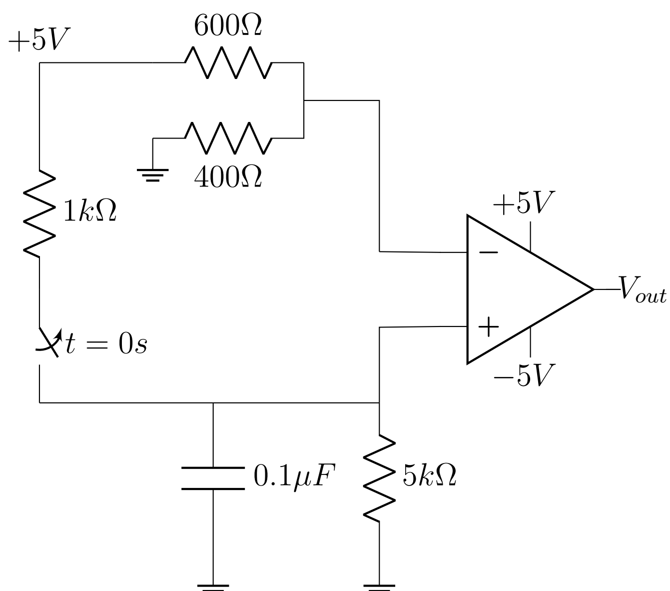
GATE 2022[IN]-64

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)



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:

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

$$= 2V \tag{4}$$

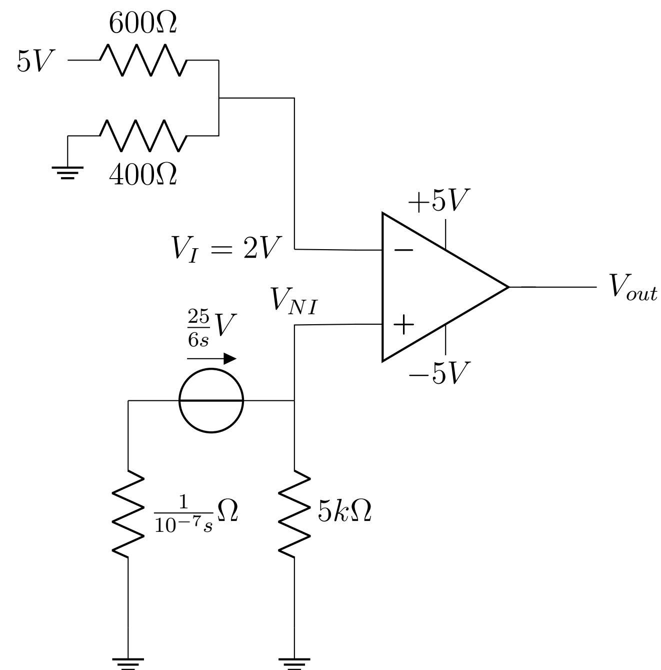


Fig. 1. circuit diagram in laplace domain at $t = 0^+$

Analysing the circuit at t=0^+ in laplace domain:
Using voltage divider rule,

$$V_{NI}\left(s\right) = V \times \left[\frac{R}{R+\frac{1}{sC}}\right] \tag{5}$$

$$= \frac{25}{6s} \times \left[\frac{s}{s+\frac{1}{RC}}\right] \tag{6}$$

$$= \frac{25}{6} \times \left[\frac{1}{s+\frac{1}{RC}}\right] \tag{7}$$

Applying inverse laplace:

$$V_{NI}\left(t\right) = \frac{25}{6}e^{\frac{t}{RC}} \tag{8}$$

$$\implies V_I = V_{NI}\left(t\right) \tag{9}$$

$$\implies 2 = \frac{25}{6} \times e^{\frac{t}{RC}} \tag{10}$$

$$\implies t = RC\ln\left(\frac{25}{12}\right) \tag{11}$$

$$= 0.1 \times 10^{-6} \times 5 \times 10^3 \ln\left(\frac{25}{12}\right) \tag{12}$$

$$= 0.367ms \tag{13}$$