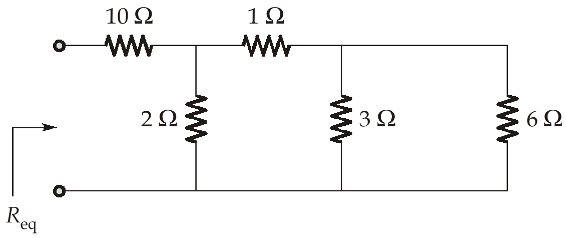
$$V_{ab} = V_1 + V_2 - 15\text{ V}$$

$\therefore$ $$V_{ab} = (-6\text{ A})(10\ \Omega) + (8\text{ A} \times 5\ \Omega) - 15$$

$$V_{ab} = -35\text{ V}$$

2. (b)

The resistance $6\ \Omega \| 3\ \Omega$ and $12\ \Omega \| 4\ \Omega$ also 1 Ω is in series with 5 Ω, thus, the circuit can be redrawn as



$\therefore$ $$R_{eq} = 10\ \Omega + 2\ \Omega \| (1 + 3\ \Omega \| 6\ \Omega)$$

$$R_{eq} = 11.2\ \Omega$$

3. (a)

$$Z_L = j\omega L = j\Omega$$

$$Z_C = \frac{1}{j\omega C} = \frac{1}{j(1)(0.05)} = -j20\ \Omega$$

$\therefore$ $$Z_{eq} = j + 2 \| (-j20) = 1.98 + j0.802\ \Omega$$

and $$Z_L(5j) = 5j\ \Omega$$

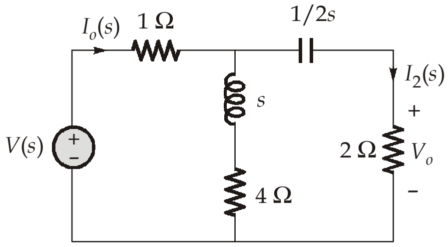
$$Z_C(5j) = -j4\ \Omega$$

$\therefore$ $$Z_{eq}(j5) = j5 + 2 \| (-j4) = 1.6 + j4.2\ \Omega$$

Now, $$I(j\omega) \propto \frac{1}{Z(j\omega)}$$

$\therefore$ $$\left|\frac{I_o(j)}{I_o(j5)}\right| = \frac{Z(j5)}{Z(j)} = \left|\frac{1.6 + j4.2}{1.98 + j0.802}\right| = 2.104$$

4. (a)



Now, applying current division rule, we get,

$$I_2(s) = \frac{(s+4)I_o(s)}{s+4+2+\frac{1}{2s}}$$

$$I_2(s) = \frac{2s(s+4)}{2s^2+12s+1}\cdot I_o(s)$$

$$V_o(s) = 2I_2(s) = \frac{4s(s+4)}{2s^2+12s+1}\,I_o(s)$$

$$\frac{V_o(s)}{I_o(s)} = \frac{4s(s+4)}{2s^2+12s+1}$$

5. (c)

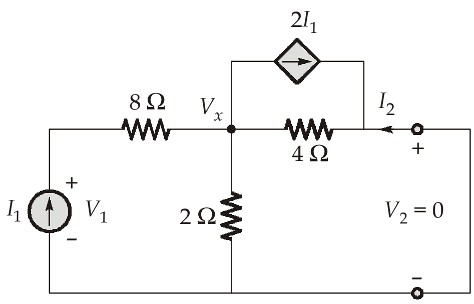
$$v_c(t) = v_c(\infty) + [v_c(0) - v_c(\infty)]\, e^{-t/\tau}$$

where, $\tau = RC = 4 \times 2 = 8, v(0)$ $= 4$ V and $v_c(\infty) = 20$ V

$\therefore$ $$v_c(t) = 20 + (4 - 20)e^{-t/8}$$

$$v_c(t) = 20 - 16\, e^{-t/8}\text{ V}$$

6. (a)



