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Open Lockdown Period Practice Series for GATE

(Also useful for ESE & Other Exams)

EC : ELECTRONICS ENGINEERING

TEST No. - 01 | NETWORK THEORY

Read the following instructions carefully

1. This question paper contains 33 MCQ's & NAQ's. Bifurcation of the questions are given below:

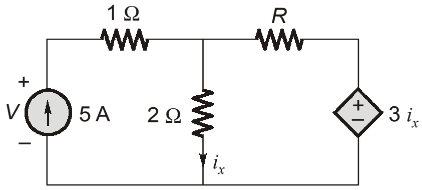
Subjectwise Test Pattern

Questions	Question Type	No. of Questions	Marks	Total Marks	Negative Marking
1 to 10	Multiple Choice Ques.	10	1	10	0.33
11 to 16	Numerical Answer Type Ques.	6	1	6	None
17 to 26	Multiple Choice Ques.	10	2	20	0.66
27 to 33	Numerical Answer Type Ques.	7	2	14	None
Total Questions : 33		**Total Marks : 50**		**Total Duration : 90 min**	

2. Choose the closest numerical answer among the choices given.

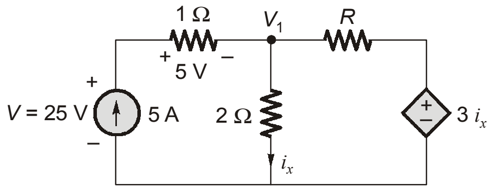
Multiple Choice Questions : Q.1 to Q.10 carry 1 mark each

Q.1 For the circuit shown below, if the voltage (V) across the current source of 5 A is 25 V, then the value of 'R' is



(a) 1 Ω
(b) 2 Ω
(c) 3 Ω
(d) 4 Ω

1. (b)



Applying Nodal analysis

$$\Rightarrow \quad \frac{V_1 - 3i_x}{R} + i_x = 5 \text{ A}$$

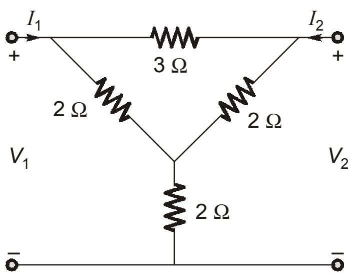
Also
$$V_1 = 2i_x = 20 \text{ V}$$
$$i_x = 10 \text{ A}$$

$$\therefore \quad \frac{2i_x - 3i_x}{R} + i_x = 5 \text{ A}$$

$$\frac{20-30}{R} + 10 = 5 \text{ A}$$

$$\Rightarrow \quad R = 2 \ \Omega$$

Q.2 For the circuit shown below, the admittance parameter matrix [Y] will be



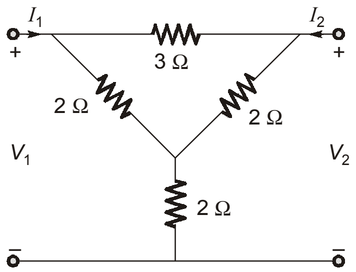
(a) $\begin{bmatrix} \frac{2}{3}\mho & -\frac{1}{2}\mho \\ \frac{1}{2}\mho & \frac{2}{3}\mho \end{bmatrix}$

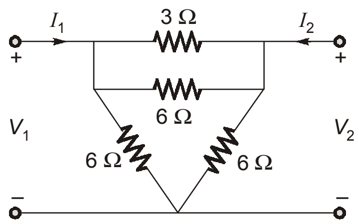
(b) $\begin{bmatrix} \frac{2}{3}\mho & -\frac{1}{2}\mho \\ -\frac{1}{2}\mho & \frac{2}{3}\mho \end{bmatrix}$

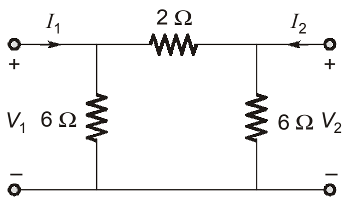
(c) $\begin{bmatrix} \frac{2}{3}\mho & -1\mho \\ -1\mho & \frac{2}{3}\mho \end{bmatrix}$

(d) $\begin{bmatrix} \frac{2}{3}\mho & 1\mho \\ 1\mho & \frac{2}{3}\mho \end{bmatrix}$

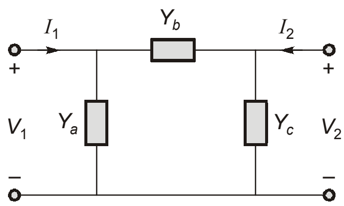
2. (b)







for Π-network



$\because$ $$[Y] = \begin{bmatrix} Y_a + Y_b & -Y_b \\ -Y_b & Y_b + Y_c \end{bmatrix}$$

for the given problem, $$Y_a = \frac{1}{6}\ \mho$$

$$Y_b = \frac{1}{2}\ \mho$$

$$Y_c = \frac{1}{6}\ \mho$$

$\therefore$ $$[Y] = \begin{bmatrix} \frac{2}{3}\ \mho & -\frac{1}{2}\ \mho \\ -\frac{1}{2}\ \mho & \frac{2}{3}\ \mho \end{bmatrix}$$

Q.3 If $V(t) = 2\cos(10t)(1 + 2\cos 5t)$ V, then the rms value of $(V(t) + \sqrt{3})$ is

(a) $3\sqrt{3}$ V
(b) $3\sqrt{2}$ V
(c) 3 V
(d) 4 V

3. (c)

Let

$$f(t) = V(t) + \sqrt{3}$$

$$V(t) = 2\cos 10t + 4\cos 10t \cdot \cos 5t$$

$$= 2\cos 10t + 2\cos 15t + 2\cos 5t$$

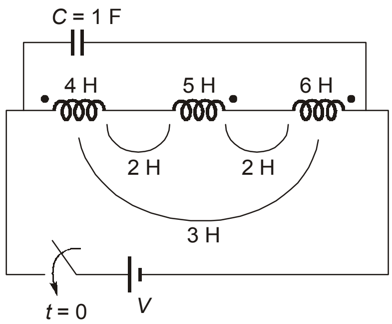
$$f(t) = \sqrt{3} + 2\cos 10t + 2\cos 15t + 2\cos 5t$$

$$\text{rms}\,\{f(t)\} = \sqrt{(\sqrt{3})^2 + \left(\frac{2}{\sqrt{2}}\right)^2 + \left(\frac{2}{\sqrt{2}}\right)^2 + \left(\frac{2}{\sqrt{2}}\right)^2}$$

$$= \sqrt{3 + \frac{4}{2} + \frac{4}{2} + \frac{4}{2}}$$

$$= \sqrt{3+6} = \sqrt{9} = 3\text{ V}$$

Q.4 For the tank circuit shown below, the time period of oscillations is



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

4. (c)

