dummy

Student Group

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capacitors, rc circuit, transient response, energy storage, industrial safety, chapter1 1

Exercise E1 Machine-Vision Strobe: Capacitor Charging and Safe Discharge

[illegible]

Solution

Data: \begin{align*} C &= 1~{\rm \mu F} \\ W &= 0.1~{\rm J} \\ I_{\rm max} &= 100~{\rm

[illegible]

Assume the DC charging source is adjusted to the required final capacitor voltage.

[illegible]

1. What voltage must be present across the capacitor so that it stores the required energy?

[illegible]

\end{align*} A practical standard value would be about $4.7~{\rm k\Omega}$.

[illegible]

\begin{align*} U_0 &= 447.2~{\rm V} \\ RC &= 4.47~{\rm ms} \end{align*}

\begin{align*} W(t) &= \frac{1}{2} C u_C^2(t) \end{align*}

Initial and final values:

\begin{align*} t_{\rm charge} &\approx 5\tau \approx 5 \cdot 4.47~{\rm ms} \approx 22.4~{\rm ms} \end{align*}

\begin{align*} \tau &= RC \approx 4.47~{\rm ms} \end{align*}

\begin{align*} u_C(0) &= 0, & u_C(\infty) &= U_0 \\ u_R(0) &= U_0, & u_R(\infty) &= 0

\begin{align*} W &= \frac{1}{2} C U^2 \\ U &= \sqrt{\frac{2W}{C}} = \sqrt{\frac{2

[illegible]

447.2~{\rm V} \end{align*}

[illegible]

exponentially.

[illegible]

\end{align*}

\begin{align*} W_0 &= 0.1~{\rm J} \end{align*}

With

After full discharge, the capacitor energy is zero, so the entire initial energy is

converted into heat in the resistor: \begin{align*} R_i C = 10~{\rm M\Omega} \cdot 1~{\rm \mu F} = 10~{\rm s} \end{align*}

\begin{align*} W_R &= W_0 = 0.1~{\rm J} \end{align*}

we get

In a real design, the resistor must therefore be checked for pulse-load capability.

\begin{align*} t &= \frac{10~{\rm s}}{2}\ln(2) \approx 3.47~{\rm s} \end{align*}

The voltage at this instant is

\begin{align*} u_C &= U_0 \cdot \frac{1}{\sqrt{2}} = \frac{447.2~{\rm V}}{\sqrt{2}} \approx 316.2~{\rm V} \end{align*}