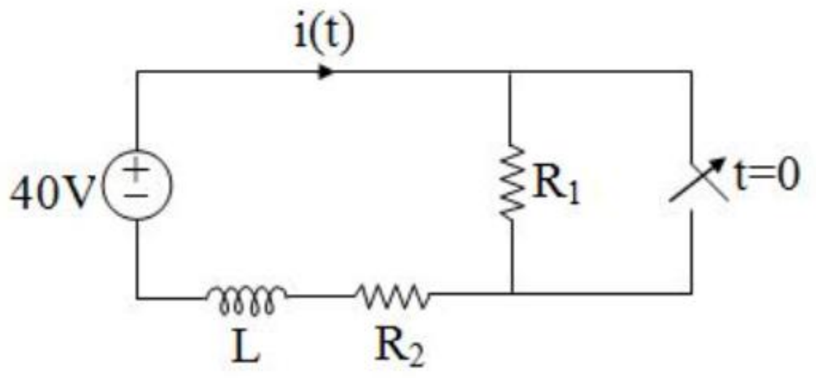
GATE 2026 TEST SERIES

Electric Circuits

Test 2

1. In circuit below, the switch is open at $t = 0$, if $i(t) = 5 + 3e^{-16t}$ A for $t > 0$, then value of R_1, R_2 and L are respectively



A) $8\Omega, 3\Omega, 128H$

B) $5\Omega, 3\Omega, \frac{1}{2}H$

C) $3\Omega, 8\Omega, 128H$

D) $3\Omega, 5\Omega, \frac{1}{2}H$

This is step response of first order circuit.

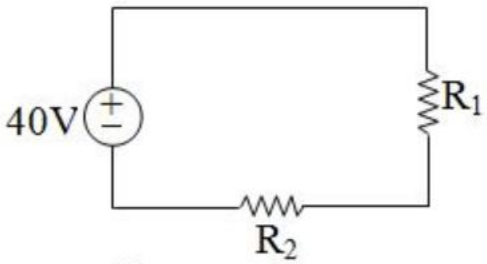
$$i(t) = I(\infty) + [I(0) - I(\infty)]e^{\frac{-t}{\tau}}$$ comparing $i(t) = 5 + 3e^{-16t}$

$\rightarrow I(\infty) = 5$

$\rightarrow I(0) - I(\infty) = 3$

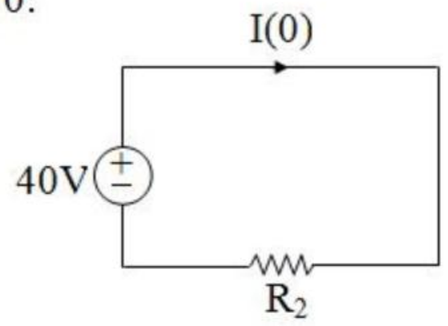
$\rightarrow \frac{1}{\tau} = 16$

So, $t > 0$:



$$I(\infty) = \frac{40}{R_1 + R_2} = 5 \ldots\ldots\ldots(1)$$

$t < 0$:



$\Rightarrow I(0) - 5 = 3$

$I(0) = 8A$

$$I(0) = \frac{40}{R_2} = 8 \rightarrow R_2 = 5\Omega \ldots\ldots(2)$$

Solve (1) and (2)

$40 = 5R_1 + 25$

$R_1 = 3\Omega$

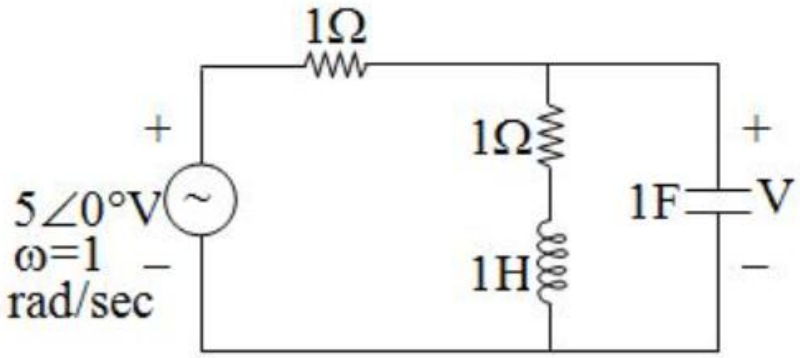
$$\tau = \frac{L}{R_{eq}} = \frac{L}{R_1 + R_2} = \frac{1}{16}$$