$$\text{Time period } (T) = \frac{2\pi}{\omega}$$

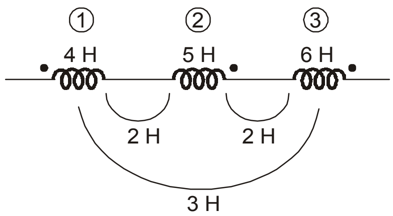
where

$$\omega = \frac{1}{\sqrt{LC}}$$

thus,

$$T = 2\pi\sqrt{LC}$$

In figure



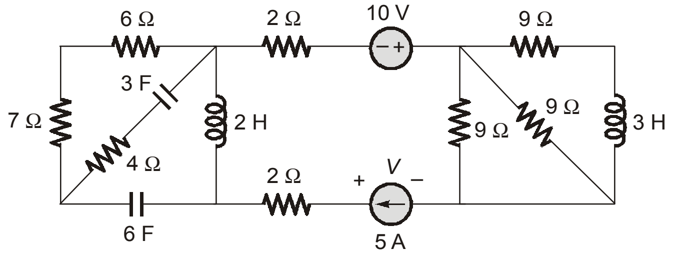
$$L_{eq} = L_1 + L_2 + L_3 - 2M_{12} + 2M_{23} - 2M_{13}$$

$$= 4 + 5 + 6 - 2(2) + 2(2) - 2(3) = 9\text{ H}$$

$$C = 1\text{ F}$$

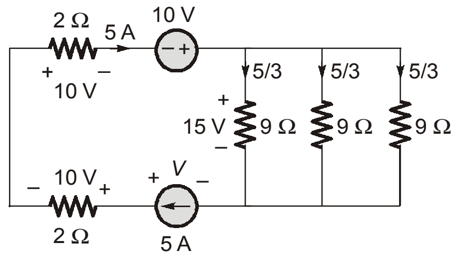
$$T = 2\pi\sqrt{9} = 6\,\pi\text{ sec}$$

Q.5 For the circuit shown below, the steady state voltage '*V*' across the current source is ________?



(a) 35 V
(b) 25 V
(c) 15 V
(d) none of these

5. (b)
The circuit can be redrawn by short circuiting inductor and open circuiting capacitor as DC sources are used.



Applying KVL

$$V - 10 - 10 + 10 - 15 = 0$$
$$V = 25 \text{ V}$$

Q.6 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	List-II
A. S = 10 kVA, pf = 0.5 (lagging)	1. $\left(5+j5\sqrt{3}\right)$kVA
B. S = 13 kVA, Q = 5 VAR (capacitative)	2. $\left(5-j5\sqrt{3}\right)$kVA
C. P = 5 kW, pf = 0.5 (inductive)	3. (12 + j5) kVA
	4. (12 – j5) kVA

Codes:

	A	B	C
(a)	1	3	2
(b)	2	4	1
(c)	1	4	1
(d)	2	4	2

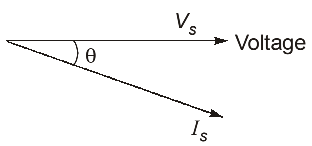
6. (c)

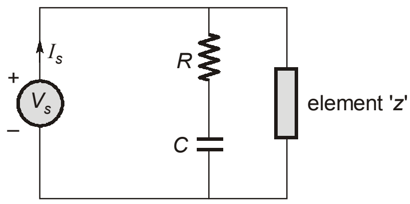
for A :
$$S = 10 \text{ kVA}; \quad \cos\phi = \text{pf} = 0.5$$
$$s = 10[\cos\phi + j\sin\phi] \text{ kVA} = \left(5+j5\sqrt{3}\right)\text{kVA}$$

for B :
$$S = 13 \text{ kVA}; \quad Q = 5 \text{ VAR}$$
$$\sin\phi = \frac{Q}{S} = \frac{5}{13} \Rightarrow \cos\phi = \frac{12}{13}$$
$$s = 13\left(\frac{12}{13} - j\frac{5}{13}\right)\text{kVA} = (12 - j5) \text{ kVA}$$

for C :
$$P = 5 \text{ kW}; \quad \cos\phi = \text{pf} = 0.5$$
$$S = \frac{P}{\text{pf}} = 10 \text{ kVA}; \quad \sin\phi = \frac{\sqrt{3}}{2}$$
$$S = 10\left(\frac{1}{2} + j\frac{\sqrt{3}}{2}\right)\text{kVA} = \left(5+j5\sqrt{3}\right)\text{kVA}$$

Q.7 For the following phasor diagram of the circuit as shown, the unknown element 'z' is

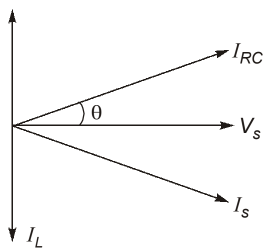




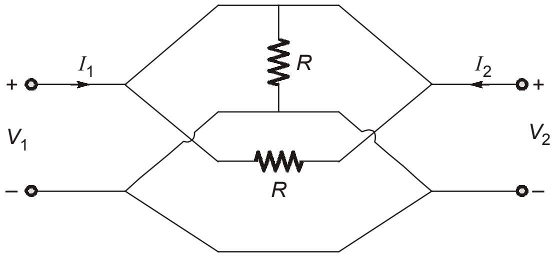
(a) R (b) C
(c) L (d) combination of RC

7. (c)

Since only L can result in lagging of current with respect to voltage.



Q.8 The Y- parameter matrix of the circuit shown below is



(a) $\begin{bmatrix} 2R & 2R \\ 2R & 2R \end{bmatrix}$

(b) $\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$

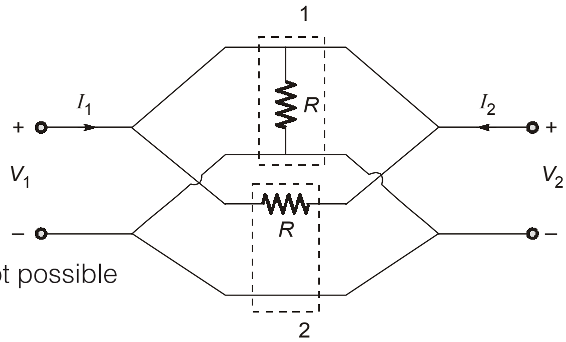
(c) $\begin{bmatrix} \frac{1}{2R} & \frac{1}{2R} \\ \frac{1}{2R} & \frac{1}{2R} \end{bmatrix}$

(d) doesn't exist

8. (d)

$$[Y] = [Y_1] + [Y_2]$$

$$[Z_1] = \begin{bmatrix} R & R \\ R & R \end{bmatrix}$$



Since determinant is zero,
therefore 'Y' parameter doesn't exist.

$$[Y] = [Z]^{-1} = \frac{1}{0}\begin{bmatrix} R & R \\ R & R \end{bmatrix} \Rightarrow \text{Not possible}$$

as $[Y_1]$ doesn't exist, $[Y]$ also doesn't exist.

