CLASS TEST

S.No.: 01JP_EC_29062024

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ELECTRONICS ENGINEERING

NETWORK THEORY

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

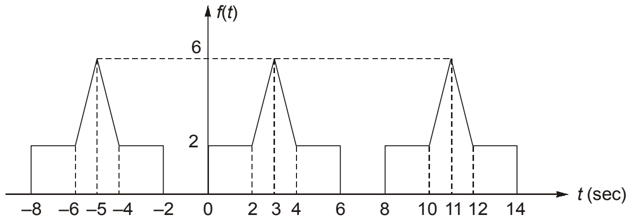
Read the following instructions carefully

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

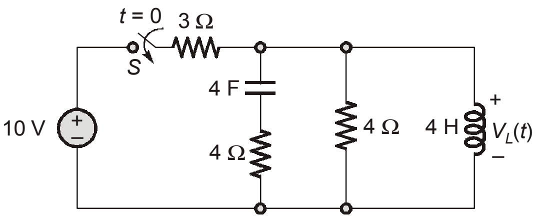
Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 The average value of the periodic signal shown below is



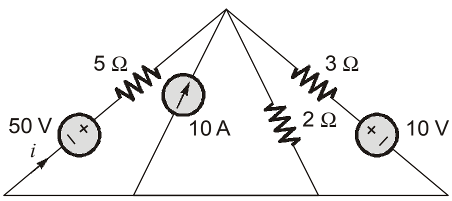
(a) 2 (b) 4
(c) 6 (d) 8

Q.2 In the circuit shown in figure, the switch S is closed at time (t = 0). The voltage across the inductance ($V_L(t)$) at $t = 0^+$, is



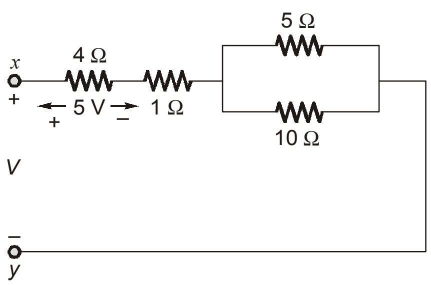
(a) 2 V (b) 4 V
(c) –6 V (d) 8 V

Q.3 Consider the circuit shown below



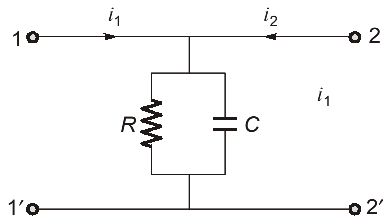
The current flowing through 50 V source is
(a) 30 A (b) 20.66 A
(c) 5.48 A (d) 2.34 A

Q.4 Determine the voltage that must be applied at x - y terminal such that the voltage across 4 Ω is 5 V.



(a) 5 V (b) 10.417 V
(c) 20.123 V (d) 25.72 V

Q.5 For the parallel RC circuit shown below, if R = 1 Ω, and C = 1 F. The value of $Z_{21}(s)$ will be



(a) $s + 1$

(b) $\frac{1}{s} + 1$

(c) $\frac{-1}{s+1}$

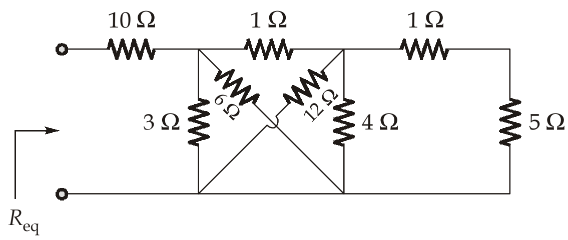
(d) $1 - \frac{s}{s+1}$

Q.6 If the current in a 20 Ω resistor is given by

$$i = 4 + 5\sin\omega t - 3\cos 3\omega t$$

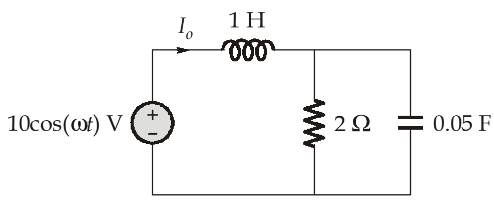
The power consumed by the resistor is
(a) 1 kW (b) 1.865 W
(c) 660 W (d) 720 W

Q.7 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

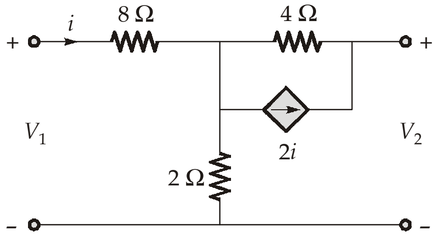
Q.8 Consider the circuit shown in the figure below:



If the $I_o(j\omega)$ is current flowing in the circuit for particular value of angular frequency ω, then the value of $\left|\frac{I_o(j)}{I_o(5j)}\right|$ is equal to

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

Q.9 Consider the circuit shown in the figure below:

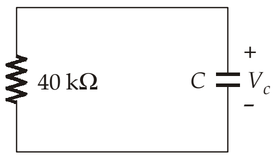


the value of Y_{21} is equal to

(a) –0.25 s (b) – 0.5 s

(c) – 0.75 s (d) – 1 s

Q.10 Consider the circuit shown in figure below:



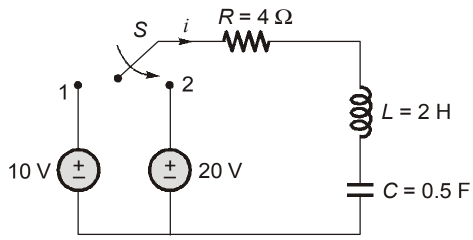
Assume $V_c(0^-) = 5$ V. If $v_c(t) = \frac{5}{e}V$ at $t = 0.1$ sec, then the value of C is

(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

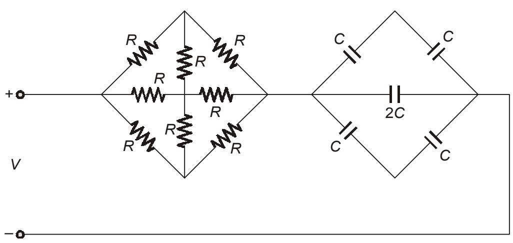


If the switch is at position '1' for a long time and at (t = 0) it is moved to position '2', then the current $i(t)$ for $t > 0$ will be

(a) $(5e^{-t} + 25e^{t})$ A (b) $(5 + 25te^{-t})$ A

(c) $(5te^{-t})$ A (d) $(25te^{-t} + 5)$ A

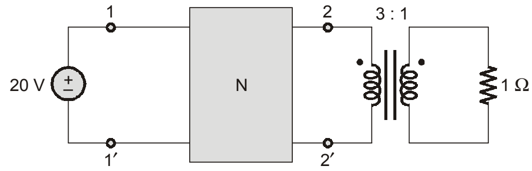
Q.12 The time constant of the circuit shown below will be



(a) RC (b) $2RC$

(c) $\frac{RC}{2}$ (d) $\frac{3RC}{2}$

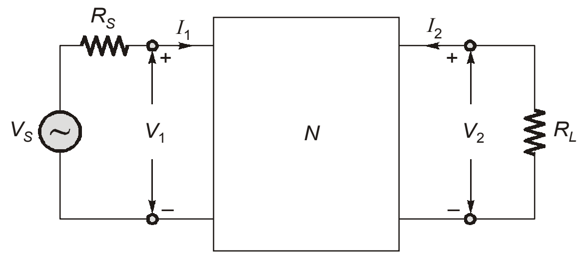
Q.13 For the circuit shown below, the network N has Z parameter matrix of $\begin{bmatrix} 4 & 8 \\ 1 & 3 \end{bmatrix}$. If the transformer used in the circuit is ideal, then the power delivered to the 1 Ω resistance will be



(a) 55.56 mW (b) 2.25 W

(c) 4.5 W (d) None of these

Q.14 The hybrid parameter of the network N shown below are $h_{11} = 2\ \Omega$, $h_{12} = 4$, $h_{21} = -5$ and $h_{22} = 2\ \mho$. The supply voltage, if the power dissipated in the load resistor $R_L (= 4\ \Omega)$ is 25 W and R_s is given by 2 Ω is



(a) 11 V (b) 22 V

(c) 43 V (d) 58 V

Q.15 For a series RLC circuit the magnitude of frequency at which the drop across the capacitor is maximum will be

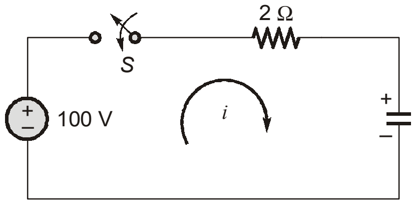
(a) $\sqrt{\frac{1}{LC} - \left(\frac{RC}{L}\right)^2}$ rad/sec

(b) $\frac{1}{\sqrt{LC}}$ rad/sec

(c) $\sqrt{\frac{1}{LC} - \frac{R^2}{2L^2}}$ rad/sec

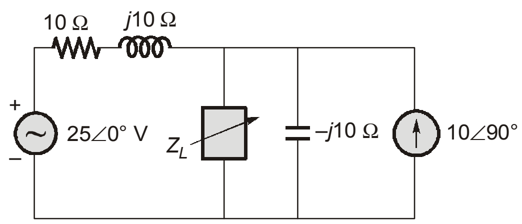
(d) $\sqrt{\frac{1}{LC} - R^2C^2}$ rad/sec

Q.16 In below figure the capacitor initially has a charge of 10 C. The current in the circuit after two seconds the switch S is closed will be



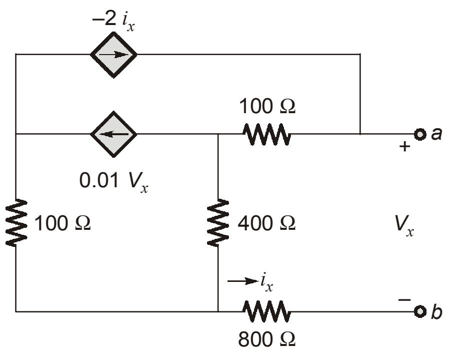
(a) 5.41 A (b) 7.21 A
(c) 8.31 A (d) 9.15 A

Q.17 Consider the circuit shown below



The maximum power absorbed by the load is
(a) 390.625 W (b) 400.125 W
(c) 500.125 W (d) 350.625 W