$$\frac{L}{5+3} = \frac{1}{16}$$

$$L = \frac{1}{2}H$$

$$R_1 = 3\Omega, R_2 = 5\Omega, L = \frac{1}{2}H,$$

2. The voltage $\overline{V}$ in circuit shown is________.



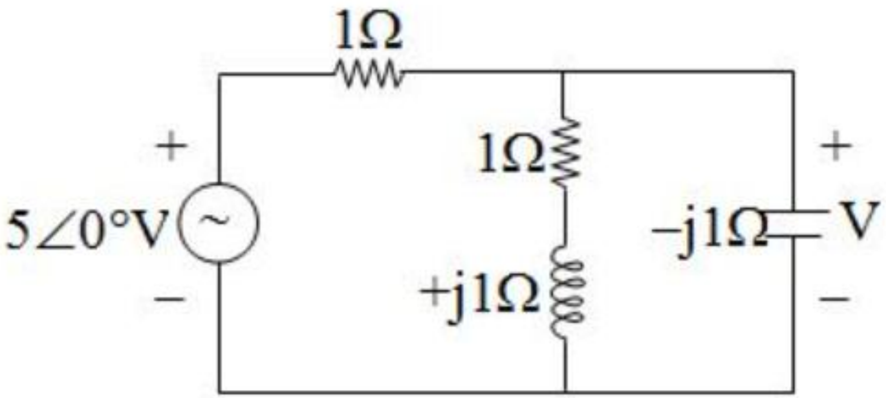
A) $5[1 + j]V$

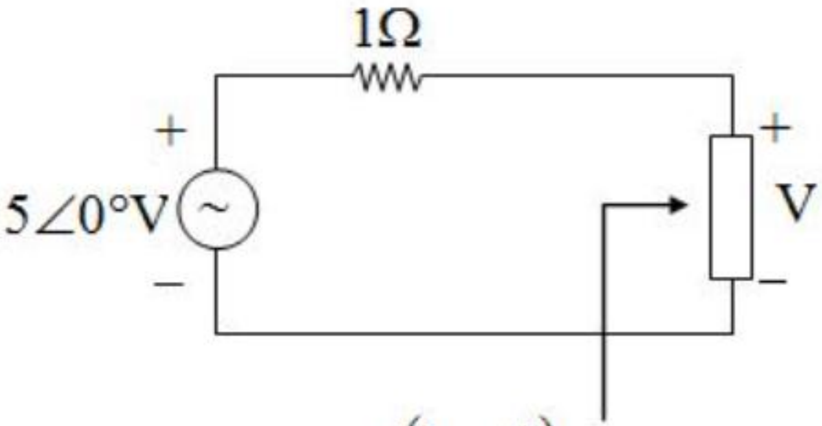
B) $1.66[1 + j]V$

C) $[3 - j1]V$

D) $0V$

Correct Answer: **C**   *Not Attempted :*   Marks : 2 / 0.66 (-Ve)





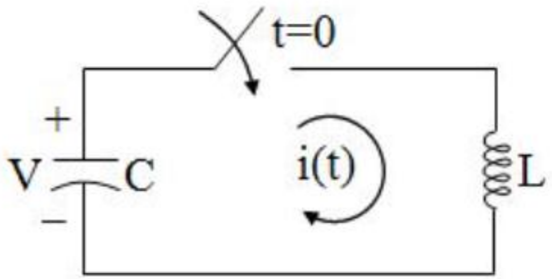
$$Z = \frac{-j(1+j1)}{1} \Rightarrow Z = (1-j)\Omega$$

$$\text{So, } V = 5\angle 0\left[\frac{1-j}{2-j}\right]\frac{(2+j)}{2+j}$$

$$= \frac{5[3-j]}{4+1}$$

$$V = (3-j1)V$$

3. The nature of current i(t), when switch is instantly closed at t = 0 is_______.



A) Sinusoidal

B) Impulse

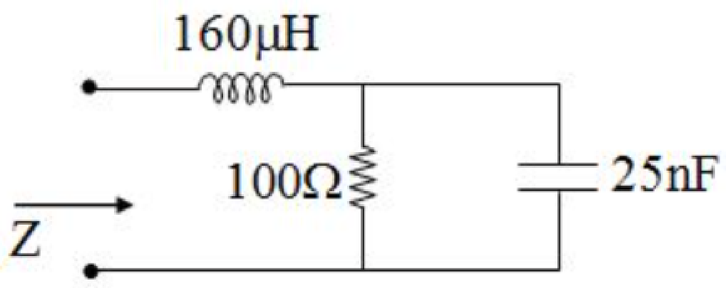
C) Ramp

D) DC current

Correct Answer: **A** *Not Attempted :* Marks : 1 / 0.33 (-Ve)

Pure L-C [Loss less] circuit is undamped as capacitor is charged, so sinusoidal option (a)