Q.9 The unit of $\frac{R}{2}\sqrt{\frac{L}{C}}$ is

(a) Ω

(b) Ω^2

(c) no unit

(d) ΩH rad

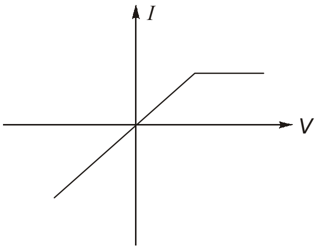
9. (b)

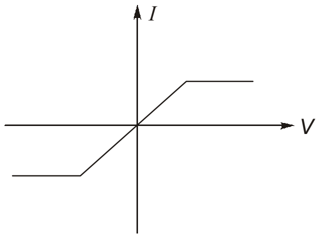
$$\frac{R}{2}\sqrt{\frac{L}{C}} \Rightarrow \qquad \frac{R}{2}\sqrt{\frac{L\omega}{C\omega}} = \frac{R}{2}\sqrt{X_L X_C}$$

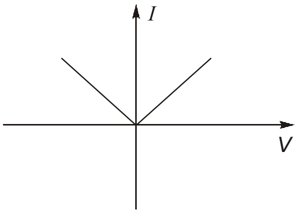
Unit of R_1 is Ω
Unit of 'X_L' and 'X_C' is Ω

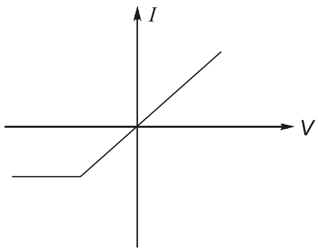
Unit of $\frac{R}{2}\sqrt{\frac{L}{C}}$ is $\Omega \times \sqrt{\Omega \times \Omega} \Rightarrow (\Omega)^2$

Q.10 Which of the following graphs, represents an ACTIVE element.

(a) 

(b) 

(c) 

(d) 

10. (c)

Numerical Answer Type Questions : Q. 11 to Q. 16 carry 1 mark each

Q.11 A parallel R, L, C circuit has R = 2 kΩ, L = 240 mH, C = 54 μF. The quality factor of the circuit at resonance is ________.

11. (30)

For parallel resonant circuit

$$Q_0 = R\sqrt{\frac{C}{L}}$$

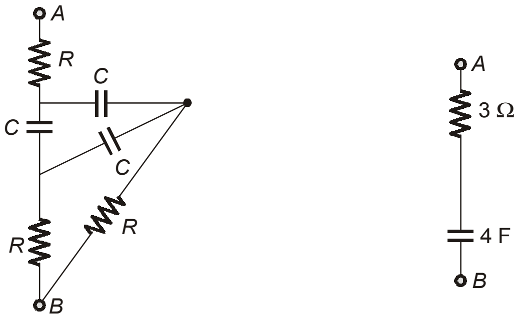
$$Q_0 = 2000\sqrt{\frac{54\times10^{-6}}{240\times10^{-3}}}$$

$$Q_0 = 2000\sqrt{\frac{9}{4}\times10^{-4}}$$

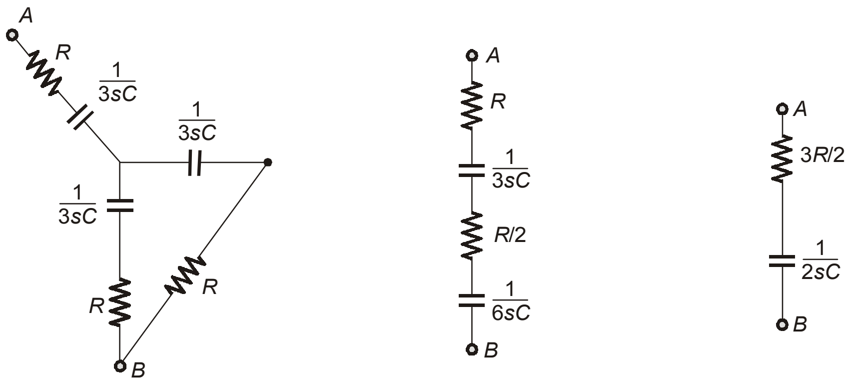
$$Q_0 = \frac{2000}{100}\times\frac{3}{2}$$

$$Q_0 = 30$$

Q.12 If both the circuits shown below are equivalent, then the value of RC is ________ sec.



12. **(4)**



compairing with given diagram

$$R_{eq} = 3\,\Omega = \frac{3R}{2} \quad \text{and } C_{eq} = 4\text{ F} = 2\text{ C}$$

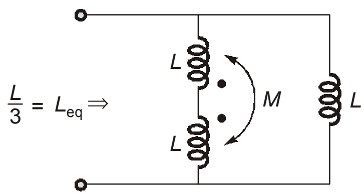
so,

$$R = 2\,\Omega$$

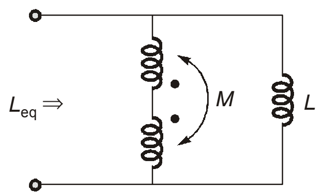
$$C = 2\text{ F}$$

$$RC = 4\text{ sec}$$

Q.13 If L_{eq} of the circuit shown below is $\left(\frac{L}{3}\right)$ H, then the coupling coefficient (k) is ________.



13. **0.75 (0.70 to 0.80)**



$$L_{eq} = (L + L - 2M) \,||\, L$$

Also

$$M = k\sqrt{L_1 L_2} = M = k\sqrt{L^2} = kL$$

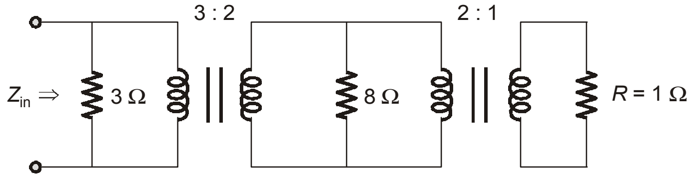
$$L_{eq} = (L + L - 2kL) \,||\, L$$

$$\frac{L}{3} = \frac{(2L - 2kL) \times L}{2L - 2kL + L}$$

on solving, we get

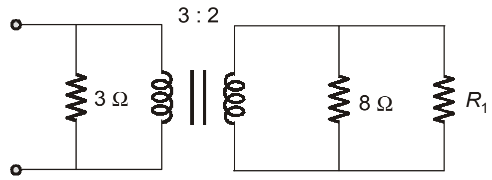
$$k = 0.75$$

Q.14 For the circuit shown below, the value of Z_{in} is ________ Ω.