Q.18 Consider the circuit shown below



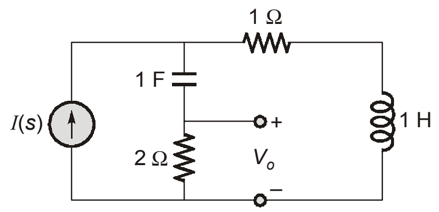
The Thevenin's equivalent resistance across the terminals a and b is
(a) 10 Ω (b) 20 Ω
(c) 30 Ω (d) 60 Ω

Q.19 A series resonance circuit has a source frequency of 5 kHz and source impedance of (2 + j4) Ω. The load impedance being (10 – j X_C) Ω. The value of C such that the power consumed by the resistor is maximum is
(a) 1.45 μF (b) 7.95 μF
(c) 2.84 μF (d) 9.87 μF

Q.20 The voltage applied to series R-L circuit at $t = t_0$ sec is given by $10\cos\left(\frac{t}{2}+45°\right)$ V. The value of resistance is 1 Ω and the value of inductance is 2 H. The value of t_0 to obtain the transient free response is

(a) $\frac{\pi}{4}$ sec (b) $\frac{\pi}{2}$ sec
(c) π sec (d) 2π sec

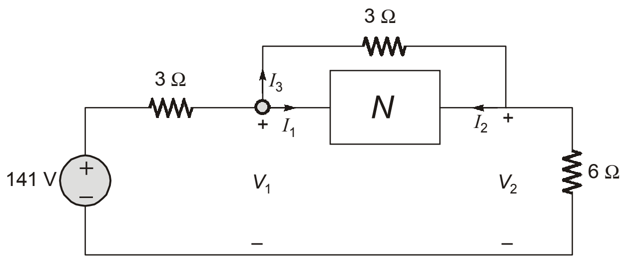
Q.21 Find the transfer function $\frac{V_o(s)}{I(s)}$ for the network shown



(a) $\frac{2s(s+1)}{s^2+3s+1}$ (b) $\frac{2(s+1)}{s^2+3s+1}$

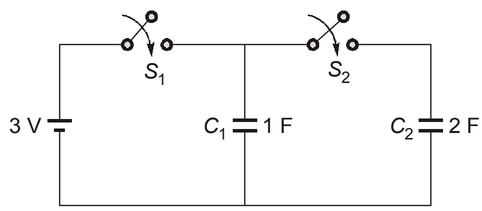
(c) $\frac{8s(s+1)}{2s^2+6s+1}$ (d) $\frac{2s(s+1)}{2s^2+6s+1}$

Q.22 For the two port network N shown below in figure Z parameter matrix is $\begin{bmatrix} 2 & 1 \\ 1 & 4 \end{bmatrix}$. The value of I_1 in Amperes is



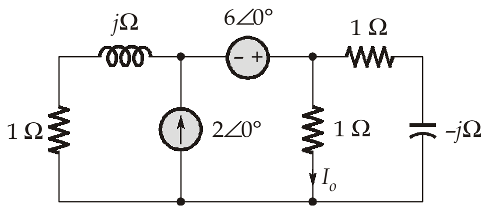
(a) 12 (b) 21
(c) 24 (d) 28

Q.23 In the figure shown, all elements used are ideal. For time $t < 0$, S_1 remain closed and S_2 open. At $t = 0$, S_1 is opened and S_2 is closed. If the voltage V_{C_2} across the capacitor C_2 at $t = 0^-$ is zero, the voltage across the capacitor combination at $t > 0$ will be



(a) 1/2 V (b) 1 V
(c) 3/2 V (d) 5/2 V

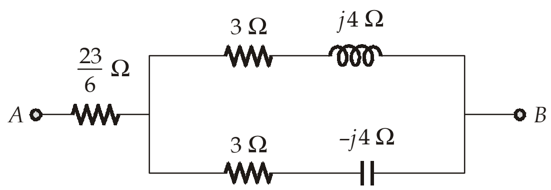
Q.24 Consider the circuit shown in the figure below:



The value of I_o is equal to

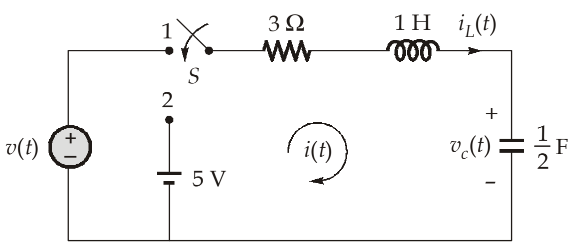
(a) 5.831∠149.03° (b) 2∠180°
(c) 6.913∠132.1° (d) 2.915∠–30.96°

Q.25 For the circuit shown below the equivalent impedance seen across the terminals *A* and *B* is



(a) 5 Ω (b) 8 Ω
(c) *j*8Ω (d) (7 + *j*10) Ω

Q.26 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

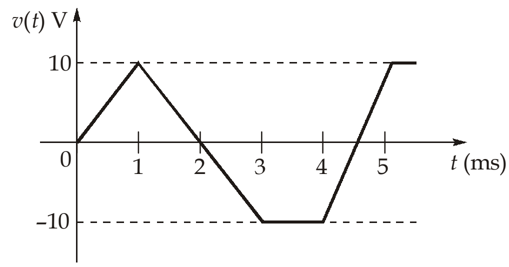


(a) $(e^{t} - e^{-2t})$ A (b) $(e^{-t} - e^{-2t})$ A
(c) $(e^{-t} + e^{-2t})$ A (d) $(e^{t} + e^{2t})$ A