4. The value of impedance Z at its natural frequency is________.



A) 100Ω

B) 64Ω

C) 80Ω

D) 40Ω

Correct Answer: **B** *Not Attempted :* Marks : 2 / 0.66 (-Ve)

First find natural frequency circuit

$$Z = j\omega L + \left[R \,//\, \frac{1}{j\omega C}\right]$$

$$= j\omega L + \frac{R}{1 + j\omega RC} \quad = j\omega L + \frac{R[1 - j\omega RC]}{1 + \omega^2 R^2 C^2}$$

$$Z = \frac{R}{1 + \omega^2 R^2 C^2} + j\left[\omega L - \frac{\omega R^2 C}{1 + \omega^2 R^2 C^2}\right]$$

At natural frequency 'Z' is purely resistive, so,

$$\omega L = \frac{\omega R^2 C}{1 + \omega^2 R^2 C^2}$$

$$L + \omega^2 R^2 C^2 L = CR^2$$

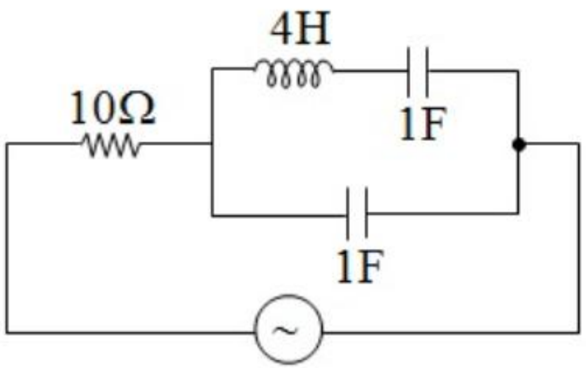
$$\omega^2 = \left.\frac{CR^2 - L}{R^2 C^2 L}\right\} = 9 \times 10^{10}$$

ω = 300k rad/sec

Now, impedance at this frequency is purely resistive so, $Z = \dfrac{R}{1 + \omega^2 R^2 C^2}$

$$Z = \frac{100}{1 + \left(300 \times 10^3\right)^2 (100)^2 \left(25 \times 10^{-9}\right)^2} = 64\Omega$$

5. The following circuit shown, resonates at_____frequency



A) All frequencies

B) $\frac{1}{2}$ rad / sec

C) 5rad/sec

D) 1rad/sec

Correct Answer: **B** *Not Attempted :* Marks : 2 / 0.66 (-Ve)

$$Z = R + \left[\left[j\omega L + \frac{1}{j\omega C}\right] // \frac{1}{j\omega C}\right]$$

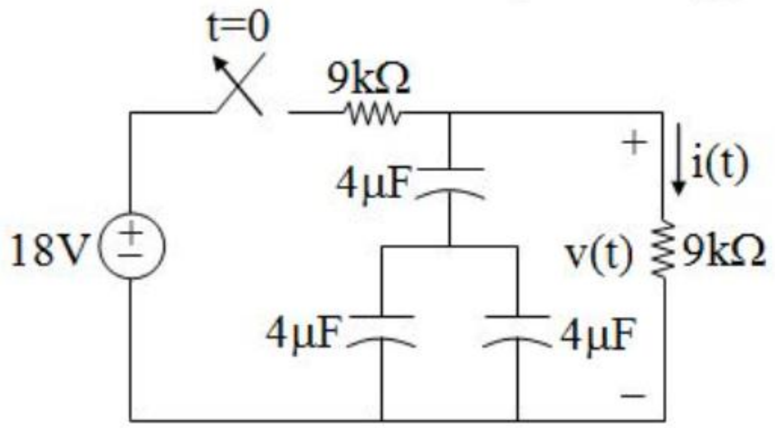
$$= R + \frac{j\left(\omega L - \frac{1}{\omega C}\right)\left(\frac{-j}{\omega C}\right)}{j\left(\omega L - \frac{1}{\omega C}\right) + \frac{-j}{\omega C}}$$