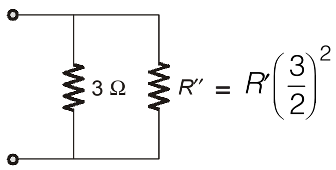
14. (2)

The circuit can be modified as



$$R_1 = \left(\frac{2}{1}\right)^2 \times 1\Omega = 4\,\Omega$$

$$R' = 4\,||\,8 = \frac{4\times 8}{12} = \frac{8}{3}\,\Omega$$

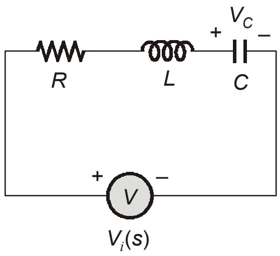


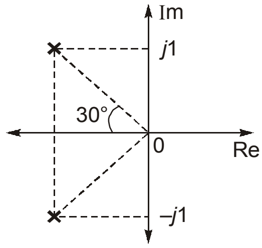
$$R'' = \frac{8}{3}\times\frac{9}{4} = \frac{72}{12} = 6\,\Omega$$

$$Z_{in} = R''\,||\,3\,\Omega = 6\,\Omega\,||\,3\,\Omega$$

$$Z_{in} = 2\,\Omega$$

Q.15 For a series RLC circuit shown below, the poles of the transfer function $\left(\frac{V_C(s)}{V_i(s)}\right)$ are plotted as shown. If $\frac{R}{C} = 2\sqrt{3}$, then the value of R is ________ ohms.



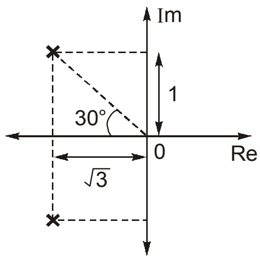


15. 1.73 (1.60 to 1.80)

$$\frac{V_C(s)}{V_i(s)} = \frac{\frac{1}{sC}}{sL + R + \frac{1}{sC}} = \frac{\frac{1}{sC}}{\frac{s^2LC + sRC + 1}{sC}} = \frac{\frac{1}{LC}}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

The characteristic equation : $s^2 + \frac{R}{L}s + \frac{1}{LC}$ ...(i)

as per graph



$$C(s) = (s + \sqrt{3} + j1)(s + \sqrt{3} - j1)$$

$$C(s) = s^2 + 2\sqrt{3}s + 3 + 1$$

$$= s^2 + 2\sqrt{3}s + 4 \quad \text{...(ii)}$$

On comparison

$$\frac{R}{L} = 2\sqrt{3} \quad \text{...(iii)}$$

$$\frac{1}{LC} = 4 \quad \text{...(iv)}$$

$$\frac{R}{C} = 2\sqrt{3} \quad \text{given} \quad \text{...(v)}$$

from (ii) and (iii)

$$\frac{\frac{R}{L}}{\frac{1}{LC}} = RC = \frac{\sqrt{3}}{2}$$

$$\frac{R}{C} = 2\sqrt{3}$$

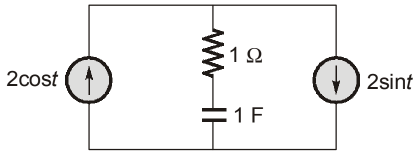
multiplying

$$R^2 = \frac{\sqrt{3}}{2} \times 2\sqrt{3} = 3$$

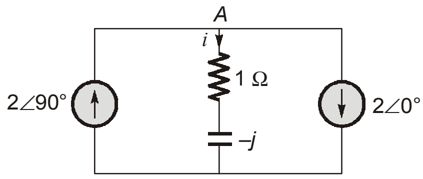
$$R = \sqrt{3}$$

$$R = 1.732\ \Omega$$

Q.16 In the circuit shown below, the average power dissipated by 1 Ω resistor is ________ Watts.



16. (4)

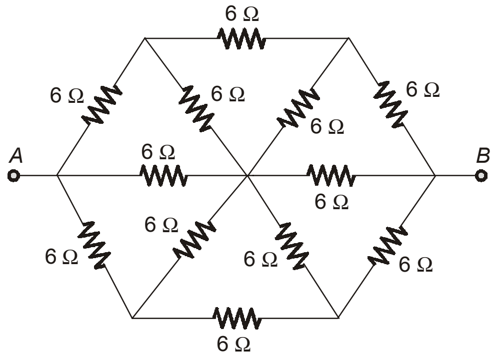


Applying KCL at node *A*

$$\begin{aligned}
i &= 2\angle 90^\circ - 2\angle 0^\circ \\
i &= 2j - 2 = -2 + 2j \\
i &= 2\cos t - 2\sin t \\
p(t) &= i^2 R \\
p(t) &= (2\cos t - 2\sin t)^2 \times 1 \\
p(t) &= 4\cos^2 t + 4\sin^2 t - 8\sin t\cos t \\
p(t) &= 4 - 4\sin 2t \\
p_{avg} &= 4 \text{ Watts}
\end{aligned}$$

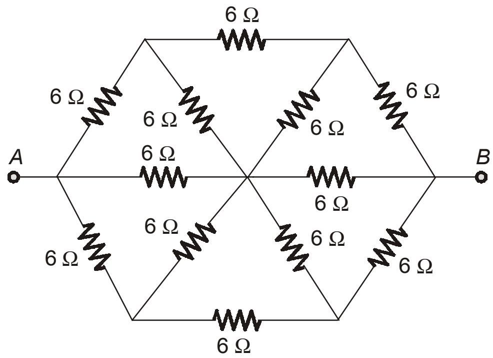
Multiple Choice Questions : Q.17 to Q.26 carry 2 marks each

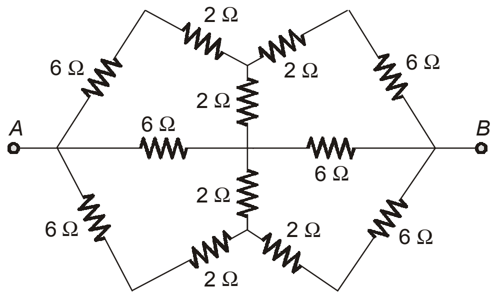
Q.17 The equivalent resistance between the terminals *A* and *B* is

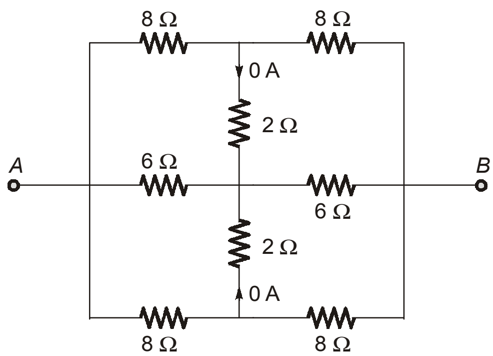


(a) 1.2 Ω
(b) 3.6 Ω
(c) 4.8 Ω
(d) 6 Ω

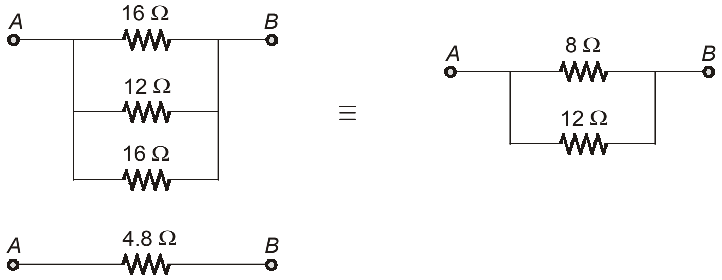
17. (c)



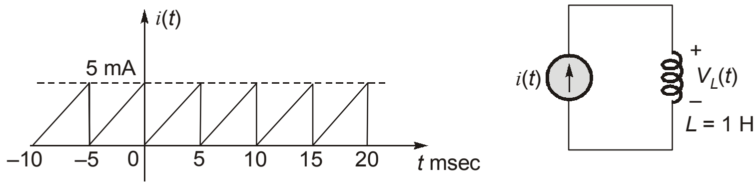




Since two Wheatstone bridges are connected parallelly, no current flows through 2 Ω resistors.



