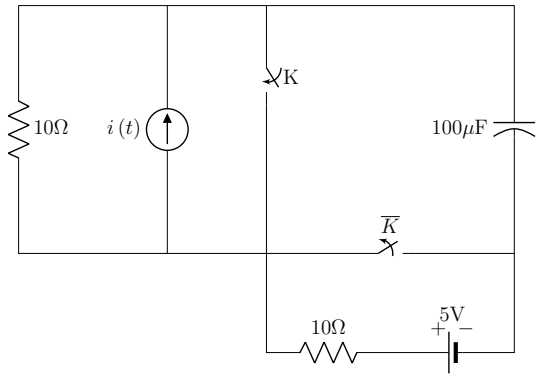
EE23BTECH11054 - Sai Krishna Shanigarapu*

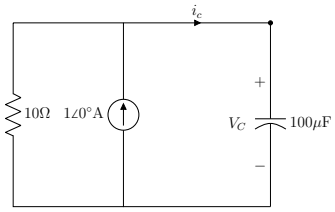
Gate EE 2023

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:

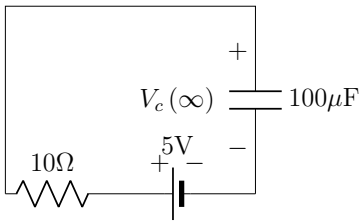
Case(i) Switch K is open and $\overline{K}$ is closed.



Symbol	description	value
i_c	current through capacitor	$\frac{10}{10-j10}A$
$V_c(t_1)$	Voltage across capacitor at t_1	$7.07\sin(1000t - 45^\circ)\,V$

TABLE I
Case1 Parameters

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



Symbol	description	value
$V_C(\infty)$	Voltage across capacitor after long time	$5V$
τ	Time constant	1 msec
$V_c(t)$	Voltage across capacitor at time t	$5 + (7.07\sin(100t - 45^\circ) - 5)\,e^{-(t-t_1)/\tau}$
R	Resistance	10Ω
C	capacitance	100μF

TABLE II
Case2 Parameters

For transient free voltage,

$$7.07\sin(100t_1 - 45^\circ) = 5 \tag{1}$$

$$1000t_1 - \frac{\pi}{4} = \frac{5}{7.07} \tag{2}$$

$$\implies t_1 \approx 1.57\text{msec} \tag{3}$$

Symbol	Description	Formula
τ	Time constant	RC
$V_c(t)$	Voltage across capacitor at time t	$V_c(\infty) + (V_c(0) - V_c(\infty))\,e^{-t/\tau}$

TABLE III
Formulae