At resonance, Im [Z] = 0

So, $\left[\omega L - \frac{1}{\omega C}\right] = 0 \Rightarrow \omega = \frac{1}{\sqrt{LC}}$

$$= \frac{1}{\sqrt{4(1)}} = \frac{1}{2} = 0.5\text{rad / sec}$$

6. In the circuit shown below, current i(t) for $t > 0$ is ______



A) $6e^{-41.67t}$mA

B) $9e^{-41.67t}$mA

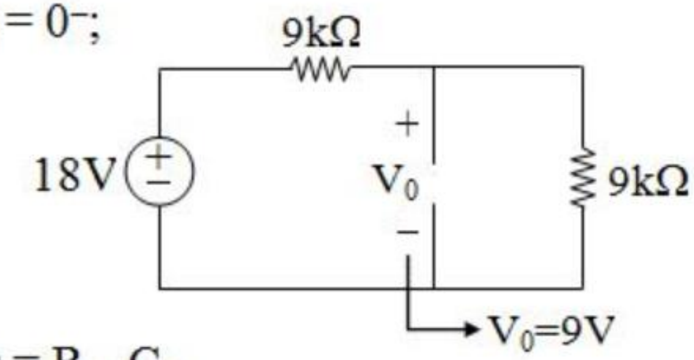
C) $e^{-41.67t}$mA

D) $4e^{-20.83t}$mA

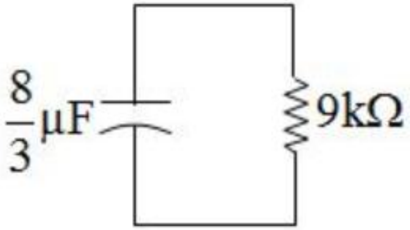
Correct Answer: **C**   *Not Attempted :*   Marks : 1 / 0.33 (-Ve)

This is source free first order circuit, so, $v(t) = v_0 e^{\frac{-t}{\tau}}$

$t = 0^-$;



$\tau = R_{eq}\, C_{eq}$

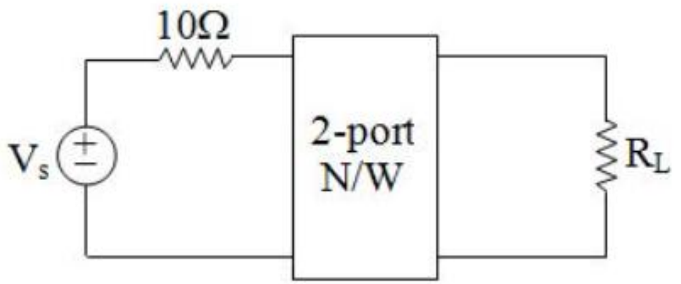


$$\tau = R_{eq}.C_{eq} = 9k\left[\frac{8}{3}\mu F\right] = \frac{72}{3} m\sec$$

$$\text{So, } v(t) = v_0 e^{\frac{-t}{\tau}} = 9e^{\frac{-3t}{72m}}$$

$$i(t) = \frac{v(t)}{9k\Omega} = \frac{9e^{\frac{-3000}{72}t}}{9k} = 1e^{-41.67t} mA$$

7. In circuit shown below ABCD parameters of two port network are $\begin{bmatrix} 4 & 20 \\ 0.1 & 2 \end{bmatrix}$. What should be the value of load R_L to transfer the maximum power?



A) $\frac{40}{3}\Omega$

B) 10Ω

C) 4Ω

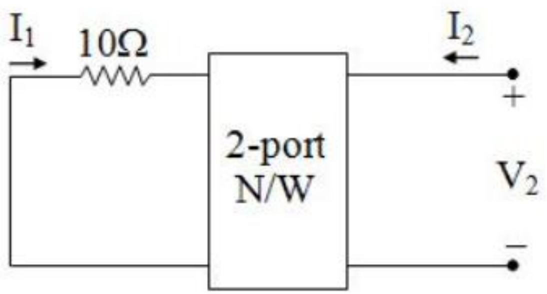
D) 8Ω

Correct Answer: **D** *Not Attempted :* Marks : 2 / 0.66 (-Ve)

$V_1 = 4V_2 - 20I_2$

$I_1 = 0.1\ V_2 - 2I_2$

To obtain maximum power transfer, we have to calculate Thevenin impedance across load terminal so,



Substitute $V_1 = -10I_1$ in above equations.

$-10I_1 = 4V_2 - 20I_2$

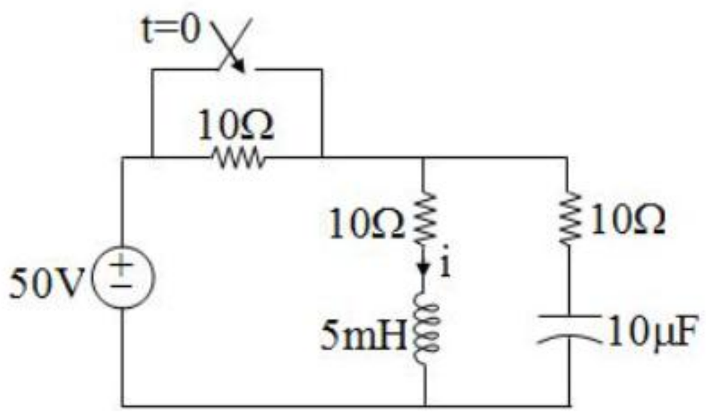
$-10[0.1V_2 - 2I_2] = 4V_2 - 20I_2$

So, $40I_2 = 5V_2$

$$Z_{TH} = \frac{V_2}{I_2} = \frac{40}{5} = 8\Omega$$

8.

