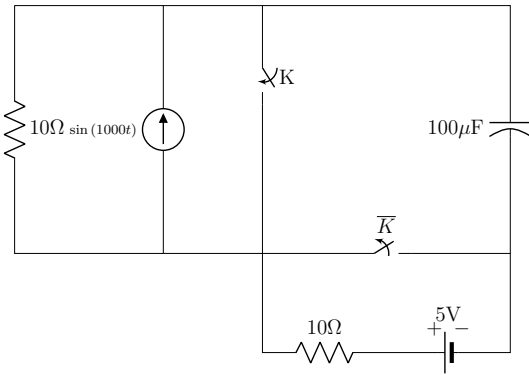


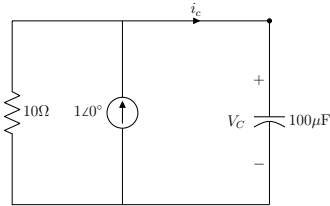
## EE23BTECH11054 - Sai Krishna Shanigarapu\*

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  $100 \mu F$  capacitor, is \_\_\_\_\_ (Round off to 2 decimal places).

**Solution:**

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



$$X_c = -10j \quad (1)$$

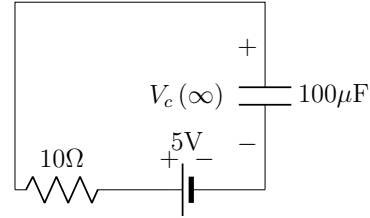
Using Current divider rule,

$$i_c = \frac{10}{10 + X_c} 1\angle 0^\circ \quad (2)$$

$$= \frac{1\angle 0^\circ}{1 - j} \quad (3)$$

$$\Rightarrow V_c = 7.07 \sin(1000t - 45^\circ) V \quad (4)$$

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



Symbol	description	value
$V_C(\infty)$	Voltage across capacitor after long time	5V
$\tau$	Time constant	1 msec
R	Resistance	10Ω
C	capacitance	100μF
f	frequency of the current source	$\frac{500}{\pi}$

TABLE I  
PARAMETERS

The voltage across capacitor at time t is given as,

$$V_c(t) = V_c(\infty) + (V_c(0) - V_c(\infty)) e^{-t/\tau} \quad (5)$$

$$\Rightarrow V_c(t) = 5 + (7.07 \sin(1000t - 45^\circ) - 5) e^{-t/\tau} \quad (6)$$

For transient free voltage,

$$7.07 \sin(1000t_1 - 45^\circ) = 5 \quad (7)$$

$$1000t_1 - \frac{\pi}{4} = \frac{5}{7.07} \quad (8)$$

$$\Rightarrow t_1 \approx 1.57 \text{ msec} \quad (9)$$

Symbol	Description	Formula
$\tau$	Time constant	RC
$X_c$	Capacitive reactance	$\frac{1}{2\pi fC}$
$V_c$	Voltage across capacitor	$i_c X_c$

TABLE II  
FORMULAE