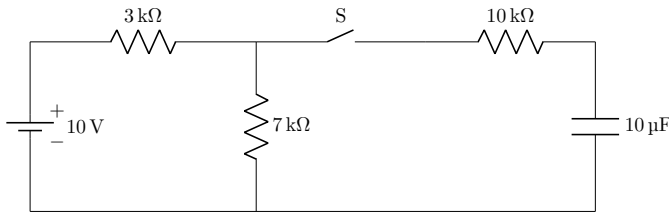


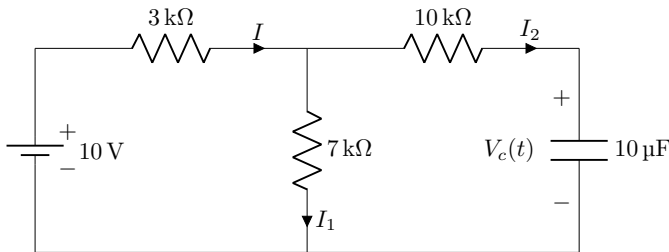
GATE 2023 BM 30

EE23BTECH11007 - Aneesh Kadiyala*

Question: In the following circuit, the switch S is open for $t < 0$ and closed for $t \geq 0$. What is the steady state voltage (in Volts) across the capacitor when the switch is closed?



Solution:



In steady state, no current flows through the capacitor.

$$I_2 = 0 \quad (1)$$

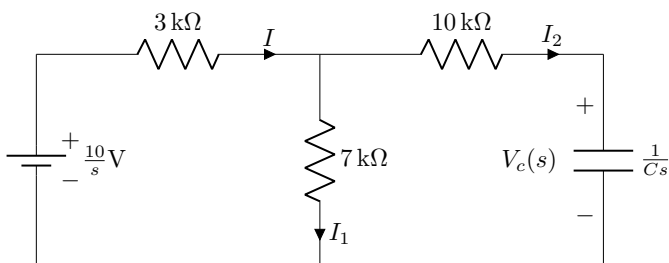
$$V_c = (7k\Omega) I_1 \quad (2)$$

$$= (7k\Omega) I \quad (3)$$

$$= (7k\Omega) \frac{10V}{10k\Omega} \quad (4)$$

$$\Rightarrow V_c = 7V \quad (5)$$

In s-domain:



$$\Rightarrow I(s) = \frac{\frac{10}{s}V}{3k\Omega + \frac{(7k\Omega)(10k\Omega + \frac{1}{sC})}{17k\Omega + \frac{1}{sC}}} \quad (6)$$

$$I = I_1 + I_2 \quad (7)$$

$$I_1 (7k\Omega) = I_2 \left(10k\Omega + \frac{1}{sC} \right) \quad (8)$$

$$I_2(s) = \frac{7k\Omega}{17k\Omega + \frac{1}{sC}} I(s) \quad (9)$$

$$\Rightarrow I_2(s) = \frac{7(10^{-5})}{0.121s + 1} \quad (10)$$

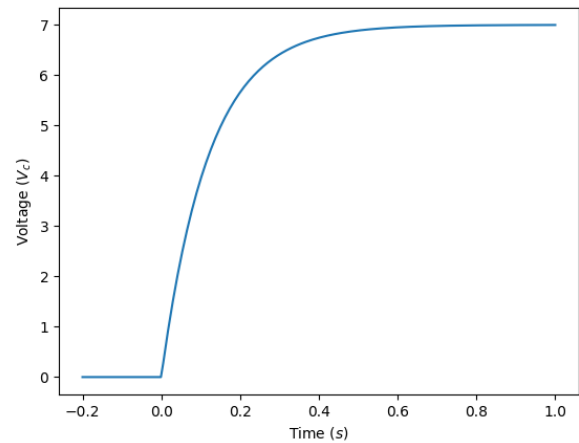
$$V_c(s) = I_2(s) \frac{1}{sC} \quad (11)$$

$$= \frac{7}{s(0.121s + 1)} \quad (12)$$

$$= 7 \left(\frac{1}{s} - \frac{1}{s + \frac{1}{0.121}} \right) \quad (13)$$

Taking inverse Laplace transform:

$$V_c(t) = 7u(t) \left(1 - e^{-\frac{t}{0.121}} \right) \quad (14)$$



In steady state $t \rightarrow \infty$. From (14):

$$\lim_{t \rightarrow \infty} V_c(t) = 7V \quad (15)$$