What is the value of $\dfrac{di(0^+)}{dt}$?



A) 1kA/sec

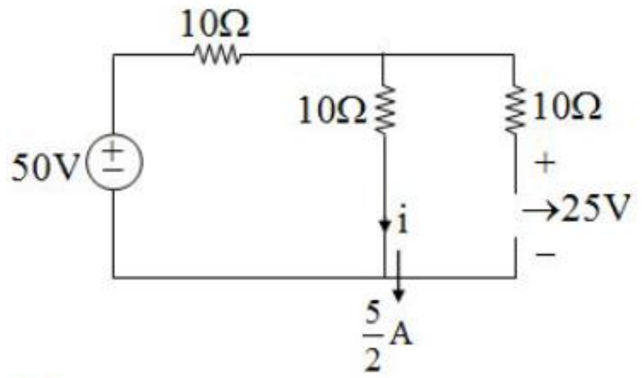
B) 5kA/sec

C) 10kA/sec

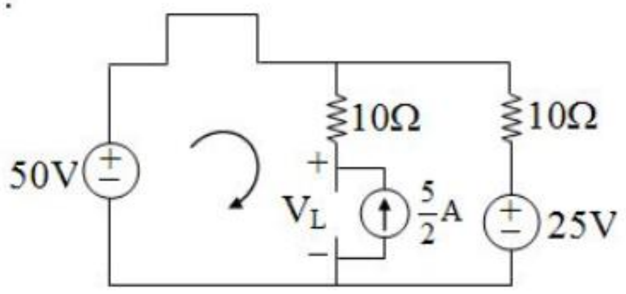
D) 25kA/sec

Correct Answer: **B** *Not Attempted :* Marks : 2 / 0.66 (-Ve)

$t = 0^-$:



$t = 0^+$:



KVL

$$-50+\frac{5}{2}(10)+V_L(0^+)=0$$

$$V_L(0^+) = 25$$

$$\frac{di(0^+)}{dt}=\frac{V_L(0^+)}{L}=\frac{25}{5m}=5kA/sec$$

9. An initially relaxed RC series network with R = 2 MΩ and C = 1 μF is switched on to a 10 V step input. The voltage across capacitor after 2 seconds will be

A) Zero

B) 3.68V

C) 6.32V

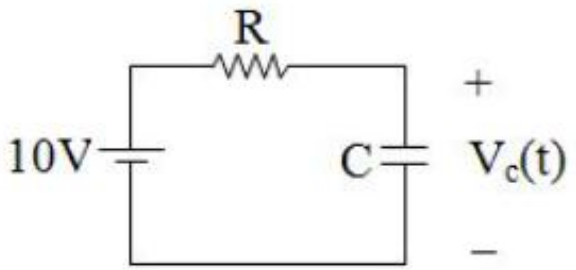
D) 10V

Correct Answer: **C**   *Not Attempted :*   Marks : 1 / 0.33 (-Ve)

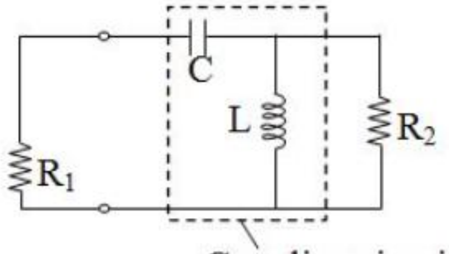
$$V_c(t) = V_{final} + (V_{initial} - V_{final})\, e^{\frac{-t}{RC}}$$

$$V_c(t) = 10 + (0-10)\, e^{\frac{-t}{2}} = 10(1 - e^{\frac{-t}{2}})$$

$$V_c(t)\big|_{t=2} = 10(1 - e^{-1}) = 6.32V$$



10. A source of internal resistance, R_1 is to be matched, at angular frequency ω, to a purely resistive load R_2 (where $R_2 > R_1$) by means of the coupling circuit shown in figure. The expressions for L and C in terms of R_1, R_2 and ω are



A) $L = \frac{R_2}{\omega}\sqrt{\frac{R_1}{(R_2 - R_1)}}, C = \frac{1}{\omega}\sqrt{\frac{1}{R_1(R_2 - R_1)}}$

B) $L = \omega R_2\sqrt{\frac{R_1}{R_2 + R_1}}, C = \omega\sqrt{\frac{R_1}{(R_2 - R_1)}}$