Q.18 A periodic sawtooth current wave is passed through an inductor of 1 H as shown below. The value of $V_L(t)$ at t = 3 msec is

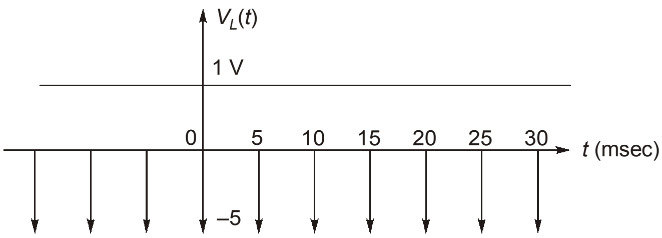


(a) 1 V
(b) 2 V
(c) 3 V
(d) 4 V

18. (a)

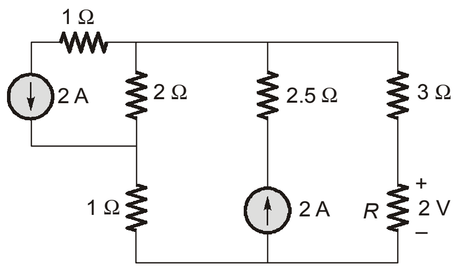
$$V_L(t) = \frac{L\,di(t)}{dt} = \frac{di(t)}{dt} \qquad \because L = 1\text{ H}$$

Differentiating $i(t)$, we get



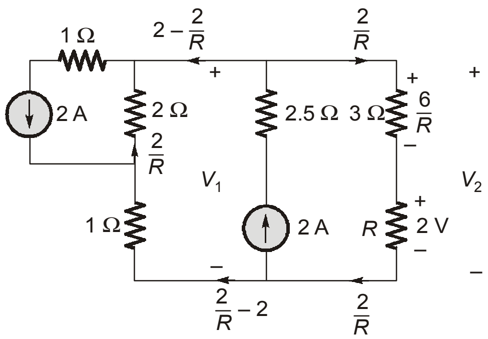
$V_L(t)$ at t = 3 msec = 1 V

Q.19 For the circuit shown below, the value of R (in ohms) is



(a) 2
(b) 4
(c) 6
(d) none of these

19. (d)



$$V_1 = -\frac{4}{R} - 1\left(\frac{2}{R} - 2\right)$$

$$V_1 = -\left(\frac{4}{R} + \frac{2}{R} - 2\right) = -\left(\frac{6}{R} - 2\right) = 2 - \frac{6}{R}$$

$$V_2 = \frac{6}{R} + 2$$

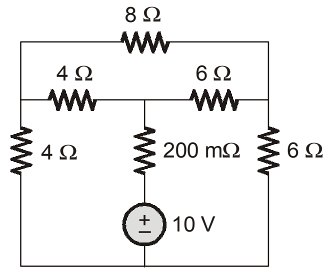
$\Rightarrow$ $V_1 = V_2$ ($\because$ for parallel branches voltage is same)

$$2 - \frac{6}{R} = \frac{6}{R} + 2$$

$$\frac{12}{R} = 0$$

$R = \infty$ (open circuit)

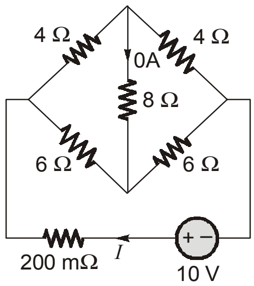
Q.20 The power absorbed by 200 mΩ resistance in the given circuit is

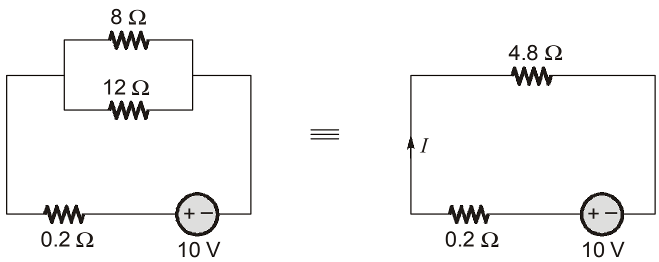


(a) 0.2 Watts
(b) 0.4 Watts
(c) 0.6 Watts
(d) 0.8 Watts

20. (d)

The circuit can be redrawn as



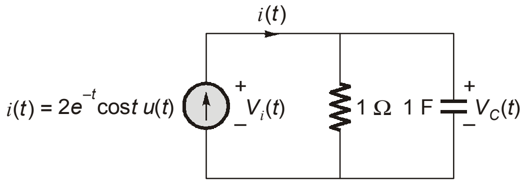


$$I = \frac{10}{5} = 2\text{ A}$$

$$P_{\text{absorbed}} = (0.2)(2)^2$$

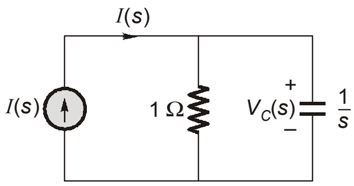
$$= 0.2 \times 4 = 0.8\text{ Watts}$$

Q.21 For the circuit shown below, if $i(t) = 2e^{-t}\cos t\, u(t)$ A, then the voltage across the capacitor $V_C(t)$ will be



(a) $2e^{-t}\cos t\, u(t)$ V
(b) $e^{-t}\cos t\, u(t)$ V
(c) $e^{-t}\sin t\, u(t)$ V
(d) $2e^{-t}\sin t\, u(t)$ V

21. (d)



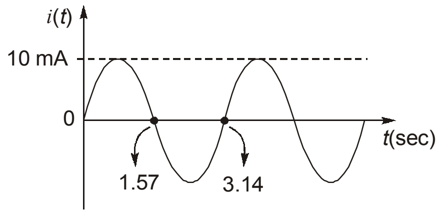
$$V_C(s) = I(s)\times\frac{1}{1+\frac{1}{s}}\times\frac{1}{s} = I(s)\times\frac{1}{s+1}$$

