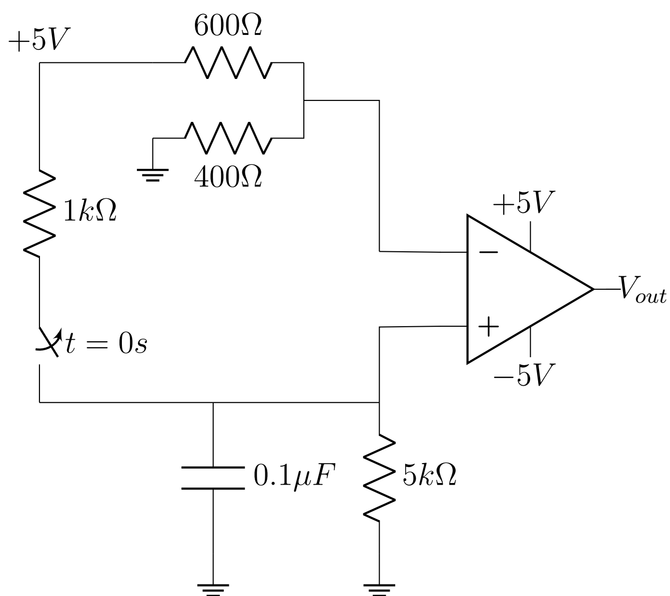
GATE 2022[IN]-64

EE23BTECH11066 - Yakkala Amarnath Karthik

Question:

In the circuit shown, the switch is initially closed. It is opened at t= 0 s and remains open thereafter. The time (in milliseconds) at which the output voltage V_{out} becomes LOW is (round off to three decimal places) (GATE 2022 IN)



Solution:

At t= 0^-, when the switch is closed,
The voltage across the capacitor is:

$$V_c\left(0^-\right) = 5 \times \frac{5}{5+1} \tag{1}$$
$$= \frac{25}{6}V \tag{2}$$

$V_c\left(0^-\right)$ is also the non inverting voltage of the OP-AMP

At $t = 0^+$, when the switch is open,
The voltage across inverting terminal is:

$$V_I = 5 \times \frac{600}{600+400} \tag{3}$$
$$= 2V \tag{4}$$

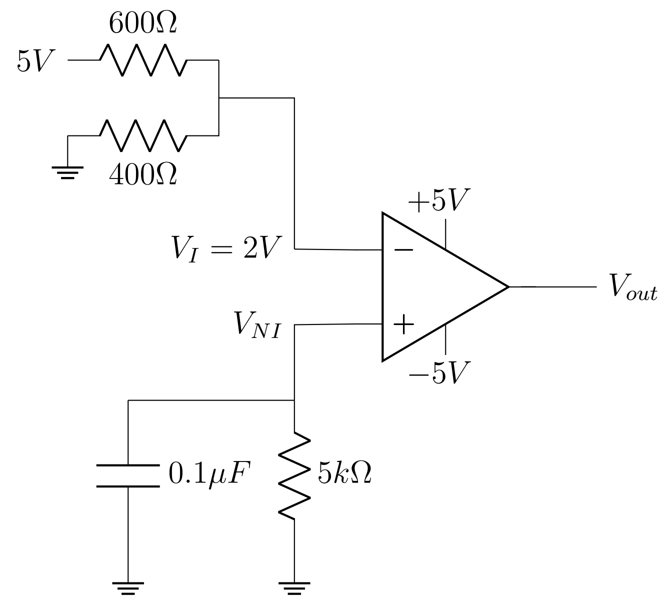


Fig. 1. circuit diagram at $t = 0^+$

Immediately after the switch is open, voltage across capacitor do not change.
So $V_{NI} > V_I$,Hence the output of OP-AMP is fixed to +5V. Later, Capacitor discharges into 5KΩ resistor.
The discharging equation is as follows:

$$V_C\left(t\right) = V_C\left(0^-\right)e^{\frac{-t}{\tau}} \tag{5}$$
$$2 = \frac{25}{6} \times e^{\frac{t_0}{RC}} \tag{6}$$
$$t = RC\ln\left(\frac{25}{12}\right) \tag{7}$$
$$= 0.1 \times 10^{-6} \times 5 \times 10^3 \ln\left(\frac{25}{12}\right) \tag{8}$$
$$t = 0.367ms \tag{9}$$