$$I_1 = \frac{V_x}{2}+\frac{V_x}{4}+2I_1$$

$$-I_1 = 0.75V_x \qquad \ldots(i)$$

$$I_2 = -\frac{V_x}{4}-2I_1 = -\frac{V_x}{4}+1.5V_x = 1.25\,V_x$$

Now, $$V_1 = 8I_1 + V_1$$

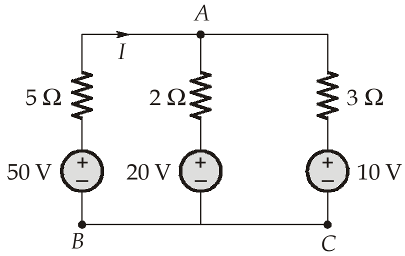
$$V_1 = -6V_x + V_x = -5\,V_x$$

$\therefore$ $$\frac{I_2}{V_1} = -\frac{1.25}{5} = -0.25\text{ S}$$

7. (c)

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

8. (a)



Using nodal analysis,
KCL at node '*A*'

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

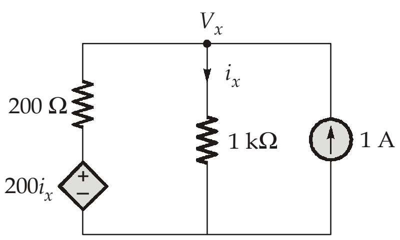
$$V_A = 22.580\ \text{V}$$

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

So, power delivered by 50 V is,

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

9. (b)



Since, $$i_x = \frac{V_x}{1\ \text{k}\Omega} = \frac{V_x}{1000}$$

$$200 i_x = 0.2 V_x$$

and $$\frac{V_x}{1000} + \frac{V_x - 0.2V_x}{200} = 1\ \text{A}$$

$$V_x = 200\ \text{V}$$

$$R_{eq} = \frac{V_x}{1\ \text{A}} = 200\ \Omega$$

10. (c)

Voltage across capacitor

$$v_c(t) = V_{\text{final}} + (V_{\text{initial}} - V_{\text{final}})e^{-t/RC}$$
$$= 0 + (5 - 0)e^{-t/RC}$$

But given, $$v_c(t) = \frac{5}{e} = 5e^{-t/RC}$$

$$\frac{5}{e} = 5e^{-(0.1/40\,k\Omega \times C)}$$

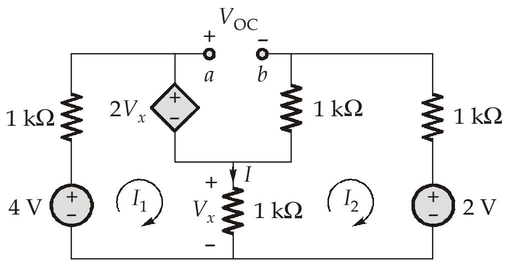
$$\frac{0.1}{40\,k\Omega \times C} = 1$$

$\therefore$ $$C = 2.5\ \mu F \quad (or) \quad 2.5 \times 10^{-6}\ F$$

11. (b)