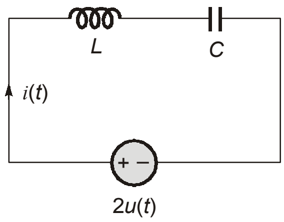
$$I(s) = \frac{2(s+1)}{(s+1)^2+1}$$

$$V_C(s) = \frac{2(s+1)}{(s+1)^2+1}\times\frac{1}{1+s} = \frac{2}{(s+1)^2+1}$$

$$v_C(t) = 2e^{-t}\sin t\, u(t)\ \text{V}$$

Q.22 The current flowing through a series LC circuit excited by a step voltage is sinusoidal as shown below. Find the values of L and C



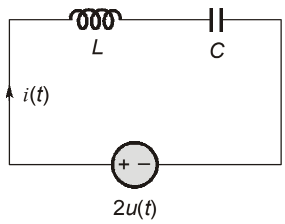


(a) L = 10 H, C = 25 mF
(b) L = 100 H, C = 2.5 mF
(c) L = 100 H, C = 25 mF
(d) L = 10 H, C = 2.5 mF

22. (b)

from the given diagram

$$i(t) = 10\sin 2t\, u(t) \text{ mA} \qquad \text{...(i)}$$



$$\Rightarrow \qquad I(s) = \frac{\frac{2}{s}}{sL + \frac{1}{sC}}$$

$$I(s) = \frac{\frac{2}{s}}{\frac{s^2LC+1}{sC}} = \frac{2C}{s^2LC+1}$$

$$I(s) = \frac{\frac{2}{L}}{s^2 + \frac{1}{LC}} \qquad \text{...(ii)}$$

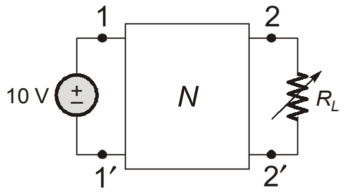
From equation (i) $$I(s) = 10 \times 10^{-3}\left(\frac{2}{s^2+4}\right) \qquad \text{...(iii)}$$

$$\therefore \qquad \frac{1}{LC} = 4 \quad \text{and} \quad \frac{2}{100} = \frac{2}{L}$$

$$L = 100 \text{ H}$$

$$C = 2.5 \text{ mF}$$

Q.23 Consider the network shown below.

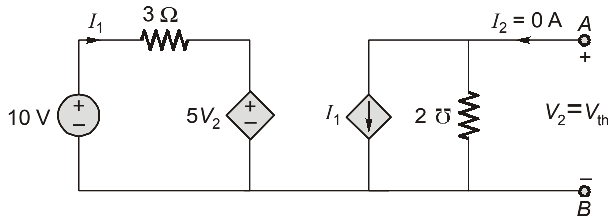


If the hybrid parameter matrix of the Network 'N' is $[h] = \begin{bmatrix} 3 & 5 \\ 1 & 2 \end{bmatrix}$, then the maximum power that can be transferred to R_L is _____.

(a) 8.33 W
(b) 16.66 W
(c) 25 W
(d) 50 W

23. (a)

to determine V_{th} :



$$I_1 = \frac{10 - 5V_2}{3} = \frac{10 - 5V_{th}}{3}$$

$$V_{th} = -\frac{I_1}{2} = \frac{5V_{th} - 10}{6}$$

$$6V_{th} = 5V_{th} - 10$$

$$V_{th} = -10 \text{ V}$$

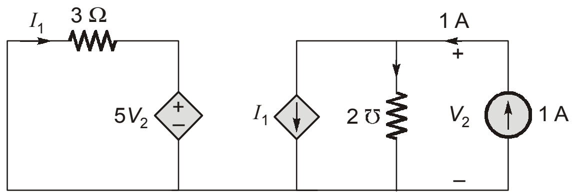
to determine R_{th}:

$$I_2 = 2V_2 + I_1$$

$$1 \text{ A} = 2V_2 + I_1$$

$$0 = 3I_1 + 5V_2$$

$$I_1 = -\frac{5}{3}V_2$$



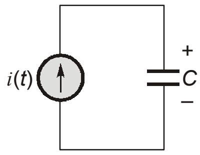
$$1 \text{ A} = 2V_2 - \frac{5}{3}V_2$$

$$V_2 = 3 \text{ V}$$

$$R_{th} = \frac{V_2}{1 \text{ A}} = 3\ \Omega$$

$$P_{L\max} = \frac{V_{th}^2}{4R_{th}} = \frac{100}{12} \text{ W} = 8.33 \text{ W}$$

Q.24 If the maximum energy stored in a capacitor shown below is finite, then the possible current source charging the capacitor is



(a) Impulse
(b) Ramp
(c) Unit step
(d) Parabolic

24. **(a)**

Maximum energy stored in a capacitor is given as

$$E_{max} = \frac{1}{2}CV_{max}^2$$

option (a) Impulse current

$$i(t) = \frac{Cdv}{dt}$$

$$\Rightarrow \quad V_C(t) = \frac{1}{C}\int_{-\infty}^{t} i(t)\,dt$$

$$i(t) = \delta(t)$$

$$V_C(t) = \frac{1}{C}u(t)$$

$$\Rightarrow \quad V_{max} = \frac{1}{C}$$

$$E_{max} = \frac{1}{2}C\left(\frac{1}{C}\right)^2 = \frac{1}{2C}$$

option (b) Ramp

$$V_C(t) = \frac{1}{C}\int \text{Ramp} = \text{parabolic}$$

$$V_{max} = \infty$$

option (c) unit step

$$V_C(t) = \frac{1}{C}\int_{-\infty}^{t} u(t)\,dt = \frac{1}{C}r(t) = \frac{1}{C}t\,u(t)$$

$$V_{max} = \infty$$

option (d) parabolic

$$V_{max} = \infty$$

Thus option (a) is the correct choice.

Q.25 If $V_{rms} = 120\angle 60°$ and $Z = 60 - j80$, then the complex power 'S' is

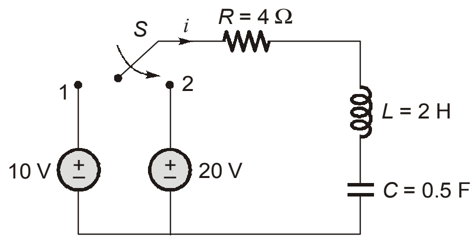
(a) $(90 - j120)$ VA
(b) $(86.4 + j115.2)$ VA
(c) $(86.4 - j115.2)$ VA
(d) $(90 + j120)$ VA

25. (c)

$$\text{Complex power '}S\text{'} = \frac{|V_{rms}|^2}{Z^*} = \frac{|120|^2}{60 + j80} = \frac{14400 \times (60 - j80)}{100 \times 100} = 1.44(60 - j80)$$

$$= (86.4 - j115.2)\text{ VA}$$

Q.26

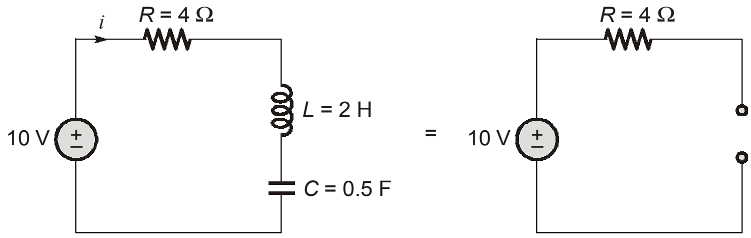


If the switch is at position '1' for a long time and at ($t = 0$) it is moved to position '2', then the current $i(t)$ for $t > 0$ will be

