dummy

Student Group

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

Result

... energy is to be dissipated in the resistor?

... capacitor voltage then?

Solution

Solution

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

Solution

$$u_R(t) = 447.2e^{-t/4.47{\rm ms}}~{\rm V}$$

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

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

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

The resistor voltage falls exponentially:

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

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

Thus,

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

... dissipated as heat in the resistor:

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

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

with

$$316.2~{\rm V}$$

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

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

Result

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

Solution

Solution

Data: $$\begin{align*} U &= 12~{\rm V} \\ R_1 &= 2~{\rm k\Omega} \\ R_2 &= 10~{\rm k\Omega} \\ R_3 &= ... \end{align*}$$

... immediately after

... With the load resistor connected, the new stationary voltage is

Initially the capacitor is uncharged and the switch is open.

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 + (10-5)e^{-t/5~{\rm ms}} \end{align*}

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

\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 mm} \end{align*}

The coil is then connected to a DC source.

1. Calculate the coil resistance R at room temperature.

The current density is

\begin{align*} j &= \frac{I}{A_{\rm Cu}} = \frac{1~{\rm A}}{0.503~{\rm mm^2}} \\ &= 1.99~{\rm A/mm^2} \end{align*}

&= 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*}

\begin{align*} A_{\rm Cu} &= \pi\left(\frac{d_{\rm Cu}}{2}\right)^2 = \pi(0.4~{\rm mm})^2 \\ &= 0.503~{\rm mm^2} \end{align*}

The total wire length is approximately

\begin{align*} l_{\rm Cu} &= N\pi d = 25\pi\cdot 20~{\rm mm} \\ &= 1570.8~{\rm mm} = 1.571~{\rm m} \end{align*}

\begin{align*} W_R &\approx R I^2 \cdot\frac{7}{2}T \\ &= 0.0556~{\rm \Omega}\cdot (1~{\rm A})^2 \cdot\frac{7}{2}\cdot 138.7~{\rm \mu s} \\ &= 27.05\cdot 10^{-6}~{\rm J} \end{align*}

Now the resistance is

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