

task_f64r8g2jf4pdomfi_with_calculation

Student Group

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Exercise E1 Conversion: Energy, Power and Area

2. What is the average power consumption of the car per day? (16 kWh) Average 160~{\rm W} per day 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}/{\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}.

$$A = \frac{16 \text{ kWh} \cdot 1000 \text{ Wh/kWh}}{460 \text{ W} \cdot 24 \text{ h}} \approx 14.3 \text{ panels}$$

.. What is the average power consumption of the car per day?
 P_car = 20 panel * 19.04 (W/panel) = 380.8 W (or 0.38 kW)
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 solution{2}} over 24 (h) panel} = 19.04 (W panel) rightarrow 20 (panels) end{align*}

$$\frac{W}{l} = \frac{16 \text{ kWh}}{100 \text{ km}} = 0.16 \frac{\text{kWh}}{\text{km}}$$

$$W = 50 \text{ km} \cdot 0.16 \frac{\text{kWh}}{\text{km}} = 8 \text{ kWh}$$

Exercise E2 Industrial Sensor Interface: Buffered Measurement Node

1. Draw the circuit diagram of the buffered measurement node. The load resistor is connected to the capacitor at the output node 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.

U_0 = 12 V, R_1 = 2 kOhm, R_2 = 10 kOhm, R_3 = 50 Ohm, C = 100 nF
 U = 12 V, R_1 = 2 kOhm, R_2 = 10 kOhm, R_3 = 50 Ohm, C = 100 nF
 The circuit is equivalent of the left-hand network as seen from the capacitor/load resistor.
 Initially, the capacitor is disconnected and the switch is open.

When the switch is closed, the capacitor is fully charged. U_th = 10 V, R_th = 50 Ohm
 .. What is the voltage across the capacitor after it is fully charged?
 U_c(t) = U_0 * (1 - exp(-t/tau)) + U_c(0) * exp(-t/tau)
 U_c(0) = 12 V, U_0 = 10 V, tau = 10 kOhm * 100 nF = 1 ms
 U_c(5 ms) = 10 V * (1 - exp(-5)) + 12 V * exp(-5) = 10 V * (1 - 0.0067) + 12 V * 0.0067 = 10.08 V

Thus, the transient load voltage is
 U_L(t) = U_c(t) * (R_3 / (R_2 + R_3)) = 10 V * (50 / (10000 + 50)) = 0.5 V
 U_L(5 ms) = 0.5 V * (1 - exp(-5)) + 12 V * exp(-5) * (50 / 10050) = 0.5 V * (1 - 0.0067) + 12 V * 0.0067 * 0.004975 = 0.5 V * 0.9933 + 0.0378 = 0.5 V

The charging time constant is: tau = R_1 * C = 2 ms
 So the load voltage starts at 10 V and decays exponentially to 5 V.
 U_L(t) = U_0 * (1 - exp(-t/tau)) + U_L(0) * exp(-t/tau)
 U_L(0) = 12 V, U_0 = 10 V, tau = 2 ms
 U_L(5 ms) = 10 V * (1 - exp(-2.5)) + 12 V * exp(-2.5) = 10 V * (1 - 0.082) + 12 V * 0.082 = 10 V * 0.918 + 0.984 = 10.164 V

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\begin{align*} t_{\text{charge}} \approx 5 \tau_1 = 5 \cdot 10^{-3} \text{ ms} = 50 \text{ ms} \end{align*}
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Exercise E3 Hall-Sensor Test Bench: Air-Core Calibration Coil

5. The coil is wound on a cylindrical core with diameter $d = 20 \text{ mm}$ and length $l = 22 \text{ mm}$. The coil is wound with a copper wire with diameter $d_{\text{Cu}} = 0.8 \text{ mm}$. The current i is increased from 0 A to 1 A in a time $t = 5 \text{ ms}$. The coil is wound as a short, single-layer cylindrical coil. The coil is wound on a cylindrical core with diameter $d = 20 \text{ mm}$ and length $l = 22 \text{ mm}$. The coil is wound with a copper wire with diameter $d_{\text{Cu}} = 0.8 \text{ mm}$. The current i is increased from 0 A to 1 A in a time $t = 5 \text{ ms}$. The coil is wound as a short, single-layer cylindrical coil.

Solution
 The coil is wound on a cylindrical core with diameter $d = 20 \text{ mm}$ and length $l = 22 \text{ mm}$. The coil is wound with a copper wire with diameter $d_{\text{Cu}} = 0.8 \text{ mm}$. The current i is increased from 0 A to 1 A in a time $t = 5 \text{ ms}$. The coil is wound as a short, single-layer cylindrical coil.

First, determine the copper cross-sectional area:

$$A_{\text{Cu}} = \frac{\pi}{4} d_{\text{Cu}}^2 = \frac{\pi}{4} (0.8 \text{ mm})^2 \approx 0.503 \text{ mm}^2$$
 The mean length of one turn is approximately the circumference:

$$l_{\text{turn}} \approx \pi d = \pi \cdot 20 \text{ mm} = 62.83 \text{ mm}$$
 Thus, the total wire length is

$$l_{\text{Cu}} = N \cdot l_{\text{turn}} = 25 \cdot 62.83 \text{ mm} \approx 1570.8 \text{ mm} = 1.571 \text{ m}$$
 Now calculate the resistance:

$$R = \rho_{\text{Cu}} \frac{l_{\text{Cu}}}{A_{\text{Cu}}} = 0.0178 \text{ mm}^2/\text{m} \cdot \frac{1.571 \text{ m}}{0.503 \text{ mm}^2} \approx 0.0556 \text{ } \Omega$$

Mathematically, the exact final value is reached only after infinite time. So the sketch starts at 0 A , rises steeply at first, and then approaches 1 A asymptotically.

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