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

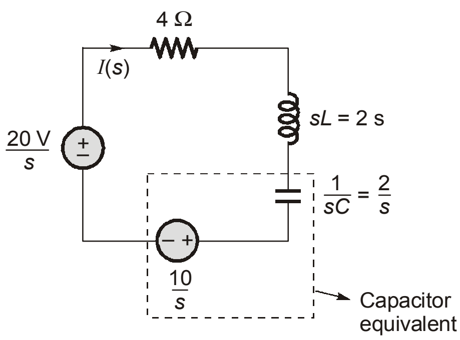
26. (c)

At ($t = 0^-$)



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

At ($t = 0^+$)



$$I(s) = \frac{10/s}{4 + 2s + \frac{2}{s}} = \frac{10/s}{\frac{4s + 2s^2 + 2}{s}} = \frac{10}{2(s^2 + 2s + 1)}$$

$$I(s) = \frac{5}{(s+1)^2}$$

$$i(t) = 5te^{-t}\,u(t)\text{ A}$$

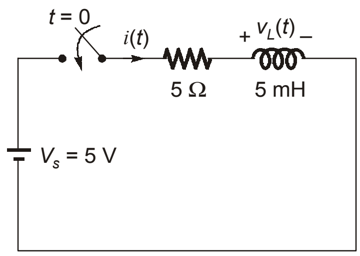
Numerical Answer Type Questions : Q.27 to Q.33 carry 2 marks each

Q.27 For the circuit shown below, the current $i(t)$ and the voltage $v_L(t)$ are given as respectively

$i(t) = A(1 - e^{-Bt})\, u(t)$ A

$v_L(t) = Ce^{-Bt}\, u(t)$ V

The value of expression $\frac{AB}{C}$ is ________.



27. (200)

For a series *RL* circuit with DC excitation,

$$i(t) = \frac{V_s}{R}\left(1 - e^{-\frac{Rt}{L}}\right) u(t) \text{ A}$$

$$v(t) = V_s\left(e^{-\frac{Rt}{L}}\right) u(t) \text{ A}$$

$$A = \frac{V_s}{R}$$

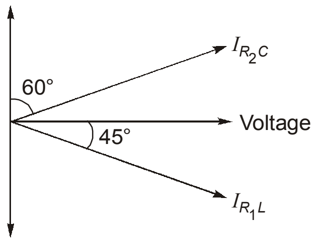
$$B = \frac{R}{L}$$

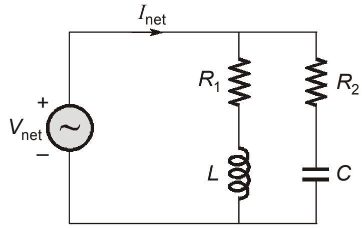
$$C = V_s$$

$$\frac{AB}{C} = \frac{\frac{V_s}{R} \times \frac{R}{L}}{V_s} = \frac{1}{L}$$

$$= \frac{1}{5 \times 10^{-3}} = 200$$

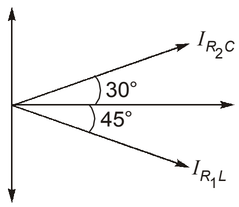
Q.28 Consider the circuit shown below.





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

28. 2.63 (2.50 to 2.80)



From phasor, we can write

$$\tan 30^\circ = \frac{X_C}{R_2}$$

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

$$\tan 45^\circ = \frac{X_L}{R_1}$$

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

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

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

we know

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

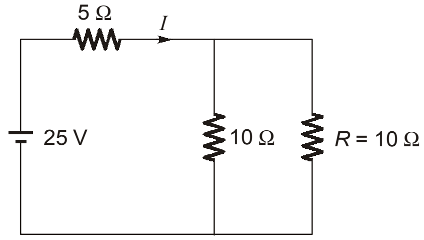
as arithmetic mean ≥ geometric mean ; (for non-negative real numbers)

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

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

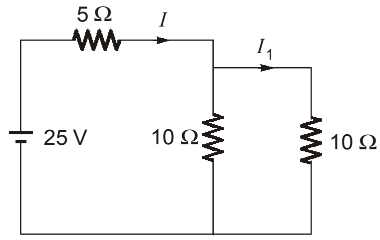
Minimum value of $R_1 + R_2 = 2.63\ \Omega$

Q.29 For the circuit shown below, if R is increased by 10%, then the change in current I will be _______ mA.

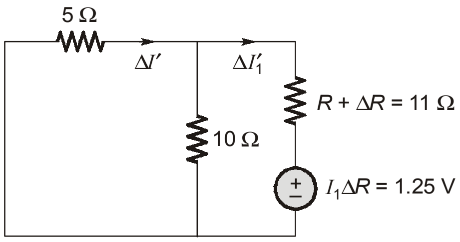


29. **–58.14 (–58.50 to –57.50)**

$$I_{\text{initial}} = 2.5 \text{ A}$$
$$I_1 = 1.25 \text{ A}$$



Using compansation theorem

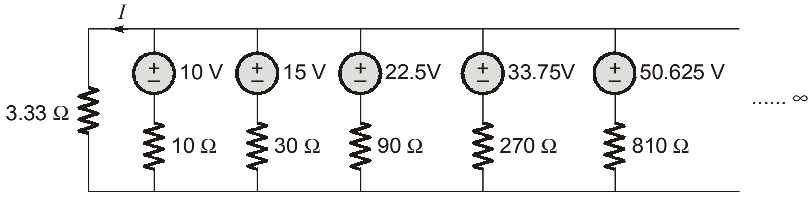


$$\Delta R = 1\ \Omega$$

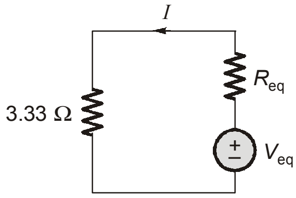
$$-\Delta I_1' = \frac{1.25}{(10\,||\,5)+11} = \frac{1.25}{14.33} = 0.08721 \text{ A}$$

$$\Delta I' = -\Delta I_1' \times \frac{10}{15} = \frac{-2}{3}\Delta I_1' = -0.05814 \text{ A} = -58.14 \text{ mA}$$

Q.30 For the circuit shown below, the current I is ______ Amp.



