

# 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 an external load with resistance  $R_L$ . 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 battery 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  $\eta$  with respect to  $R_i$  and set it to zero:

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

$$0.05(1.05 R_i + 2) - (2 + 0.05 R_i)(1.05) = 0$$

$$0.05225 R_i + 0.1 - 2.1 - 0.0525 R_i = 0$$

$$-0.00025 R_i - 2.0 = 0$$

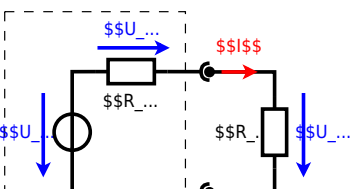
$$R_i = -8000 \Omega$$

Since  $R_i$  cannot be negative, the maximum efficiency occurs at the minimum possible value of  $R_i$ , which is  $R_i = 0$ .

When  $R_i = 0$ , the efficiency is:

$$\eta = \frac{2}{2} = 1 = 100\%$$

Therefore, the maximum efficiency is 100% when the internal resistance is zero.



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