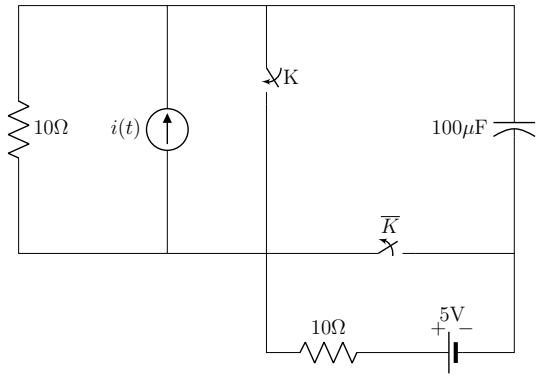
EE23BTECH11054 - Sai Krishna Shanigarapu*

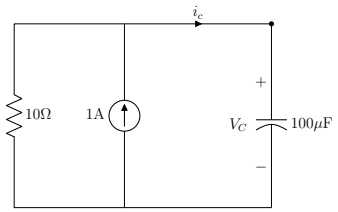
Gate EE 2023

54. The circuit shown in the figure is initially in the steady state with the switch K in open condition and $\overline{K}$ in closed condition. The switch K is closed and $\overline{K}$ is opened simultaneously at the instant $t = t_1$, where $t_1 > 0$. The minimum value of t_1 in milliseconds such that there is no transient in the voltage across the 100 μF capacitor, is ____ (Round off to 2 decimal places).



Solution:

Case(i) Switch K is open and $\overline{K}$ is closed.



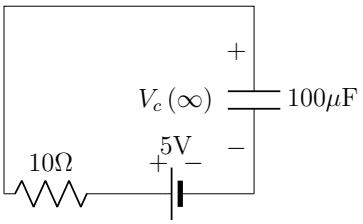
$$i_c = \frac{10}{10 - j10} \text{ x } 1\angle 0^\circ \tag{1}$$

$$V_c = \frac{10}{10 - 10j} \text{ x } (-j10) \tag{2}$$

$$= 7.07\angle(-45^\circ)\, V \tag{3}$$

$$V_c(t_1) = 7.07 \sin(1000t - 45^\circ)\, V \tag{4}$$

Case(ii) Switch K is closed and $\overline{K}$ is open.



$$V_c(\infty) = 5V \tag{5}$$

$$\tau = 1\text{msec} \tag{6}$$

$$V_c(t) = 5 + (7.07 \sin(100t_1 - 45^\circ) - 5)\, e^{-t/\tau} \tag{7}$$

For transient free voltage,

$$7.07 \sin(100t_1 - 45^\circ) - 5 = 5 \tag{8}$$

$$1000t_1 - \frac{\pi}{4} = \frac{\pi}{4} \tag{9}$$

$$\implies t_1 = 1.57\text{msec} \tag{10}$$

Symbol	formula
τ	RC
$V_c(t)$	$V_c(\infty) + (V_c(0) - V_c(\infty))\, e^{-t/\tau}$

TABLE I
Formulae