30. **1.33 (1.30 to 1.40)**



Applying Millman's Theorem

$$\frac{1}{R_{eq}} = \frac{1}{10}+\frac{1}{30}+\frac{1}{90}+.....$$

$$\frac{1}{R_{eq}} = \frac{1}{10}\left(1+\frac{1}{3}+\frac{1}{9}+...\right)$$

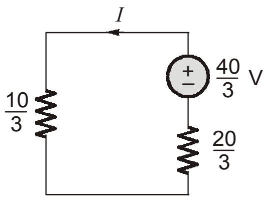
$$\frac{1}{R_{eq}} = \frac{1}{10}\left(\frac{1}{1-\frac{1}{3}}\right) = \frac{3}{10\times 2} = \frac{3}{20}$$

$$R_{eq} = \frac{20}{3}\,\Omega$$

$$V_{eq} = \frac{\frac{E_1}{R_1}+\frac{E_2}{R_2}+\frac{E_3}{R_3}+...}{\frac{1}{R_{eq}}}$$

$$= \frac{1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+....}{\frac{3}{20}} = \frac{\frac{1}{1-\frac{1}{2}}}{\frac{3}{20}} = \frac{20}{3}\times 2$$

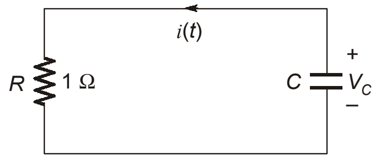
$$V_{eq} = \frac{40}{3}\text{ V}$$



$$I = \frac{\frac{40}{3}}{\frac{20}{3}+\frac{10}{3}} = \frac{\frac{40}{3}}{\frac{30}{3}} = \frac{4}{3}\text{ A}$$

$$I = 1.33\text{ A}$$

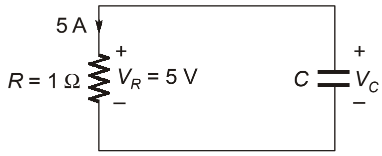
Q.31 For the circuit shown below,



If $i(0^-) = 5$ A and $i(t)\big|_{t = 3\text{ msec}} = 2.5$ A, then the value of C is _______ mF.

31. 4.328 (4.20 to 4.50)

at $t = 0^-$:

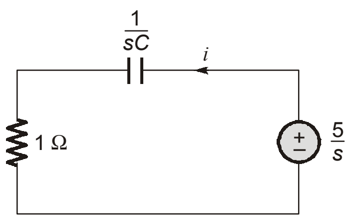


$$V_R - V_C = 0$$

$$\Rightarrow \quad V_R = V_C = 5\text{ V}$$

thus $$V_C(0^-) = 5\text{ V} = V_C(0^+)$$

Taking Laplace domain



$$I(s) = \frac{\frac{5}{s}}{1 + \frac{1}{sC}}$$

$$I(s) = \frac{\frac{5}{s}}{\frac{sC+1}{sC}}$$

$$I(s) = \frac{5C}{1+sC} = \frac{5}{s + \frac{1}{C}}$$

$$i(t) = 5e^{-t/C}\,u(t)$$

$$i(t)\big|_{3\text{ msec}} = 2.5$$

$$2.5 = 5e^{-\frac{3\times10^{-3}}{C}}$$

$$\frac{1}{2} = e^{-\frac{3\times10^{-3}}{C}}$$

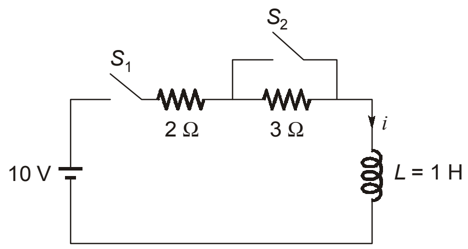
$$-\ln 2 = \frac{-3\times10^{-3}}{C}$$

$$C = \frac{3\times10^{-3}}{\ln 2}$$

$$C = \frac{3}{\ln 2}\text{ mF}$$

$$C = 4.328\text{ mF}$$

Q.32 For the circuit shown below, the switch S_1 and S_2 are open for a long time. At $t = 0$, S_1 is closed, while S_2 is open. At $t = 2$ sec, S_2 is also closed.



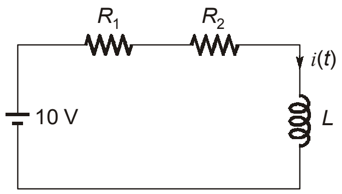
The value of current i at $t = 3$ sec is ______ A.
(Take appropriate approximations).

32. 4.594 (4.40 to 4.70)

At ($t = 0^-$), both the switches are opened.

L is initially uncharged $i_L(0^-) = 0$

At ($t = 0^+$)



$$i(t) = i(\infty) + (i(0^+) - i(\infty))\, e^{-\frac{R_{eq}t}{L_{eq}}}$$

$$R_{eq} = 5\ \Omega$$
$$L_{eq} = 1\ \text{H}$$
$$i(0^+) = 0\ \text{A}$$

$$i(t) = 2 + (0-2)e^{-\frac{5t}{1}}\ \text{A} ;\ \text{for } t > 0$$

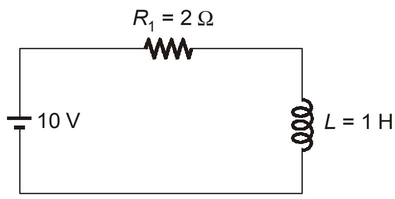
At ($t = 2^-$)

$$i(2^-) = 2 - 2e^{-\frac{10}{1}}\ \text{A}$$
$$i(2^-) \approx 2\ \text{A}$$

At ($t = 2^+$)

$$i(2^-) = i(2^+) = 2\ \text{A}$$

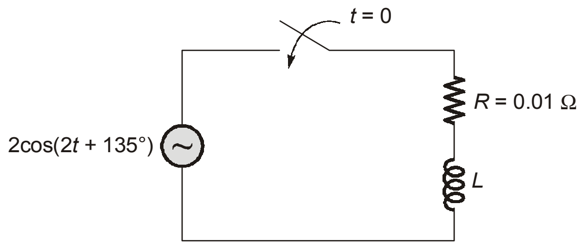
for $t > 2$ sec



$$i(t) = i(\infty) + (i(2^+) - i(\infty))\, e^{-\frac{R_1(t-2)}{L}} ;\ \text{for } t > 2$$

$$i(t)\big|_{t=3s} = 5 + (2-5)e^{-\frac{2}{1}(3-2)} = 5 - 3e^{-2}$$
$$= 4.594\ \text{A}$$

Q.33 If the circuit shown below has zero transient response, then the value of L is _______ mH.



33. (5)

$$V = 2\cos(2t + 135°)$$

In AC transients, for transient free response

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

$$135° = \tan^{-1}\left(\frac{\omega L}{R}\right) + 90°$$

$$\tan(45°) = \frac{\omega L}{R}$$

$\Rightarrow$ $$\omega L = R$$

$\Rightarrow$ $$R = 2L$$

$$\frac{R}{2} = L = \frac{0.01}{2}$$

$$L = 5\text{ mH}$$

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