C) $L = \frac{R_1}{\omega R_2}\left(\frac{1}{R_2 + R_1}\right), C = \frac{1}{\omega}\frac{R_1}{(R_2 + R_1)}$

D) $L = \frac{\omega R_1}{R_1^2 + R_2^2}, C = \frac{\omega R_2}{R_1^2 + R_2^2}$

Correct Answer: **A** *Not Attempted :* Marks : 2 / 0.66 (-Ve)

For matching we must have:

$$R_1 = -\frac{j}{\omega C} + \frac{j\omega L R_2}{R_2 + j\omega L}$$

Equating real and imaginary parts,

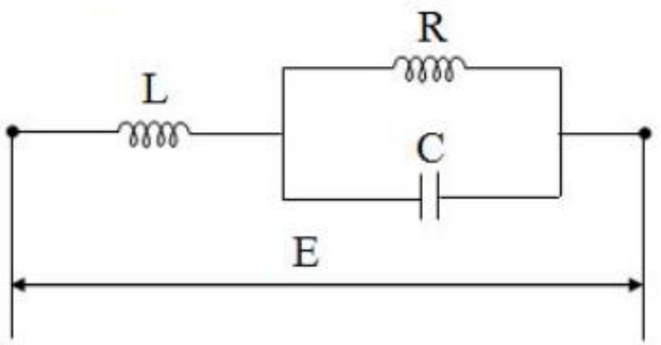
$L = CR_1R_2$ and $R_1\omega^2 LC = R_2\omega^2 LC - R_2$

$$\therefore L = \frac{R_2}{\omega}\sqrt{\frac{R_1}{(R_2 - R_1)}}, C = \frac{1}{\omega}\sqrt{\frac{1}{R_1(R_2 - R_1)}}$$

11. For the circuit give in figure, the applied e.m.f. is given by:

$E = 10 + 12\sin 2\pi ft + 9\sin[4\pi ft + (\pi/4)]V$

and L is a pure inductance whose reactance at frequency f is 2Ω and C is a pure capacitance whose reactance at frequency f is 6Ω. The resistance of R is 5Ω.



The r.m.s. value of the total current(in A) taken from the supply is

Correct Answer: **4.5** Answer Range: **(4 , 5)** *Not Attempted :* Marks : 2 / 0 (-Ve)

The reactive components have no effect on the steady component of current due to the steady component of p.d.

$$\therefore\ I_{DC} = \frac{E_{DC}}{R} = \frac{10}{5} = 2A$$

At frequency f,

$$\omega L = 2\Omega, \frac{1}{\omega L} = 6\Omega$$

$$\therefore\ I_{f(peak)} = \frac{12}{j2-(5\times j6)/(5-j6)} = \frac{3(5-j6)}{3-j5}$$

$$\therefore\ I_{f(peak)} = \frac{3\sqrt{(25+36)}}{\sqrt{(9+25)}} = 4.02A$$

$$\therefore\ I_{f(r.m.s)} = \frac{4.02}{\sqrt{2}} = 2.84A$$

At frequency 2f,

$$\omega L = 4\Omega, \frac{1}{\omega L} = 3\Omega$$

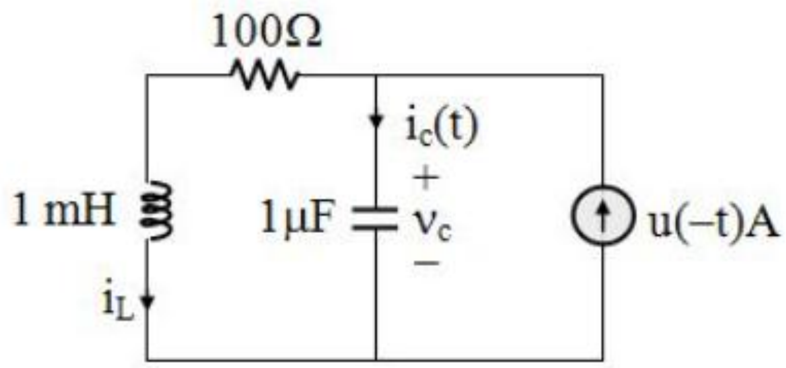
$$\therefore\ I_{2f(peak)} = \frac{9}{j4-(5\times j3)/(5-j3)} = \frac{9(5-j3)}{12+j5}$$