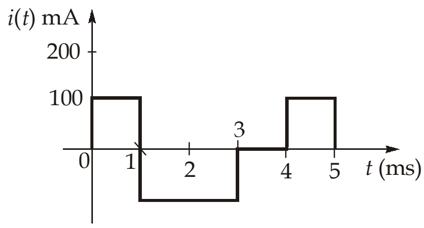
Q.27 The resonant frequency of a series *RLC* circuit is 1.5 MHz with the resonating capacitor set at 150 pF. If the bandwidth is 10 kHz, then the effective resistance of the circuit would be (approximately)

(a) 1.25 Ω (b) 2.25 Ω
(c) 3.25 Ω (d) 4.71 Ω

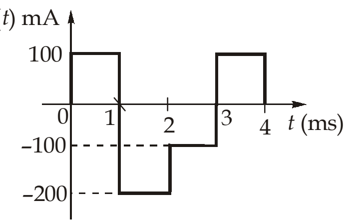
Q.28 A voltage signal *v*(*t*) is applied to a capacitor with capacitance equal to 10 μF. The voltage wave is shown in the figure below. Which of the following plot is correct for the current *i*(*t*) through the capacitor?



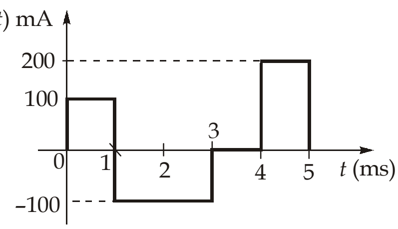
(a)



(b)

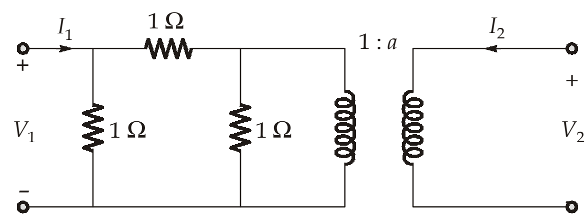


(c)



(d) None of these

Q.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,

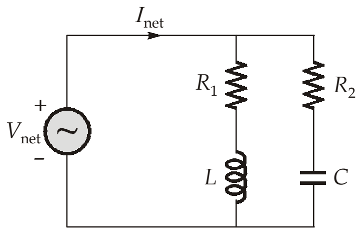


Figure -1

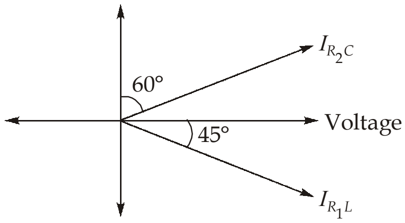


Figure -2

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

■■■■

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NETWORK THEORY

ELECTRONICS ENGINEERING

Date of Test : 29/06/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

The average value of periodic signal can be calculated by considering one time period

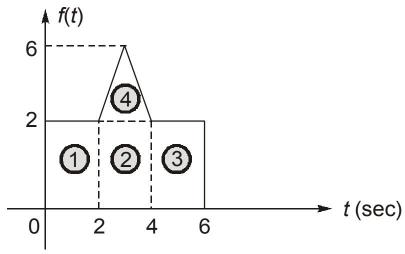
$$= \frac{\text{Total area under the graph for one period}}{T_0}$$

Total area under the graph for one period = Area 1 + Area 2 + Area 3 + Area 4

here Area 1 = Area 2 = Area 3 = Area 4 = 4

and T_0 = 8 sec

$$\text{Average value} = \frac{4+4+4+4}{8} = \frac{16}{8} = 2$$

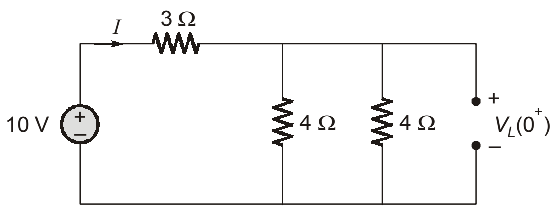


2. (b)

Before closing the switch, the circuit was not energized, therefore, current through inductor and voltage across capacitor are zero.

After closing the switch, at $t = 0^+$ inductor acts as open-circuit and capacitor acts as short-circuit.

