task_f64r8g2jf4pdomfi_with_calculation

Student Group

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Exercise E1 Conversion: Energy, Power and Area

[illegible] ${{16~{\rm kWh}}\over{100~{\rm km}}}$ [illegible] and an usable battery capacity of $60~{\rm kWh}$. Solar panels produces per $1~\rm m^2$ in average in December $0.2~{{{\rm kWh}}\over{{\rm m^{2}}}}$. The car is driven $50~{\rm km}$ per day. The size of a distinct solar module with $460~{\rm W_p}$ (Watt peak) is $1.9~{\rm m} \times 1.1~{\rm m}$.

Result

Solution

Solution

[illegible]

1. What is the average power consumption of the car per day?

$$A_{\rm panel} = 1.9~{\rm m} \cdot 1.1~{\rm m} = 2.1~{\rm m^2}$$

[illegible] $= 19.04~{\rm panels} \rightarrow 20~{\rm panels}$

Solution

$$\begin{align*} {{W}\over{l}} &= {{16~{\rm kWh}}\over{100~{\rm km}}} = 0.16 {{~{\rm kWh}}\over{~{\rm km}}} \\ W &= 50~{\rm km} \cdot 0.16 {{~{\rm kWh}}\over{~{\rm km}}} = 8~{\rm kWh} \end{align*}$$

Exercise E2 Industrial Sensor Interface: Buffered Measurement Node

[illegible] network. The capacitor in the output node is used to smooth the signal and to provide a stable voltage for a short measurement cycle. At first, the measurement electronics are disconnected. Once the capacitor is fully charged, a switch closes and the measurement load is connected.

Result

Solution

Solution

Data:

$$\begin{align*} U &= 12~{\rm V} \\ R_1 &= 2~{\rm k\Omega} \\ R_2 &= 10~{\rm k\Omega} \\ R_3 &= 3.33~{\rm k\Omega} \\ C &= 2~{\rm \mu F} \\ R_L &= 5~{\rm k\Omega} \end{align*}$$

Initially, the capacitor is uncharged and the switch S is open.

[illegible] Thevenin equivalent of the left-hand network as seen from the capacitor/load node:

$$\begin{align*} U_{\rm th} &= 10~{\rm V} \\ R_{\rm th} &= 5.00~{\rm k\Omega} \end{align*}$$

1. What is the voltage across the capacitor after it is fully charged?

$$R_1 \parallel R_2 = \frac{R_1 R_2}{R_1 + R_2} = \frac{2~{\rm k\Omega} \cdot 10~{\rm k\Omega}}{2~{\rm k\Omega} + 10~{\rm k\Omega}}$$

Solution

the time-dependent capacitor voltage is

Thus, the Thevenin resistance is

Thus, the transient load voltage is

$$u_C(t) = 10\left(1 - e^{-t/(10~{\rm ms})}\right)~{\rm V}$$

It starts at $0~{\rm V}$ and rises exponentially toward $10~{\rm V}$.

[illegible] No current flows through R_3 once the capacitor is fully charged. Therefore, there is no voltage drop across R_3, and the capacitor voltage is equal to the divider voltage of R_1 and R_2:

The charging time constant is

So the load voltage starts at $10~{\rm V}$ and decays exponentially to $5~{\rm V}$.

$$\begin{align*} \tau_1 &= R_{\rm th} C \\ &= 5.00~{\rm k\Omega} \cdot 2~{\rm \mu F} \\ &= 10~{\rm ms} \end{align*}$$

$$\begin{align*} U_C(\infty) &= U \cdot \frac{R_2}{R_1 + R_2} \\ &= 12~{\rm V} \cdot \frac{10~{\rm k\Omega}}{2~{\rm k\Omega} + 10~{\rm k\Omega}} \\ &= 12~{\rm V} \cdot \frac{10}{12} \\ &= 10~{\rm V} \end{align*}$$

In practice, the capacitor is considered fully charged after about $5\tau_1$:

\begin{align*} t_{\rm charge} &\approx 5\tau_1 = 5 \cdot 10~{\rm ms} = 50~{\rm ms} \end{align*}

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

[illegible] air-core design is chosen because it avoids hysteresis and remanence effects of iron cores. The coil is wound as a short, single-layer cylindrical coil.

Solution

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

[illegible] from $0~\rm A$ to $1~\rm A$.

[illegible] ntly. Therefore:

[illegible]

[illegible] entered in inches.

[illegible] to the finally

A useful engineering rule is: after about 5τ, the current has reached more than [illegible]

\begin{align*} i(t) &= \left(1-e^{-t/\tau}\right) \end{align*}

[illegible] &= \frac{1}{2}\cdot 7.94\cdot [illegible]

with the time constant

[illegible]

\begin{align*} \tau = \frac{L}{R} \end{align*}

[illegible] &\approx 1.99~{\rm A/mm^2} \end{align*}

Mathematically, the exact final value is reached only after infinite time.

So the sketch starts at $0~\rm A$, rises steeply at first, and then approaches $1~\rm A$ asymptotically.

First, determine the copper cross-sectional area:

\begin{align*} A_{\rm Cu} &= \frac{\pi}{4} d_{\rm Cu}^2 = \frac{\pi}{4}(0.8~{\rm mm})^2 \\ &= 0.503~{\rm mm^2} \end{align*}

The mean length of one turn is approximately the circumference:

\begin{align*} l_{\rm turn} &\approx \pi d = \pi \cdot 20~{\rm mm} = 62.83~{\rm mm} \end{align*}

Thus, the total wire length is

\begin{align*} l_{\rm Cu} &= N \cdot l_{\rm turn} = 25 \cdot 62.83~{\rm mm} \\ &= 1570.8~{\rm mm} = 1.571~{\rm m} \end{align*}

Now calculate the resistance:

\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}} \\ &\approx 0.0556~{\rm \Omega} \end{align*}