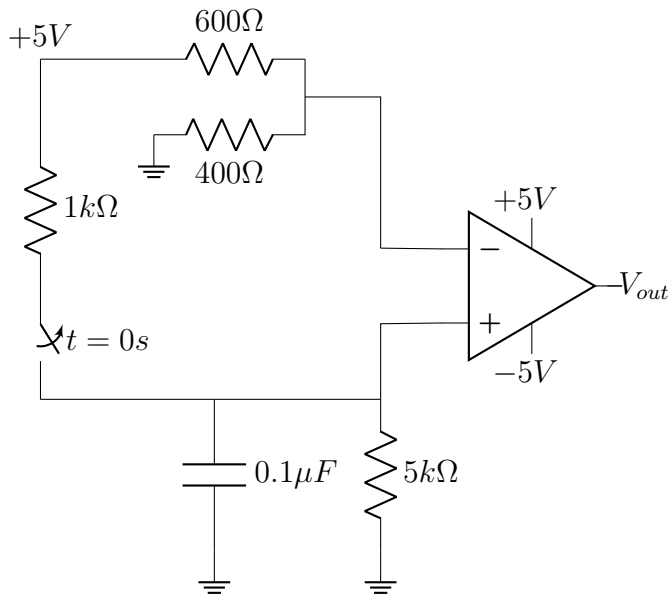


GATE 2022[IN]-64

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:

$$V_c(0^-) = 5 \times \frac{5}{5+1} \quad (1)$$

$$= \frac{25}{6} V \quad (2)$$

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

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

$$V_I = 5 \times \frac{600}{600+400} \quad (3)$$

$$= 2V \quad (4)$$

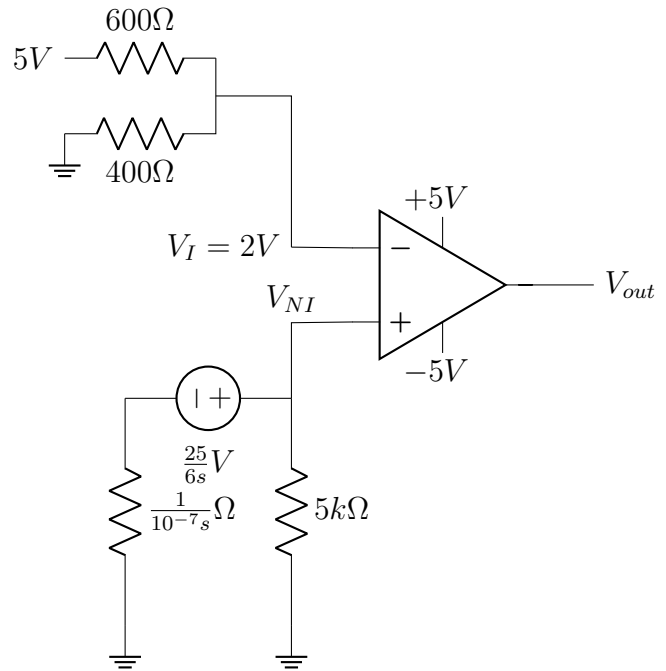


Fig. 1. circuit diagram in laplace domain at $t = 0^+$

Analysing the circuit at $t=0^+$ in laplace domain:

Using voltage divider rule,

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

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

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

Applying inverse laplace:

$$V_{NI}(t) = \frac{25}{6} e^{\frac{-t}{RC}} \quad (8)$$

$$\Rightarrow V_I = V_{NI}(t) \quad (9)$$

$$\Rightarrow 2 = \frac{25}{6} \times e^{\frac{-t}{RC}} \quad (10)$$

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

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

$$= 0.367 ms \quad (13)$$