Equivalent circuit at $t = 0^+$



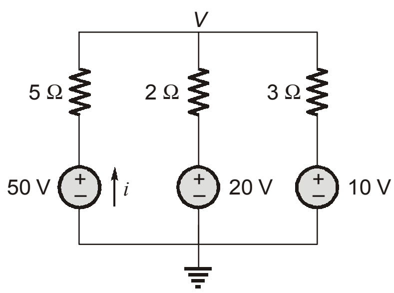
$$I = \frac{10}{3+4||4} = 2 \text{ A}$$

$$V_L(0^+) = I \times (4||4)$$

$$= 2 \times 2 = 4 \text{ V}$$

3. (c)

using source transformation



applying KCL at V

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

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

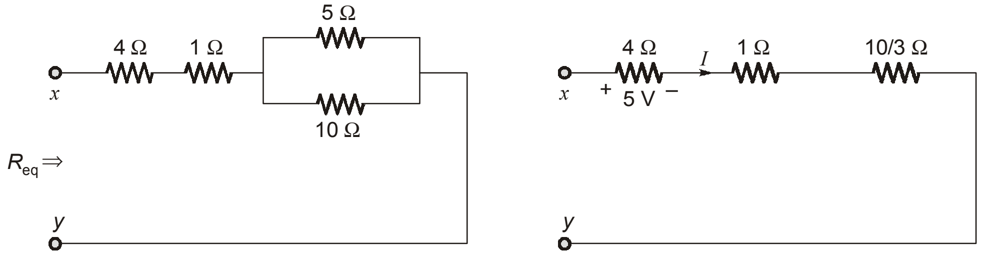
$$31V-700 = 0$$

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

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

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

4. (b)



(a) (b)

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

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

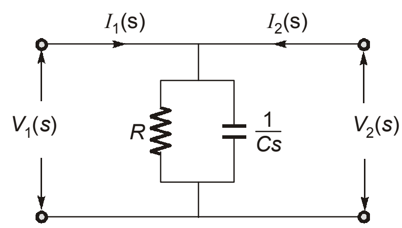
$$= 5+\frac{10}{3} = \frac{25}{3}\ \Omega$$

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

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

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

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

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

6. (c)

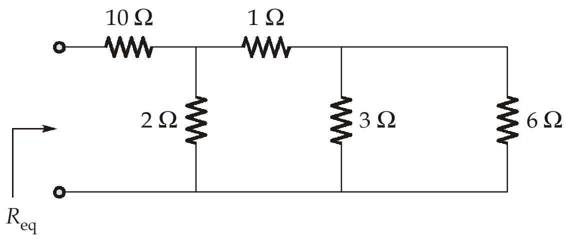
$$P = P_0 + P_1 + P_2$$

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

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

7. (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



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

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

8. (a)

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

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

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

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

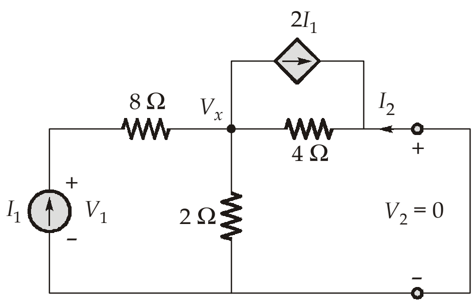
$$Z_C(5j) = -j4\,\Omega$$

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

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

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

9. (a)



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

$$-I_1 = 0.75V_x \qquad \text{...(i)}$$

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

Now,
$$V_1 = 8I_1 + V_1$$
$$V_1 = -6V_x + V_x = -5\,V_x$$
$$\therefore \quad \frac{I_2}{V_1} = -\frac{1.25}{5} = -0.25\text{ S}$$

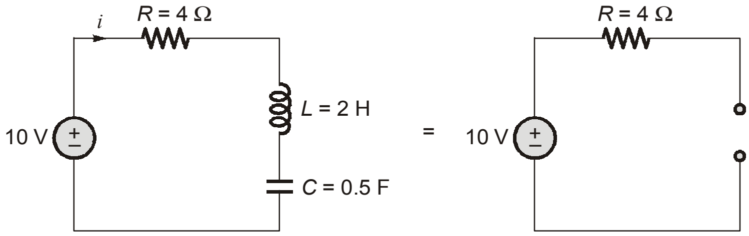
10. (c)

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,
$$v_c(t) = \frac{5}{e} = 5e^{-t/RC}$$
$$\frac{5}{e} = 5e^{-(0.1/40\text{ k}\Omega \times C)}$$
$$\frac{0.1}{40\text{ k}\Omega \times C} = 1$$
$$\therefore \quad C = 2.5\ \mu\text{F} \quad \text{(or)} \quad 2.5 \times 10^{-6}\text{ F}$$

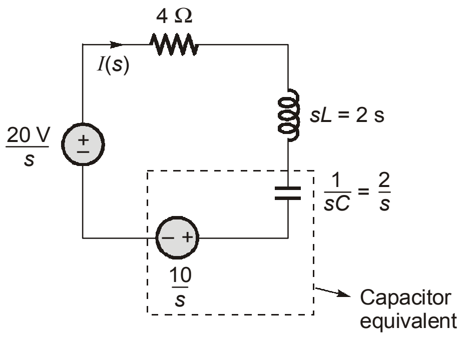
11. (c)

At ($t = 0^-$)



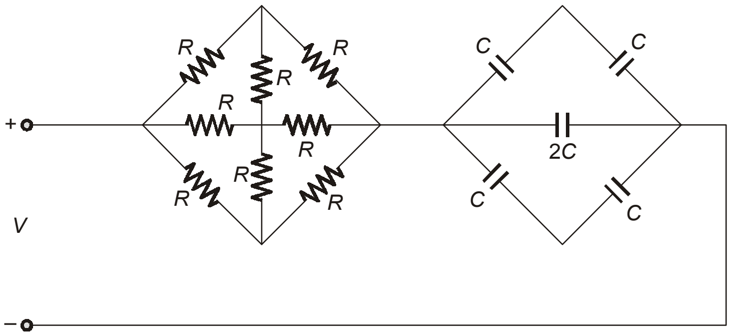
$$V_C(0^-) = 10\text{ V}$$
$$i_L(0^-) = 0\text{ A}$$

