

# dummy

## Student Group

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

**A. Problem:** In a machine-vision application, a capacitor is used to store energy for a strobe light. The capacitor is charged to a voltage  $U_0$  and then discharged through a resistor  $R$ . The capacitor is rated for a maximum voltage  $U_{max}$  and a maximum energy  $W_{max}$ . The resistor is rated for a maximum power  $P_{max}$ . The capacitor is charged to a voltage  $U_0$  and then discharged through a resistor  $R$ . The capacitor is rated for a maximum voltage  $U_{max}$  and a maximum energy  $W_{max}$ . The resistor is rated for a maximum power  $P_{max}$ . The capacitor is charged to a voltage  $U_0$  and then discharged through a resistor  $R$ . The capacitor is rated for a maximum voltage  $U_{max}$  and a maximum energy  $W_{max}$ . The resistor is rated for a maximum power  $W_{max}$ .

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Solution
\begin{align*} C &= 1 \sim \{\rm \mu F\} \quad W &= 0.1 \sim \{\rm J\} \quad U_{\max} &= 100 \sim \{\rm V\} \\ \end{align*}
\begin{align*} U_0 &= 447.2 \sim \{\rm V\} \quad RC &= 4.47 \sim \{\rm ms\} \quad \tau &= 4.47 \sim \{\rm ms\} \\ \end{align*}
Assume the capacitor is charged to the rated final capacitor voltage  $U_0 = U_{\max}$ .
\begin{align*} \tau &= RC = 4.47 \sim \{\rm ms\} \quad U_0 &= 447.2 \sim \{\rm V\} \quad W_{\max} &= 0.1 \sim \{\rm J\} \\ \end{align*}
... What if the capacitor is charged to a voltage  $U_0$  and then discharged through a resistor  $R$ ?
\begin{align*} A \text{ practical standard value would be about } &4.7 \sim \{\rm k\Omega\}. \\ \end{align*}
Some capacitor manufacturers specify that a capacitor is fully charged after about
\begin{align*} U_0 &= 447.2 \sim \{\rm V\} \quad RC &= 4.47 \sim \{\rm ms\} \quad \tau &= 4.47 \sim \{\rm ms\} \\ \end{align*}
\begin{align*} W(t) &= \frac{1}{2} C u_C^2(t) \\ \end{align*}
Initial and final values:
\begin{align*} \tau &= RC \approx 4.47 \sim \{\rm ms\} \\ \end{align*}
\begin{align*} W_C(t) &= \frac{1}{2} C (U_0 e^{-t/\tau})^2 = \frac{1}{2} C U_0^2 e^{-2t/\tau} \\ \end{align*}
\begin{align*} W_R(t) &= \frac{1}{2} C U_0^2 (1 - e^{-2t/\tau}) \\ \end{align*}
\begin{align*} W_C(0) &= 0.1 \sim \{\rm J\} \\ \end{align*}
\begin{align*} W_R(0) &= 0 \\ \end{align*}
\begin{align*} W_C(\tau) &= 0.1 \sim \{\rm J\} e^{-2} \approx 0.135 \sim \{\rm J\} \\ \end{align*}
\begin{align*} W_R(\tau) &= 0.1 \sim \{\rm J\} (1 - e^{-2}) \approx 0.065 \sim \{\rm J\} \\ \end{align*}
The capacitor energy decays exponentially with a time constant  $\tau = RC$ .
\begin{align*} \tau &= RC = 4.47 \sim \{\rm ms\} \\ \end{align*}
\begin{align*} W_0 &= 0.1 \sim \{\rm J\} \\ \end{align*}
With
After full discharge, the capacitor energy is zero, so the entire initial energy is
\begin{align*} W_R &= W_0 = 0.1 \sim \{\rm J\} \\ \end{align*}
\begin{align*} W_R &= W_0 = 0.1 \sim \{\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 \sim \{\rm s\}}{\ln(2)} \approx 3.47 \sim \{\rm s\} \\ \end{align*}
The voltage at this instant is
\begin{align*} u_C &= U_0 \cdot \frac{1}{\sqrt{2}} = \frac{447.2 \sim \{\rm V\}}{\sqrt{2}} \approx 316.2 \sim \{\rm V\} \\ \end{align*}

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