

dummy

Student Group

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

A. Problem: In a machine-vision system, 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 P_{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 &= RC \\ \end{align*}
Assume the capacitor is charged to the rated final capacitor voltage  $U_0$ .
\begin{align*} \tau &= RC = 4.47 \sim \{\rm ms\} \quad U_0 &= 447.2 \sim \{\rm V\} \quad U_{\max} &= 100 \sim \{\rm V\} \\ \end{align*}
... What if the capacitor is charged to the rated final capacitor 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 a capacitor that is fully charged after about
\begin{align*} U_0 &= 447.2 \sim \{\rm V\} \quad RC &= 4.47 \sim \{\rm ms\} \quad \tau &= RC \\ \end{align*}
\begin{align*} W(t) &= \frac{1}{2} C u_C^2(t) \quad \end{align*}
Initial and final values: charge  $Q_0$  and  $Q_{\infty}$ 
\begin{align*} \tau &= RC \approx 4.47 \sim \{\rm ms\} \quad \tau &= RC \approx 4.47 \sim \{\rm ms\} \quad \tau &= RC \approx 4.47 \sim \{\rm ms\} \\ \end{align*}
\begin{align*} W_C(t) &= \frac{1}{2} C (U_0 e^{-t/RC})^2 \quad U_0 = \sqrt{2W_C / C} \quad W_C = \frac{1}{2} C U_0^2 e^{-2t/RC} \\ \end{align*}
The capacitor energy  $W_C(t)$  decays exponentially with a time constant  $\tau = RC$ .
\begin{align*} \tau &= RC \approx 4.47 \sim \{\rm ms\} \quad \tau &= RC \approx 4.47 \sim \{\rm ms\} \quad \tau &= RC \approx 4.47 \sim \{\rm ms\} \\ \end{align*}
The energy stored in the capacitor is  $W_C(t) = \frac{1}{2} C U_0^2 e^{-2t/RC}$ .
\begin{align*} W_0 &= 0.1 \sim \{\rm J\} \quad \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*} W_R &= W_0 = 0.1 \sim \{\rm J\} \quad \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\} \quad \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\} \quad \end{align*}

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