$$R_{ab} = \frac{V_{OC}}{I_{SC}}$$

To find open circuit voltage



$$I = I_1 - I_2$$

Applying KVL in loop 1, we get,

$$(1\ k\Omega)I_1 + 2V_x + I(1\ k\Omega) = 4$$

$$V_x = I(1\ k\Omega)$$

$\therefore$ $$(4\ k\Omega)I_1 - 3\ k\Omega\ I_2 = 4 \quad \text{...(i)}$$

Applying KVL in loop 2, we get,

$$(1\ k\Omega)I_2 + (1\ k\Omega)I_2 - (1\ k\Omega)I = -2$$

$$-(1\ k\Omega)I_1 + (3\ k\Omega)I_2 = -2 \quad \text{...(ii)}$$

Solving equations (i) and (ii), we get,

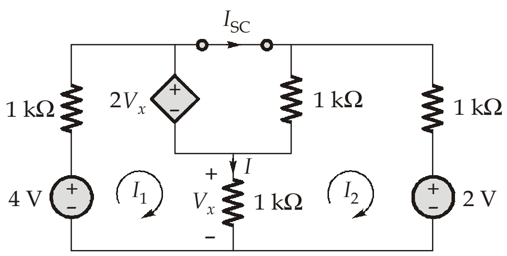
$$I_1 = 0.667\ mA$$

$$I_2 = -0.444\ mA$$

$\therefore$ $$V_{OC} = 2V_x + (1\ k\Omega)I_2$$

$$V_{OC} = 1.78\ V$$

Finding short circuit current



$$I_{SC} = I' + I_2$$

$$I' = I_{SC} - I_2$$

$$I + I_2 = I_1$$

$$I = I_1 - I_2$$

Applying KVL in loop (1)

$$(4\ k\Omega)I_1 + 2V_x - (3\ k\Omega)I_2 = 4 \quad \text{...(i)}$$

Applying KVL in loop (ii)

$$(-1\ \text{k}\Omega)I_{SC} - (1\ \text{k}\Omega)I_1 + (3\ \text{k}\Omega)I_2 = -2 \qquad \text{...(ii)}$$

$$V_x = (1\ \text{k}\Omega)I = (1\ \text{k}\Omega)\ (I_1 - I_2)$$

Thus, $I_1 = 1.43$ mA

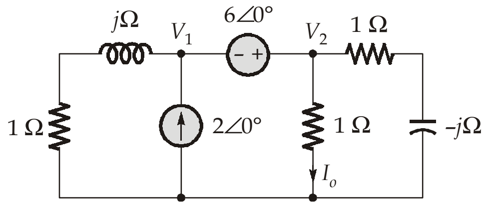
$I_2 = 0.57$ mA

$$\therefore \quad I_{SC} = \frac{(-1\,\text{k}\Omega)I_1 + (3\,\text{k}\Omega)I_2 + 2}{1\,\text{k}\Omega} = 2.29\ \text{mA}$$

$$\therefore \quad R_{Th} = \frac{1.78}{2.29}\times 10^3\ \Omega = 777\ \Omega$$

12. (d)

Applying KCL on supernode



$$\frac{V_1}{1+j} - 2 + \frac{V_2}{1} + \frac{V_2}{1-j} = 0$$

and $V_1 + 6 = V_2$

$$\therefore \quad \begin{bmatrix} 0.5-0.5j & 1.5+0.5j \\ 1 & -1 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 2 \\ -6 \end{bmatrix}$$

$$\therefore \quad V_2 = \frac{\begin{bmatrix} 0.5-0.5j & 2 \\ 1 & -6 \end{bmatrix}}{\begin{bmatrix} 0.5-0.5j & j0.5+0.5j \\ 1 & -1 \end{bmatrix}}$$

$$V_2 = \frac{5.83095\angle 149.036}{2\angle 180°}$$

$$V_2 \approx 2.915\angle -30.96°$$

$$\text{Thus,} \quad I_o = \frac{V_2}{1\,\Omega} = 2.915\angle -30.96°$$

13. (a)

$$V_c(t) = \frac{-1}{10\times 10^{-6}}\left[\int_0^t 0.2e^{-800\tau}d\tau - \int_0^t 0.04e^{-200\tau}d\tau\right] + 5$$

$$= 25e^{-800t} - 20e^{-200t}$$

$$V_L(\text{t}) = 150\times 10^{-3}\frac{dI_o}{dt} = 150(-160e^{-800t} + 8e^{-200t})\times 10^{-3}$$

$$= -24\,e^{-800t} + 1.2e^{-200t}$$

$$V_o(t) = V_c(t) - V_L(t)$$

$$= (25e^{-800t} - 20e^{-200t}) - (-24e^{-800t} + 1.2e^{-200t})$$

$$V_o(t) = (49e^{-800t} - 21.2e^{-200t})\ \text{V}$$

14. (b)

