Basic Electronics (ECE113)

Quiz 3_Solution

Ans 1.

$V = 100\,V$; $\tau = 0.8\,s$, $R = 50\,k\Omega$

(a) Since time constant $\tau = CR$

$$\Rightarrow C = \tau/R$$

$$\Rightarrow C = \frac{0.8}{50 \times 10^3} = \boxed{16\,\mu F}$$

(b) $v_c = V e^{-t/\tau}$ $\Rightarrow 20 = 100\,e^{-t/0.8}$

$$\Rightarrow e^{t/0.8} = 5 \Rightarrow t = 0.8 \ln 5$$

$$= \boxed{1.29\,s}$$

(c) $i = I e^{-t/\tau}$

The initial current flowing $I = V/R = \frac{100}{50 \times 10^3}$ $= 2\,mA$

$$\therefore\ i = I e^{-t/\tau} = 2\,e^{(-0.5/0.8)}$$

$$= 2\,e^{-0.625} = 2 \times 0.535$$

$$= \boxed{1.07\,mA}$$

(d) $v_R = v_c = V e^{-t/\tau}$

$$\doteq 100\,e^{-1/0.8} = 100\,e^{-1.25}$$

$$= 100 \times 0.287 = \boxed{28.7\,V}$$

Ans 2.

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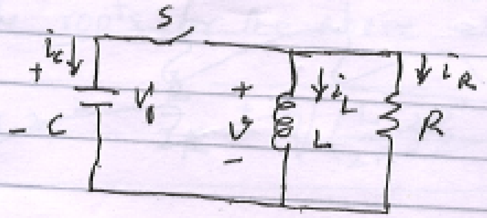


$L = 0.5H$

$R = 400\Omega$

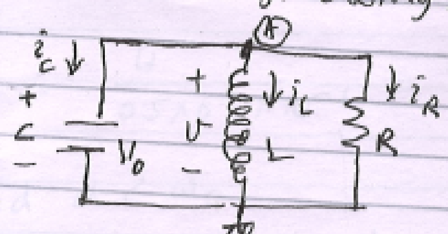
$C = 0.5\mu F$

$V_0 = 30V$

At $t < 0$

$i_c(t) = 0A \quad v(t) = 0V \quad i_L(t) = 0A \quad i_R(t) = 0A$

At $t = 0_+$, the switch is closed. The equivalent ckt will be seen as following:



Since the capacitor voltage can not change between $t = 0_-$ to $t = 0_+$ (i.e. closing of switch), so voltage across inductor is same as capacitor voltage.

$v(t=0_+) = V_0 = 30V$

The current through R is given as $(i_R(t=0_+)) = \frac{30}{R}$

$= 75mA$

The current in the inductor cannot change instantly, so $i_L(t=0_+) = 0\,mAm$

At junction ①, $i_c + i_L + i_R = 0$

So, $i_C = -i_L - i_R = -75$ mAmp

For $t > 0$, we can obtain the solution from following equation by writing node equation at Ⓐ.

$$\frac{1}{L}\int v\,dt + \frac{v}{R} + C\frac{dv}{dt} = 0$$

differenting again we get,

$$C\frac{d^2v}{dt^2} + \frac{1}{R}\frac{dv}{dt} + \frac{1}{L}v = 0$$

$$\frac{d^2v}{dt^2} + \frac{1}{RC}\frac{dv}{dt} + \frac{1}{LC}v = 0$$

$$s_{1,2} = -\frac{1}{2RC} \pm \frac{1}{2}\sqrt{\left(\frac{1}{RC}\right)^2 - \frac{4}{LC}}$$

$$= -\frac{1}{2RC} \pm \sqrt{\left(\frac{1}{2RC}\right)^2 - \frac{1}{LC}}$$

$\alpha = \frac{1}{2RC}$ → damping factor

here $\omega_n = \frac{1}{\sqrt{LC}}$

$$\beta = \sqrt{\left(\frac{1}{2RC}\right)^2 - \frac{1}{LC}}$$

$$\beta = \sqrt{\alpha^2 - \omega_n^2}$$

$$\Rightarrow \beta = \omega_n\sqrt{\xi^2 - 1}$$

$$\xi = \frac{\alpha}{\omega_n} = \frac{\frac{1}{2RC}}{\frac{1}{\sqrt{LC}}}$$

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

$$= \frac{1}{2 \times 400}\sqrt{\frac{0.5}{0.5 \times 10^{-6}}} = \frac{1}{800} \times 10^3 = \frac{10}{8} = 1.25$$

So it is a overdamped system.