At ($t = 0^+$)



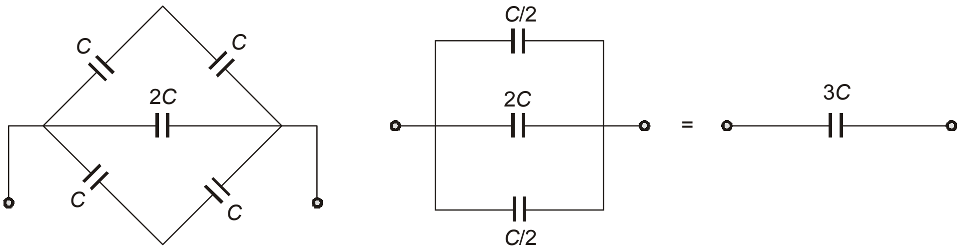
$$I(s) = \frac{10/s}{4 + 2s + \frac{2}{s}} = \frac{10/s}{\frac{4s + 2s^2 + 2}{s}} = \frac{10}{2(s^2 + 2s + 1)}$$
$$I(s) = \frac{5}{(s+1)^2}$$
$$i(t) = 5te^{-t}\,u(t)\text{ A}$$

12. (b)

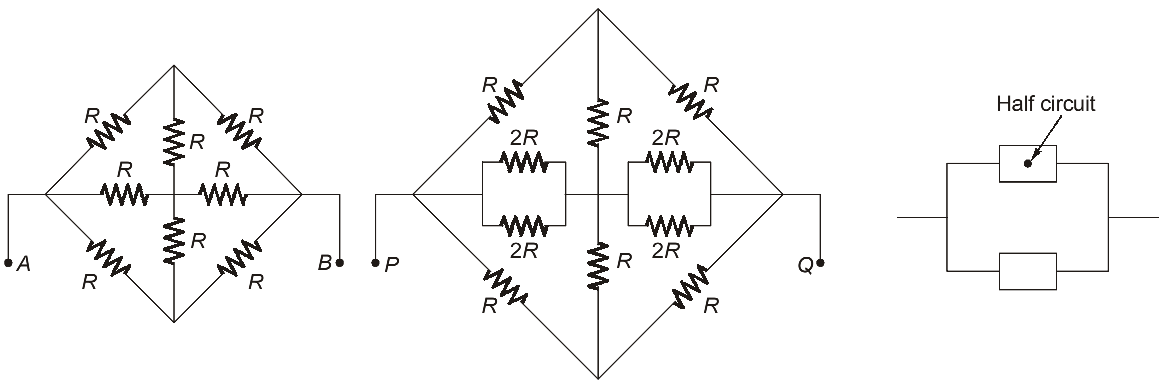


The time constant of an *RC* circuit is $\tau = R_{eq}C_{eq}$

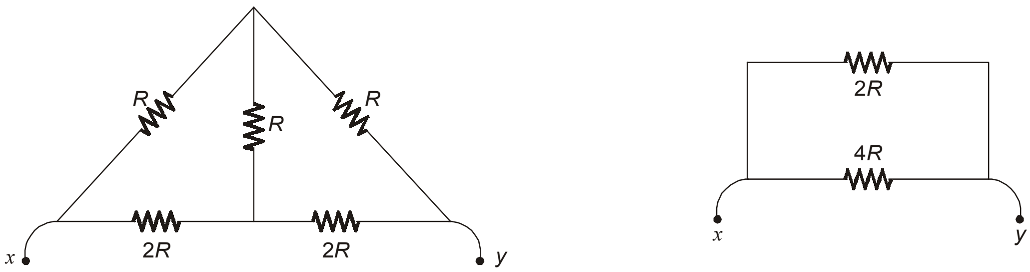
Calculation of C_{eq}



Calculation of R_{eq}



It is Wheatstone bridge.



$$(R_{eq})_{\text{Half circuit}} = \frac{4R \times 2R}{6R} = \frac{4R}{3}$$

$$R_{eq} = (R_{eq})_{\text{Half circuit}} \,||\, (R_{eq})_{\text{Half circuit}}$$

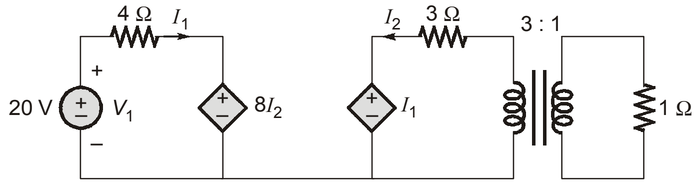
$$= \left(\frac{4R}{3}\right) \bigg\| \left(\frac{4R}{3}\right) = \left(\frac{2R}{3}\right)$$