The 20 Ω impedance can be reflected to the primary side as

$$Z_R = \frac{20}{n^2} = \frac{20}{4} = 5\,\Omega$$

$$\therefore \quad Z_i = 4 - 6j + 5$$

$$= 9 - 6j = 10.82\angle -33.69°\ \Omega$$

$$I_1 = \frac{120\angle 0°}{Z_{in}} = \frac{120\angle 0°}{10.82\angle -33.69°} = 11.09\angle 33.69°$$

$$\therefore \quad I_2 = -\frac{1}{n} I_1 = -5.545\angle 33.69°\ \text{A}$$

$$V_o = 20I_2 = 110.9\angle 213.69°\ \text{V}$$

15. (b)

$$\text{The transfer function,} H(s) = \frac{v_o}{v_i} = \frac{R \| 1/sC}{sL + R \| 1/sC}$$

$$H(s) = \frac{\frac{R}{1+sRC}}{sL + \frac{R}{1+sRC}} = \frac{R}{s^2RLC + sL + R}$$

$$H(j\omega) = \frac{R}{-\omega^2 RLC + j\omega L + R}$$

$$\text{At corner frequency,} |H(j\omega)| = \frac{1}{\sqrt{2}} |H(j\omega)|_{max}$$

Now,

$$|H(j\omega)| = \frac{R}{\sqrt{(R - \omega^2 RLC)^2 + \omega^2 L^2}}$$

$$|H(j\omega)|^2 = \frac{1}{2} = \frac{R^2}{(R - \omega^2 RLC)^2 + \omega^2 L^2}$$

$$2 = (1 - \omega_o^2 LC)^2 + \left(\frac{\omega_o L}{R}\right)^2$$

$$2 = (1 - \omega_o^2 4 \times 10^{-6})^2 + (\omega_o \times 10^{-3})^2$$

$$16\omega_o^4 - 7\omega_o^2 - 1 = 0 \text{(where } \omega_o \text{ is in Krad/s)}$$

$$\therefore \quad \omega_o = 0.742\ \text{K rad/sec} = 742\ \text{rad/sec}$$

16. (b)

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

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

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

17. (a)

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

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

$$f_o = \frac{1}{2\pi\sqrt{4\times0.1\times10^{-9}}} = 7.96 \text{ kHz}$$

18. (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 = $\frac{1}{2}\begin{bmatrix} 3/5 & -2/5 \\ -2/5 & 3/5 \end{bmatrix} = \begin{bmatrix} 0.3 & -0.2 \\ -0.2 & 0.3 \end{bmatrix}$

19. (b)

We know that, for a transformer

$$R_s = \left(\frac{n_1}{n_2}\right)^2 R_L$$

$$100 \text{ k}\Omega = \left(\frac{n_1}{n_2}\right)^2 10$$

$$\left(\frac{n_1}{n_2}\right)^2 = 10^4$$

$$\therefore \quad \frac{n_1}{n_2} = 100$$

20. (c)

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

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

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

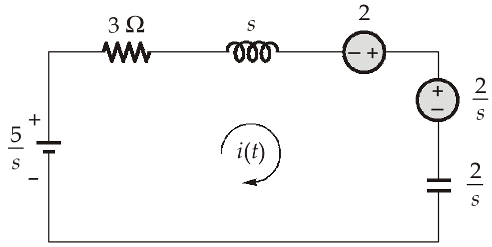
For inductor, $$v(t) = L\frac{di(t)}{dt}$$

$\therefore$ The element is inductor of 2 H

21. (c)

