Course Title E-N-A

Module 4th

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Q1

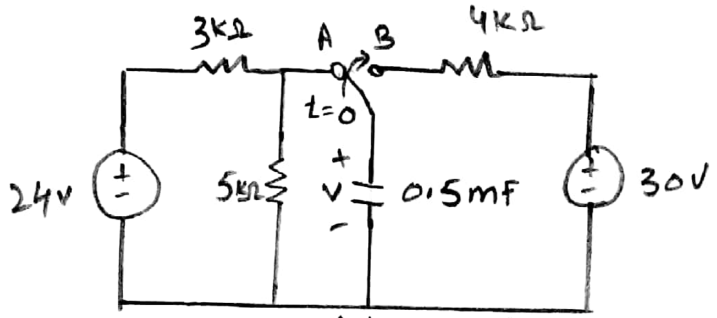

Figure 1

Solution :- For t < 0 the switch is at Position A. Capacitor act like an open circuit to dc. but v is same as the voltage across 5 kΩ resistor. Hence the voltage across the capacitor just before t = 0 is obtained by voltage division as.

$$V(0^-) = \frac{5}{5+3}(24)$$

$$V(0^-) = \frac{5}{8}(24)$$

$$V(0^-) = 15\ V$$

Using the fact that capacitor voltage can't change instantaneously.

$$V(0) = V(0^-) = V(0^+) = 15\ V$$

t > 0 the switch is position B. Thevenin resistance connect to the capacitor $R_{Th} = 4\,k\Omega$ the time const is

$$\tau = R_{Th} C = 4 \times 10^3 \times 0.5 \times 10^{-3}$$

$$\tau = 2\ s$$

Since the capacitor act like an open circuit to dc at steady state

$$V(\infty) = 30\ V$$

Thus

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$$V(t) = v(\infty) + \left[v(0) - v(\infty)\right] e^{-t/\tau}$$

$$= 30 + (15 - 30) e^{-t/2}$$

$$= 30 + (-15) e^{-t/2}$$

$$= \left(30 - 15 e^{-0.5}\right) V$$

At $t = 2$, $\quad V(2) = 30 - 15 e^{-\frac{2}{2}}$

$$V(2) = 30 - 15 e^{-1}$$

$$V(2) = 24.48 \text{ V}$$

At $t = 8$, $\quad V(8) = 30 - 15 e^{-\frac{8}{2}}$

$$V(8) = 30 - 15 e^{-4}$$

$$V(8) = 29.72 \text{ V}$$

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Q2

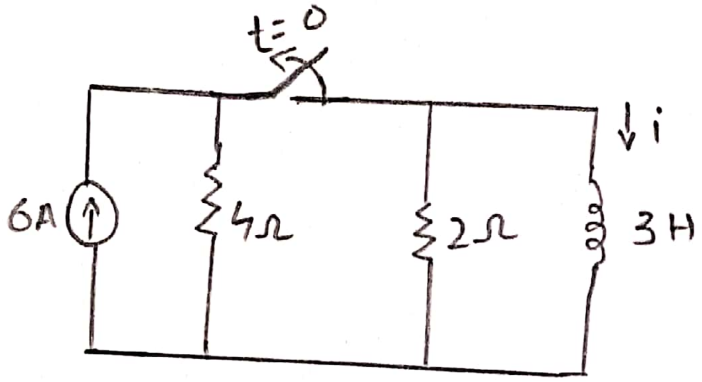

Figure 2

Solution:

For $t<0$ the switch is closed and inductor act as ~~show~~ short circuit

Therefore inductor current $i = 6A$

For $t>0$ the switch is opened and

time constant $\tau = \frac{L}{R}$

$$\tau = \frac{3}{2}$$

Now the inductor current $i(t) = 6^{-\frac{t}{T}}$

$$i(t) = 6e^{-\frac{t}{3/2}}$$

$$i(t) = 6e^{-\frac{2t}{3}} \, u(t) \text{ A.}$$

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Q NO 3

Step 1

The step respone of branch voltage of the given RLC circuit is describe by

$$L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{i}{c} = 10$$

Divide by L

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = \frac{10}{L}$$

R.H. Side of equation xing by $\frac{C}{C}$

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = \frac{10C}{LC}$$

And $c = 0.2F$ thus

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = \frac{2}{LC}$$

Substitute

$$\frac{d^2i}{dt^2} + 8\frac{di}{dt} + 10i = 20 \quad \ldots\ldots (1)$$

G. Equation for source-Free series RLC circuit is given by

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{1}{LC}i = \frac{I_s}{LC} \quad \ldots\ldots (2)$$