$$\therefore\ I_{2f(peak)} = \frac{9\sqrt{(25+9)}}{\sqrt{(144+25)}} = 4.04A$$

$$\therefore\ I_{2f(r.m.s)} = 2.85A$$

$$\text{Total } I_{(r.m.s)} = \sqrt{\left(2^2 + 2.84^2 + 2.85^2\right)} = 4.5A$$

12. For the circuit shown in the given figure, $\frac{dv_c(0^+)}{dt}$ is



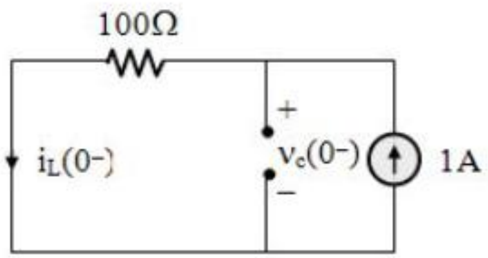
A) 10^6 V/sec

B) -10^6 V/sec

C) 10^3 V/sec

D) -10^3 V/sec

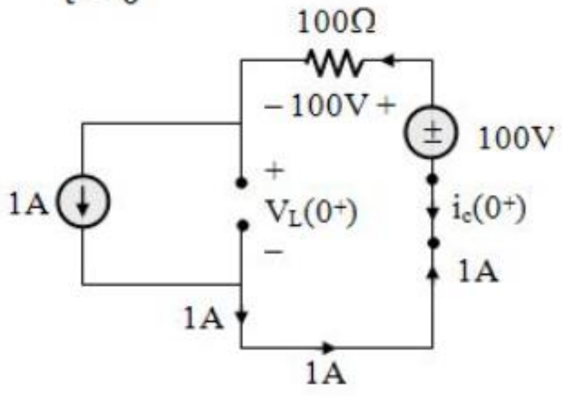
Correct Answer: **B** *Not Attempted :* Marks : 1 / 0.33 (-Ve)



$v_C(0^-) = 1 \times 100 = 100V = v_C(0$

$i_L(0^-) = 1A = i_L(0^+)$

$t = 0^+$

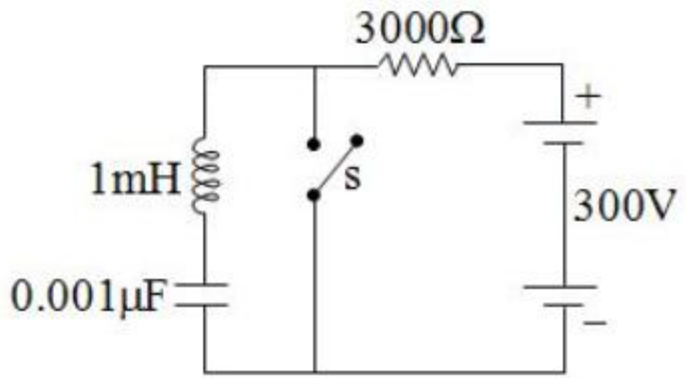


$i_c(0^+) = -1$

$$\frac{Cdv_c(0^+)}{dt} = -1$$

$$\frac{dv(0^+)}{dt} = \frac{-1}{C} = -10^6 \text{ V/sec}$$

13. The circuit below contains a rapid acting switch S. After the circuit has reached a steady state, the switch is closed and automatically re-opens permanently when the current through it becomes zero. Find for how long the Switch remains closed?



A) 15.5μsec

B) 15.5 msec

C) 3.48μsec

D) 50msec

Correct Answer: **C** *Not Attempted :* Marks : 2 / 0.66 (-Ve)

Before closing, the charge q on C is CV and dq/dt = 0.

After closing

$$v = L\frac{d}{dt}\left(-V\frac{dv}{dt}\right)$$

$$\therefore\ \frac{d^2v}{dt^2} + \frac{v}{LC} = 0$$

$$\therefore\ v = V\cos\omega t \quad \text{where } \omega = \frac{1}{\sqrt{(LC)}}$$

The current through $S = \frac{V}{R} - C\frac{dv}{dt}$

$$= \frac{V}{R} + \omega CV\sin\omega t$$

$\therefore$ switch opens when

$$\omega CV\sin\omega t + \frac{V}{R} = 0$$

$$\therefore\ \sin\omega t = -\frac{1}{\omega CR}$$

$$\text{but } \omega = \frac{1}{\sqrt{(LC)}}$$

$$\therefore\ \sin\omega t = -\frac{1}{R}\sqrt{\frac{L}{C}}$$

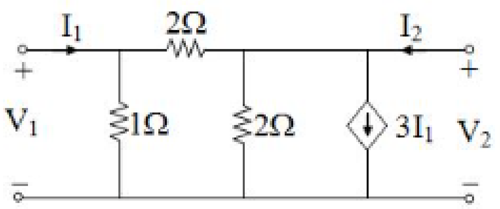
$L = 10^{-3}$H, $C = 10^{-9}$F, $R = 3 \times 10^{3}\Omega$, $\omega = 10^{6}$rad/sec

$$\therefore\ \sin\omega t = -1/3$$

$$\therefore\ t = \left(\pi + \sin^{-1}\frac{1}{3}\right)\mu\text{sec}$$

$$= 3.48\mu\text{sec}$$

14. Consider the following network



The transmission parameters are

A) $\begin{pmatrix} \frac{-1}{4} & \frac{-1}{8} \\ \frac{-3}{8} & \frac{-5}{16} \end{pmatrix}$