At $t = 0$, switch is closed

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



Applying KVL, we get,

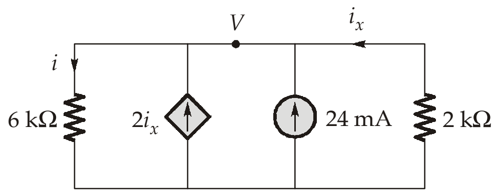
$$\frac{5}{s}-\frac{2}{s}+2 = \left(3+s+\frac{2}{s}\right)I(s)$$

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

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

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

22. (a)



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

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

Therefore, from equations (i) and (ii)

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

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

Hence, power supplied by independent current source

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

23. (d)

Given, $\quad f = 1.5\text{ MHz}$

$C = 150\text{ pF}$

$\text{BW} = 10\text{ kHz}$

For series RLC circuit, $\quad Q = \frac{f_o}{\text{BW}} = \frac{1.5\times10^6}{10\times10^3} = 150$

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

$$\frac{1}{150} = 2\pi\times1.5\times10^6\times150\times10^{-12}\times R$$

$$R = \frac{10^6}{2\pi\times1.5\times150\times150} = 4.71\ \Omega$$

24. (b)

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

Therefore, $\quad i_L(0^-) = i_L(0^+) = 0\text{ A}$

$v_c(0^-) = v_c(0^+) = 0\text{ V}$

For $t > 0$, $\quad i_c(0^+) = 2\text{ mA}$

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

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

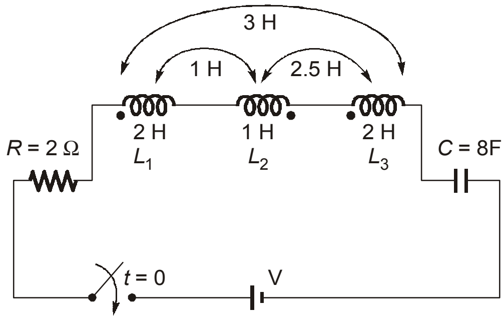
25. (c)

For a capacitor $$i(t) = \frac{cdv(t)}{dt} = 10\times10^{-6}\frac{dv(t)}{dt}\times10^3\text{ A}$$

$$= 10^{-2}\frac{dv(t)}{dt}\text{ A} = 10\frac{dv(t)}{dt}\text{ mA}$$

26. (a)

For the circuit



$$L_{eq} = L_1 + L_2 + L_3 - 2M_{12} - 2M_{23} + 2M_{13}$$

$L_1 = 2$ H

$L_2 = 1$ H

$L_3 = 2$ H

$M_{12} = 1$ H

$M_{23} = 2.5$ H

$M_{13} = 3$ H

$L_{eq} = 2 + 1 + 2 - 2 - 5 + 6$

$= 11 - 7$

$= 4$ H

$C = 8$ F

$R = 2\ \Omega$

$$\therefore \quad \omega_n = \frac{1}{\sqrt{L_{eq}C}} = \frac{1}{\sqrt{8\times4}} = 0.176\text{ rad/sec} \approx 0.18\text{ rad/sec}$$

Note : M_{12}, M_{23} is negative, because both L_1, L_2 and L_2, L_3 opposes the flux of respective loops.

27. (b)

$\because$ $p(t)$ varies with time, thus it can be concluded that the network is not purely resistive circuit.

$\therefore$ let, $$v(t) = \sqrt{2}V_{rms}\cos(\omega t + \theta_v)$$

$$i(t) = \sqrt{2}I_{rms}\cos(\omega t + \theta_I)$$

then, the instantaneous power into the network N is given as,

$$p(t) = v(t)\,i(t) = 2V_{rms}I_{rms}\cos(\omega t + \theta_v)\cos(\omega t + \theta_I)$$

$$= V_{rms}I_{rms}[\underbrace{\cos(\theta_v - \theta_I)}_{\text{constant}} + \underbrace{\cos(2\omega t + \theta_v + \theta_I)}_{\text{time varying}}]$$

thus, for minimum power delivered,

$$\cos(2\omega t + \theta_v + \theta_I) = -1$$

and for maximum power delivered

$$\cos(2\omega t + \theta_v + \theta_I) = 1$$

$$p(t)_{max} = V_{rms}\, I_{rms} \cos(\theta_v - \theta_I) + V_{rms}\, I_{rms} \quad \text{...(i)}$$

$$p(t)_{min} = V_{rms}\, I_{rms} \cos(\theta_v - \theta_I) - V_{rms}\, I_{rms} \quad \text{...(ii)}$$