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Step 2

Compare 1 & 2

$$\frac{R}{L} = 8 \rightarrow (3)$$

$$\frac{1}{LC} = 10 \rightarrow (4)$$

$$\frac{I_s}{LC} = 20 \rightarrow (5)$$

Step 3

From (3) α is given by

$$\alpha = \frac{R}{2L} = \frac{8}{2} = 4 \text{ rad/s} \rightarrow (6)$$

Natural frequency ω_0 is given by

$$\omega_0 = \sqrt{\frac{1}{LC}}$$

From (4)

$$\omega_0 = \sqrt{10} \text{ rad/s} \longrightarrow (7)$$

From (6) & (7)

$\because \alpha > \omega_0$

$\therefore$ The circuit is overdamped

Root of characteristic equ are given

$$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2}$$

$$= -4 + \sqrt{4^2 - \sqrt{10}^2}$$

$$= -4 + \sqrt{6} \text{ rad/s}$$

From (5) steady state current is given by

RW

$\sqrt{4^2 - \sqrt{10}^2}$

$\sqrt{4^2 - 10}$

$\sqrt{16 - 10}$

$\sqrt{6}$

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$I_s = 20 \times LC$

$$20 \times 0.5 \times 0.2 = 2A \rightarrow (8)$$

Step (4)

Current for overdamped case is given by

$$i(t) = I_s + A_1 e^{s_1 t} + A_2 e^{s_2 t} \quad t > 0 \rightarrow (9)$$

Substitute $t = 0$,

$$i(0) = I_s + A_1 + A_2$$

Substitute,

$$1 = 2 + A_1 + A_2$$

Thus

$$A_1 + A_2 = -1 \rightarrow (10)$$

Step (5)

From (9) Find $\frac{di(t)}{dt}$

$$\frac{di(t)}{dt} = A_1 S_1 + A_2 S_2$$

Substitute the Value

$$(-4+\sqrt{6})A_1 + (-4-\sqrt{6})A_2 = 0 \rightarrow (11)$$

Solve (10) & (11) simultaneously

$$A_1 = -1.316$$

$$A_2 = 0.316$$

Step (6)

$$i(t) = 2 - 1.316 e^{(-4+\sqrt{6})t} + 0.316 e^{(-4-\sqrt{6})t} \; A$$

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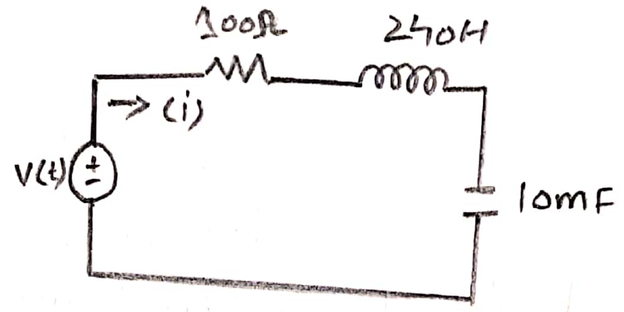
Q4 A series of RLC Circuit .... - - - -

- - - - - - - - - - - - Find the current flowing through the circuit.



Consider the following voltage is applied the series RLC Circuit.

$V(t) = 10 \cos 2t$ V

Here

Ampilitude $V_m = 10V$

Angular frequency $\omega = 2$ rad/s

Phase Angle $\phi = 0°$

So phase for voltage, v(t)

$V(t) = 10\angle 0°$ V

Inductive Reactance of the circuit

$X_L = \omega L$

$\omega = 2$ rad/s , $L = 240$ H

$X_L = (2 \text{ rad/s})(240 \text{ H})$

$X_L = 480\ \Omega$

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Now for capacitive reactance

$$X_C = \frac{1}{WC}$$

$\cancel{X_C}/7$ $\omega = 2$ rad/s , $C = 10$ mF

$$X_C = \frac{1}{2(10 \times 10^{-3})} \rightarrow$$

Bases same power will be added

$$\Rightarrow \frac{1}{2(10^{+1-3})}$$

$$\Rightarrow \frac{1}{2(10^{-2})}$$

$$\Rightarrow \frac{1 \times 10^{2}}{2} \Rightarrow \frac{100}{2} = 50$$

$$X_C = 50\,\Omega$$

Now for impedence of the circuit.