B) $\begin{pmatrix} \frac{-15}{16} & \frac{-3}{8} \\ \frac{-1}{8} & \frac{-1}{4} \end{pmatrix}$

C) $\begin{pmatrix} \frac{+1}{8} & \frac{-1}{4} \\ \frac{-5}{16} & \frac{-3}{8} \end{pmatrix}$

D) $\begin{pmatrix} \frac{-3}{8} & \frac{-5}{16} \\ \frac{-1}{4} & \frac{-1}{8} \end{pmatrix}$

Correct Answer: **C** *Not Attempted :* ! Marks : 2 / 0.66 (-Ve)

: Nodal $\Rightarrow -I_1 + \frac{V_1}{1} + \frac{V_1 - V_2}{2} = 0$

$\Rightarrow I_1 = 1.51V_1 - 0.5V_2$ …….. (1)

Nodal $\Rightarrow -I_2 + 3I_1 + \frac{V_2}{2} + \frac{V_2 - V_1}{2} = 0$

$\Rightarrow I_2 = 3I_1 + V_2 - 0.5V_1$ …… (2)

Substituting eqn. (1) in (2)

$\Rightarrow I_2 = 4V_1 - 0.5V_2$

$\Rightarrow V_1 = \frac{1}{8}V_2 + \frac{1}{4}I_2$ ………… (3)

Substituting eqn. (3) in (1)

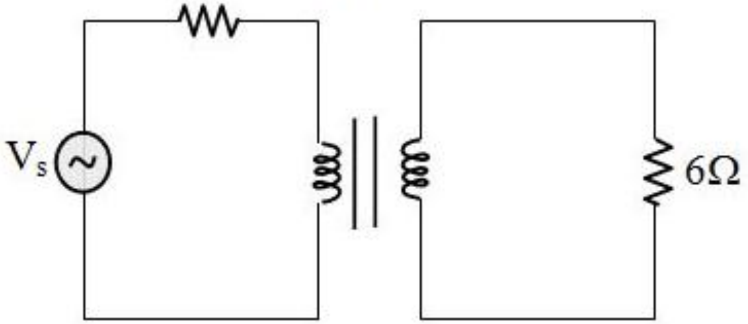
$\Rightarrow I_1 = 1.5\left(\frac{1}{8}V_2 + \frac{1}{4}I_2\right) - 0.5V_2$

$= \frac{-5}{16}V_2 + \frac{3}{8}I_2$ …….. (4)

From eqns (3) & (4)

$\Rightarrow (T) = \begin{pmatrix} \frac{1}{8} & \frac{-1}{4} \\ \frac{-5}{16} & \frac{-3}{8} \end{pmatrix}$

15. Consider the following circuit for maximum power transfer to 6 Ω resistance, determine value of n.



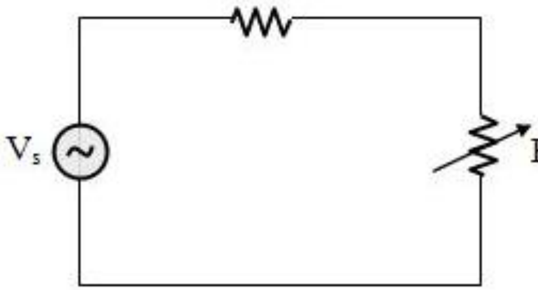
A) 6

B) $2\sqrt{6}$

C) $\sqrt{6}$

D) $\frac{1}{\sqrt{6}}$

Correct Answer: **D**   *Not Attempted :*   Marks : 1 / 0.33 (-Ve)



$$R_L = R_2^1 = \frac{R_2}{K^2} = \frac{R_2}{n^2}$$

$$\frac{N_2}{N_1} = \frac{n}{1} = K$$

For MPT $\Rightarrow R_L = R_S$

$$\frac{R_2}{n^2} = 36$$

$$\frac{6}{n^2} = 36$$

$$n^2 = \frac{6}{36} = \frac{1}{6}$$

$$n = \frac{1}{\sqrt{6}}$$