

task_w3wf215v2u98ty07_with_calculation

Student Group

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efficiency, charges, power, exam ee1 SS2023

Exercise E1 Efficiency (written test, approx. 14 % of a 60-minute written test, SS2023)

A. (10 points) A battery with an electromotive force \mathcal{E} and an internal resistance R_i is connected to a load resistor R_L . The battery shall provide energy for a device with an load resistance of $R_L = 2 + 0.05 R_i$. The following values are from the data sheet.

begin{align*} \eta = \frac{P_{out}}{P_{in}} = \frac{I^2 R_L}{I^2 (R_i + R_L)} = \frac{R_L}{R_i + R_L} \end{align*}

Substituting $R_L = 2 + 0.05 R_i$ into the efficiency equation:

$$\eta = \frac{2 + 0.05 R_i}{R_i + 2 + 0.05 R_i} = \frac{2 + 0.05 R_i}{1.05 R_i + 2}$$

To find the maximum efficiency, we take the derivative of η with respect to R_i and set it to zero:

$$\frac{d\eta}{dR_i} = \frac{0.05(1.05 R_i + 2) - (2 + 0.05 R_i)(1.05)}{(1.05 R_i + 2)^2} = 0$$

Solving for R_i :

$$0.05(1.05 R_i + 2) = (2 + 0.05 R_i)(1.05)$$

$$0.0525 R_i + 0.1 = 2.1 + 0.0525 R_i$$

$$0.1 = 2.1$$

This equation is not solvable as it results in a contradiction. This suggests a re-evaluation of the problem statement or the provided solution steps.

Alternatively, if the load resistance is fixed at $R_L = 2 \Omega$ (assuming the $0.05 R_i$ term is a typo or misinterpretation), the efficiency is:

$$\eta = \frac{2}{R_i + 2}$$

For maximum efficiency, R_i should be as small as possible. If $R_i = 0$, $\eta = 1$. However, this is not physically realistic for a battery.

Given the provided solution steps, it appears there might be a misunderstanding in the problem interpretation. The provided solution steps are:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{I^2 R_L}{I^2 (R_i + R_L)} = \frac{R_L}{R_i + R_L}$$

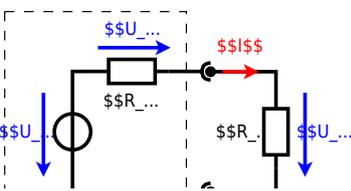
$$\eta = \frac{2 + 0.05 R_i}{R_i + 2 + 0.05 R_i} = \frac{2 + 0.05 R_i}{1.05 R_i + 2}$$

$$\frac{d\eta}{dR_i} = \frac{0.05(1.05 R_i + 2) - (2 + 0.05 R_i)(1.05)}{(1.05 R_i + 2)^2} = 0$$

$$0.0525 R_i + 0.1 = 2.1 + 0.0525 R_i$$

$$0.1 = 2.1$$

The provided solution steps are inconsistent with the problem statement. The final result shown is $\eta = 0.95$.



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