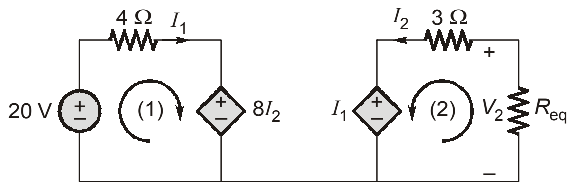
$$\therefore \quad \tau = R_{eq} C_{eq}$$

$$= \frac{2R}{3} \times 3C = 2RC$$

13. (b)

Network 'N' can be replaced as





$$R_{eq} = (1) \times \left(\frac{3}{1}\right)^2 = 9\,\Omega$$

Applying KVL at loop (1)

$$20 = 4I_1 + 8I_2$$

also $\quad V_2 = -9I_2 = I_1 + 3I_2$

$\Rightarrow \quad I_1 = -12I_2$

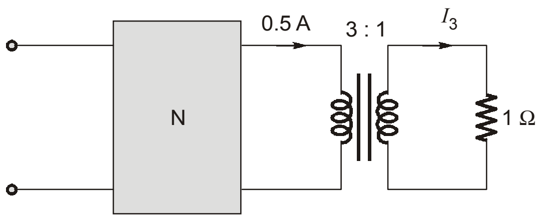
$$20 = 4(-12I_2) + 8I_2$$

$$20 = -40I_2$$

$\Rightarrow \quad I_2 = -0.5\text{ A}$

$$I_1 = -12(-0.5) = 6\text{ A}$$

Now,



$$\frac{I_{primary}}{I_{secondary}} = \frac{1}{3}$$

$\Rightarrow \quad 3I_{primary} = I_{secondary}$

$$3(-I_2) = I_3$$

$\Rightarrow \quad I_3 = 1.5\text{ A}$

Power delivered to 1 Ω $= (I_3)^2 \times R_L = (1.5)^2 \times 1$

$= 2.25$ Watts

14. (d)

The h-parameter

$$V_1 = 2I_1 + 4V_2$$

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

Power dissipated in R_L

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

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

$\because \quad V_2 = -I_2 R_L$

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

substituting the values

we get $\quad V_1 = 2I_1 + 40$

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

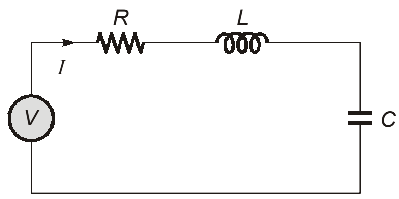
$\therefore \quad I_1 = 4.5\text{ A} \quad$ and $\quad V_1 =$

49 V

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

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

15. (c)



For series RLC circuit,

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

The circuit current

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

$\therefore$ 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

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

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

16. (a)

Using KCL

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

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

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

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

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

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

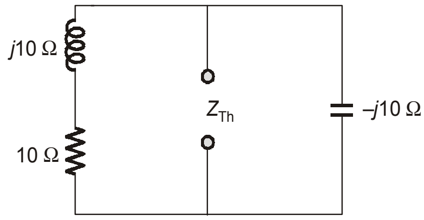
$$i = \frac{dQ}{dt} = \left(\frac{100C - Q_0}{RC}\right)e^{-t/RC} = \left(\frac{50 - 10}{1}\right)e^{-t/RC}$$

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

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

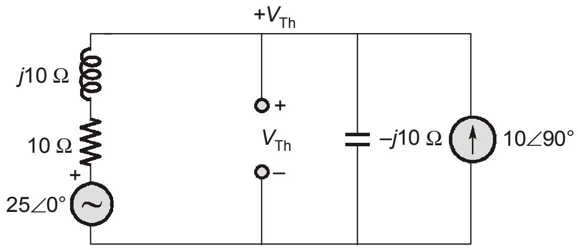
17. (a)

Z_{Th} :



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

V_{Th} :



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

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

$$(V_{Th})j10 - 250j - 10V_{Th} - 10j\,V_{Th} = -100(10+10j)$$

$$j10\,V_{Th} - 250j - 10V_{Th} - 10j\,V_{Th} = -1000(1+j)$$

$$-10V_{Th} = -1000 - 1000j + 250j$$

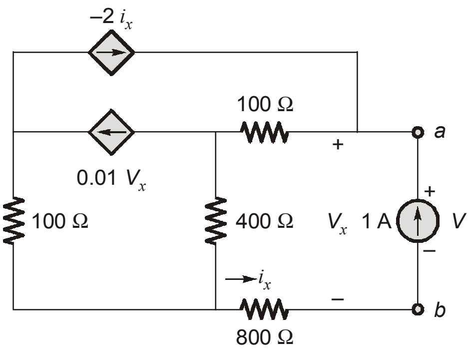
$$-10V_{Th} = -1000 - 750j$$

$$V_{Th} = 100 + j75$$

$$Z_L = Z_{Th}^{*} = 10 + j10$$

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

18. (d)



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

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

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

$\therefore$ $V = 60$ V

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

19. (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.

$$\because \quad X_L = X_C$$

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

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

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

20. (c)

Condition for Transient free response is given by

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

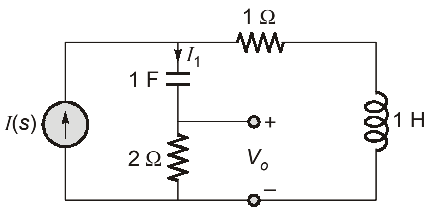
here, $$\omega = \frac{1}{2}, \qquad \theta = 45°$$