$$Z = R + jX_L - jX_C$$

$R = 100\,\Omega$, $X_L = 480\,\Omega$, $X_C = 50\,\Omega$

$$\Rightarrow (100 + 480 - 50)\,\Omega$$

$$Z \Rightarrow (100 + j430)\,\Omega$$

Represent the impedance , Z is phasor form.

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$$Z = (100 + j430)\,\Omega$$

$$= \sqrt{(100)^2 + (430)^2} \angle \tan^{-1}\left(\frac{430}{100}\right)$$

$$= \sqrt{10000 + 184900} \angle \tan^{-1}(4.3)$$

$$= \sqrt{194900} \angle \tan^{-1}(4.3)$$

$$= 441.47 \angle 76.90^\circ\,\Omega$$

Now the current flowing i

$$i = \frac{V(t)}{Z}$$

$V(t) = 10\angle 0$, $Z = 441.47 \angle 76.9^\circ$

$$i = \frac{10 \angle 0^\circ \text{ V}}{441.47 \angle 76.9^\circ\,\Omega}$$

$$= \frac{10}{441.47} \angle [0 - 76.9] \text{ A}$$

$$= 22.6 \times 10^{-3} \angle -76.9^\circ \text{ A}$$

$$= 22.6 \angle -76.9^\circ \text{ mA}$$

So ~~The~~ The General expression for current, i.

$$i = 22.6 \cos(2t - 76.9^\circ) \text{ mA}.$$

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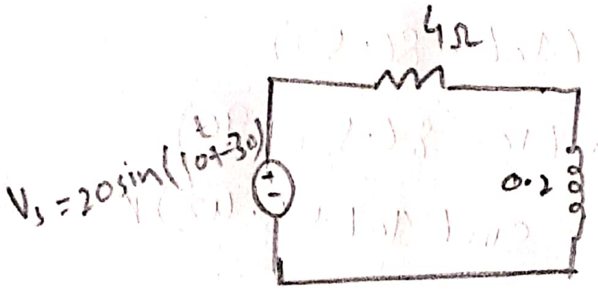
Q No 5



$$V_S = 20\sin(10t + 30)\,V \quad , \quad R = 4\Omega , \; L = 0.2H$$

$$V_s = 20\sin(10t + 30)\,V$$

$$20\cos(10t + 30^\circ - 90)\,V$$

$$20\cos(10t - 60^\circ)\,V$$

$$V_S = 20\angle -60^\circ V$$

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

$$X_L = j\omega L$$

$$0.2H = j \times 10 \times 0.2$$

$$0.2H = j2\Omega$$

Now

$$Z = 4 + j2\Omega$$

$$j = \frac{20\angle -60^\circ}{4+j2}$$

$$I = \frac{20\angle -60}{\sqrt{4^2+2^2}\angle \tan^{-1}\left(\frac{2}{4}\right)}$$

$$I = \frac{20\angle -60^\circ}{4.72\angle 26.57^\circ}$$

$$I = 4.472 \angle -86.57$$

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Now

$i(t) = 4.472 \cos(10t - 86.57)$

$i(t) = 4.472 \sin(10t - 86.57 + 90)$

$i(t) = 4.472 \sin(10t + 3.43^\circ)$ A

As

$V = j2 \times (4.47 \angle -86.57)$

$V = j2 \times (0.2675 - j4.464)$

$V = 8.92 + j0.53512$

From Rectangular to Polar Form

$V = \sqrt{(8.926)^2 + (0.53512)^2} \angle \tan^{-1}\left(\frac{0.5312}{8.928}\right)$

$V = 8.944 \angle 3.4$ V

Now

$V(t) = 8.944 \cos(10t + 3.4)$

$V(t) = 8.944 \sin(10t + 3.4^\circ + 90^\circ)$

$V(t) = 8.944 \sin(10t + 93.4)$ V

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