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Student Group

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Exercise E1 Machine-Vision Strobe Unit: Charging and Safe Discharge of a Flash Capacitor

A. The circuit in the figure is used to charge a capacitor. The capacitor is initially uncharged. The charging current is 1 A. The capacitor is charged to 447.2 V. The capacitor is then discharged through a resistor. What is the capacitor voltage then?

Solution

$$C = 1 \mu\text{F} \quad W_e = 0.1 \text{ J} \quad I_{\text{max}} = 1 \text{ A}$$

$$U_C(t) = U \cdot e^{-t/RC} = 447.2 \cdot e^{-t/4.47 \text{ ms}} \text{ V}$$

What is the energy stored in the capacitor have so that it stores the required energy?

At the beginning of charging, the capacitor behaves like a short circuit, so the maximum current is $I_C = U/R = 447.2 \text{ V} / 10 \text{ M}\Omega = 44.72 \mu\text{A}$.

The engineering practice, a capacitor is considered practically fully charged after about three time constants $T = 3 \cdot RC = 13.41 \text{ ms}$.

So the capacitor is fully charged after about 13.41 ms . The capacitor voltage is $U_C = 447.2 \text{ V}$ and the resistor voltage is $U_R = 447.2 \text{ V}$.

The complete stored energy is converted into heat in the resistor:

$$W_R = \int_0^T U_R \cdot I_C dt = \int_0^T U^2 \cdot e^{-2t/RC} dt = \frac{U^2 \cdot RC}{2} = 316.2 \text{ J}$$

For the discharge through the internal resistance:

$$u_C(t) = U \cdot e^{-t/T_2}$$

with

$$T_2 = R_{\text{ic}} = 10 \text{ M}\Omega \cdot 1 \mu\text{F} = 10 \text{ s}$$

Set $u_C(t) = U'$:

$$U \cdot e^{-t/T_2} = U' \quad t = T_2 \cdot \ln\left(\frac{U}{U'}\right) = 10 \text{ s} \cdot \ln\left(\frac{447.2}{316.2}\right) \approx 3.47 \text{ s}$$

rc circuit, thevenin equivalent, transient response, sensor interface, industrial electronics, chapter1 1

Exercise E2 Sensor Input Buffer: Source, T-Network and Capacitor

A. The circuit in the figure is used to charge a capacitor. The capacitor is initially uncharged. The charging current is 1 A. The capacitor is charged to 12 V. The capacitor is then discharged through a resistor. What is the capacitor voltage then?

Solution

$$U = 12 \text{ V} \quad R_1 = 2 \text{ k}\Omega \quad R_2 = 10 \text{ k}\Omega$$


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\begin{align*} R &= \rho_{\text{Cu}} \frac{I_{\text{Cu}}}{A_{\text{Cu}}} \approx 25 \cdot 10^{-3} \text{ m} \cdot 208.9 \frac{\text{g}}{\text{mol}} \cdot 1.571 \cdot 10^6 \text{ A} \cdot 0.503 \cdot 10^{-6} \text{ m}^2 \\ &= 0.0178 \sim \text{mm}^2 \cdot 0.0556 \sim \Omega \end{align*}

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Thus,

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\begin{align*} R &= \rho_{\text{Cu}} \frac{I_{\text{Cu}}}{A_{\text{Cu}}} \approx 0.0178 \sim \text{mm}^2 \cdot 0.0556 \sim \Omega \\ &= 0.0178 \sim \text{mm}^2 \cdot 0.0556 \sim \Omega \end{align*}

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