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

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

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

21. (a)

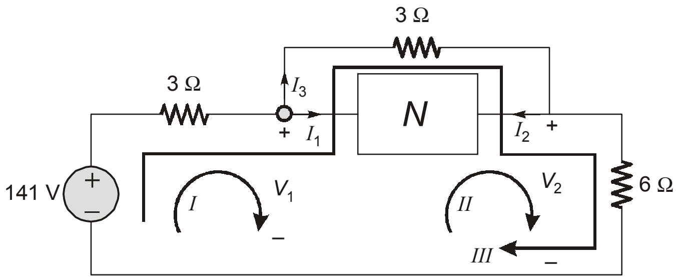


$$I_1(s) = \frac{I(s)\,(1+s)}{\frac{1}{s} + 2 + 1 + s} = \frac{I(s)\,(s+1)\,s}{s^2 + 3s + 1}$$

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

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

22. (c)



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

Applying KVL

Loop I

$$3(I_1 + I_3) + V_1 = 141$$
$$3I_1 + 3I_3 + 2I_1 + I_2 = 141$$
$$5I_1 + I_2 + 3I_3 = 141 \quad \ldots(i)$$

Loop II

$$V_2 = (I_3 - I_2) \cdot 6$$
$$V_2 = I_1 + 4I_2$$
$$I_1 + 4I_2 = 6I_3 - 6I_2$$
$$I_1 + 10I_2 - 6I_3 = 0 \quad \ldots(ii)$$

Loop III

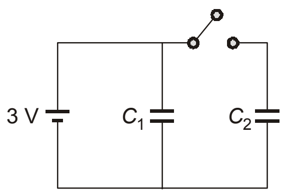
$$3(I_1 + I_3) + 3I_3 + 6(I_3 - I_2) = 141$$
$$3I_1 - 6I_2 + 12I_3 = 141 \quad \ldots(iii)$$

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

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

23. (b)

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



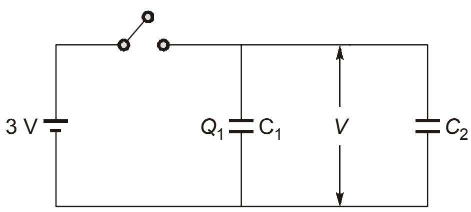
C_1 gets charged upto 3 V charge stored in C_1

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

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)

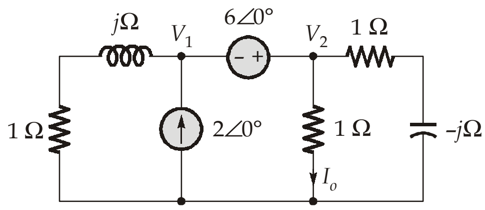
$$Q_1 = 1\,C$$

and $$Q_2 = 2\,C$$

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

24. (d)

Applying KCL on supernode



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

and $$V_1 + 6 = V_2$$

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

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

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

$$V_2 \approx 2.915\angle -30.96°$$

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

25. (b)

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

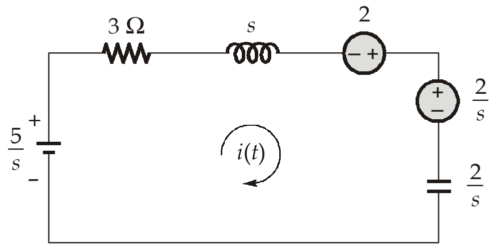
$$= \frac{23}{6} + \frac{(3+j4)\,(3-j4)}{6} = \frac{23+25}{6} = \frac{48}{6}\,\Omega = 8\,\Omega$$

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

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

27. (d)

Given,

$$f = 1.5 \text{ MHz}$$
$$C = 150 \text{ pF}$$
$$\text{BW} = 10 \text{ kHz}$$

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

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

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

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

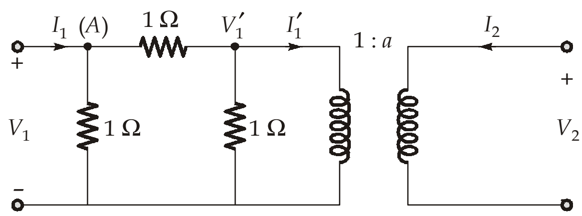
28. (c)

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

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

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

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

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

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

For the Z-parameter to not exist.

$$|Y| = 0$$

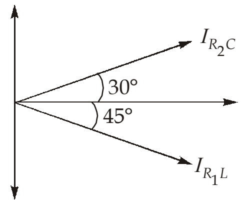
$$\therefore \qquad |Y| = \frac{4}{a^2} - \frac{1}{a^2} = \frac{3}{a^2}$$

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

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

30. (a)

From phasor, we can write



$$\tan 30° = \frac{X_C}{R_2}$$

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

$$\tan 45° = \frac{X_L}{R_1}$$

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

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

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

we know

$$\frac{R_1 + R_2}{2} \geq \sqrt{R_1R_2}$$

as arithmetic mean $\geq$ 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 $R_1 + R_2 = 2.63\ \Omega$

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