dummy

Student Group

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

... energy remains in the capacitor ... and what is the capacitor voltage then?

Result

Solution

Solution

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

Solution

\begin{align*} ... \end{align*}

&= 447.2e^{-t/4.47{\rm ms}}~{\rm V} \end{align*}

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

The capacitor voltage rises exponentially:

At $t=0$, the capacitor is uncharged, therefore the maximum charging current is

\begin{align*} T = RC = 447.2~{\rm \Omega}\cdot 10~{\rm \mu F} = 4.47~{\rm ms}

Using the same resistor, the discharge time is again approximately

Solution

\begin{align*} i_{C,\max} = i_C(t=0) = \frac{U}{R} \end{align*}

The resistor voltage falls exponentially:

\begin{align*} t_{\rm discharge} \approx 5T = 22.35~{\rm ms} \end{align*}

Thus,

A practical engineering approximation is that the capacitor is essentially charged after

\begin{align*} u_R(t) = Ue^{-t/T} \end{align*}

The stored energy is proportional to U^2: dissipated as heat in the resistor:

\begin{align*} R &\ge \frac{U}{I_{\rm max}} = \frac{447.2~{\rm V}}{0.1~{\rm A}}

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

with

\sqrt{\frac{2\cdot 0.1~{\rm J}}{1\cdot 10^{-6}~{\rm F}}} \\ &= 447.2~{\rm V}

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

\end{align*}

\begin{align*} T = RC = 4.47~{\rm ms} \end{align*}

For discharge:

Thus, u_C starts at $0~\rm V$ and approaches $447.2~\rm V$, while u_R starts at $447.2~\rm V$ and falls to $0~\rm V$.

\begin{align*} u_C(t) = U e^{-t/T_2} \end{align*}

with

\begin{align*} T_2 = R_iC = 10~{\rm M\Omega}\cdot 1~{\rm \mu F} = 10~{\rm s} \end{align*}

Set $u_C(t)=U'$:

\begin{align*} Ue^{-t/T_2} &= U' \\ t &= T_2 \ln\left(\frac{U}{U'}\right) \\ &= 10~{\rm s}\cdot \ln\left(\frac{447.2}{316.2}\right) \\ &= 3.47~{\rm s} \end{align*}

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

Exercise E2 Industrial Sensor Interface: Source, T-Network and Capacitor

... capacitor is connected. ... the stationary capacitor voltage? At first, the load is disconnected. After the capacitor has been charged, a load resistor is connected by a switch.

Result

Solution

Solution

Data: \begin{align*} U &= 12~{\rm V} \\ R_1 &= 2~{\rm k\Omega} \\ R_2 &= 10~{\rm k\Omega} ...

\end{align*}

At the capacitor, the stationary capacitor voltage is $u_C(\infty)=10~\rm V$. Immediately after initially the capacitor is uncharged and the switch is open.

Now use the equivalent source. With the load resistor connected, the new stationary voltage is

\begin{align*} u_C(t) = U_{\rm eq}\left(1-e^{-t/T}\right) ... \end{align*} k\Omega}} \\ &= 3.33~{\rm k\Omega} \end{align*}

The final value is

Solution

Thus,

ms} \end{align*}

Therefore, the capacitor voltage decays exponentially:

Practical settling time:

With the switch open, use the equivalent source voltage:

\begin{align*} u_C(t) &= U_{0e}' + \left(U_{0e}-U_{0e}'\right)e^{-t/T'} \\ &= 5 +

k\Omega}}{2~{\rm k\Omega}+10~{\rm k\Omega}}\cdot 12~{\rm V} = 10~{\rm V}

\begin{align*} t_{\rm charge} \approx 5T = 50~{\rm ms} \end{align*}

inductors, air core coil, magnetic field, sensor calibration, transient response, current density, chapter1 1

Exercise E3 Hall-Sensor Test Bench: Air-Core Calibration Coil

no remanence occurs.

Solution

Data: \begin{align*} l &= 22~{\rm mm} \\ d &= 20~{\rm mm} \\ d_{\rm Cu} &= 0.8~{\rm

The coil is then connected to a DC source.

1. Calculate the coil resistance R at room temperature.

The current density is

\begin{align*} S &= \frac{I}{A_{\rm Cu}} = \frac{1~{\rm A}}{0.503~{\rm mm^2}}

&= 25^2 \cdot \frac{4\pi\cdot 10^{-7}~{\rm Vs/(Am)} \cdot 3.1416\cdot

\frac{1}{1+\frac{20}{2\cdot 22}} \\ &= 7.71\cdot 10^{-6}~{\rm H} \end{align*}

mm})^2 \\ &= 0.503~{\rm mm^2} \end{align*}

The total wire length is approximately

27.05\cdot 10^{-6}~{\rm J} \end{align*}

Now the resistance is

$$\begin{align*} R &= \rho_{\rm Cu}\frac{l_{\rm Cu}}{A_{\rm Cu}} \\ &= 0.0178~{\rm \Omega\,mm^2/m}\cdot \frac{1.571~{\rm m}}{0.503~{\rm mm^2}} \\ &= 0.0556~{\rm \Omega} \end{align*}$$