Thus, from equation (i) and (ii), we get,

thus, $2V_{rms}\, I_{rms} = 2500$

$$V_{rms}\, I_{rms} = 1250$$

$$I_{rms} = \frac{1250}{V_{rms}} = \frac{1250}{100} = 12.5 \text{ A}$$

28. (c)

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-3} \times 0.4 \times 10^{-6}}} = 50 \text{ krad/sec}$$

$$Q = \frac{\omega_0 L}{R} = \frac{50 \times 10^3 \times 10^{-3}}{2} = 25$$

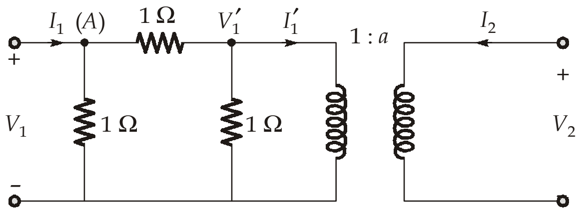
$$B = \frac{\omega_0}{Q} = \frac{50 \times 10^3}{25} = 2 \text{ krad/sec}$$

now, $\omega_1 = \omega_0 - \frac{B}{2} = 50 - 1 = 49 \text{ krad/sec}$

now, $\omega_2 = \omega_0 + \frac{B}{2} = 50 + 1 = 51 \text{ krad/sec}$

Hence, option (c) is incorrect.

29. (d)



Now, applying KCL at node A, we get,

$$I_1 = V_1 + (V_1 - V_1')$$

$$= 2V_1 - V_1'$$

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

For I_2, we can write

$$I_2 = -\frac{1}{a}I_1' = -\frac{1}{a}\left[-V_1' + (V_1 - V_1')\right]$$

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

$$\therefore \quad \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 2 & -\frac{1}{a} \\ -\frac{1}{a} & \frac{2}{a^2} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

For the Z-parameter to not exist.

$$|Y| = 0$$

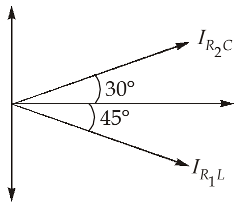
$\therefore$ $$|Y| = \frac{4}{a^2} - \frac{1}{a^2} = \frac{3}{a^2}$$

$\because$ $$|Y| \neq 0$$

Thus, no such value exist for which $|Y| = 0$.

30. **(a)**

From phasor, we can write



$$\tan 30° = \frac{X_C}{R_2}$$

$\Rightarrow$ $$R_2 = X_C\sqrt{3} = \frac{\sqrt{3}}{\omega C}$$

$$\tan 45° = \frac{X_L}{R_1}$$

$\Rightarrow$ $$R_1 = X_L = \omega L$$

$$R_1R_2 = \frac{\sqrt{3}}{\omega C} \times \omega L = \frac{L}{C}\sqrt{3}$$

$$R_1R_2 = \sqrt{3} = 1.732$$

we know

$$\frac{R_1 + R_2}{2} \geq \sqrt{R_1 R_2}$$

as arithmetic mean ≥ geometric mean ; (for non-negative real numbers)

$$R_1 + R_2 \geq 2\sqrt{\sqrt{3}}$$

$$R_1 + R_2 \geq 2(3)^{1/4}$$

Minimum value of $R_1 + R_2 = 2.63\ \Omega$

■■■■