

task_y7dozgdsljqvnqge_with_calculation

Student Group

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electrostatic, capacitor, plate capacitor, capacity, exam ee2 SS2022

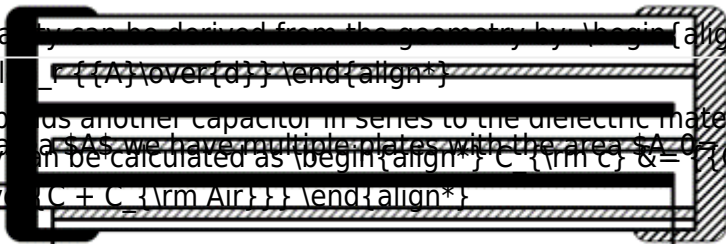
Exercise E5 Capacitor
(written test, approx. 7 % of a 120-minute written test, SS2022)

Calculate the capacitance of the capacitor shown in the picture. The dielectric constant of the dielectric material is $\epsilon_r = 3$ and the thickness of the dielectric material is $d = 1.0 \text{ mm}$. The length of the capacitor is $l = 1.5 \text{ cm}$ and the width of the capacitor is $w = 0.7 \text{ cm}$. The distance between the plates is $d = 1.0 \text{ mm}$.

- Depth of component: $w = 0.7 \text{ mm}$
- Number of layers (as shown in the picture): 3 left-side and 3 right-side layers.

The capacity can be derived from the geometry by:
$$C = \epsilon_0 \epsilon_r \frac{A}{d}$$

The air is another capacitor in series to the dielectric material. Therefore, the capacity can be calculated as
$$\frac{1}{C_{\text{total}}} = \frac{1}{C_{\text{dielectric}}} + \frac{1}{C_{\text{air}}}$$



The capacity of air is
$$C_{\text{air}} = \epsilon_0 \epsilon_{\text{air}} \frac{N \cdot l \cdot w}{d}$$

The material shall have a dielectric permittivity of $\epsilon_r = 3$.

The following calculation shall ignore boundary effects on the end of the layers.

$$\frac{1}{C_{\text{total}}} = \frac{1}{\epsilon_0 \epsilon_r \frac{3 \cdot l \cdot w}{d}} + \frac{1}{\epsilon_0 \frac{3 \cdot l \cdot w}{d}}$$

For this, we have to count facing areas A_0 . There are $N=5$.

.. What is the field strength in the dielectric material between the layer, when a voltage of $U=6.3 \text{ V}$ is applied?

The electric field strength E is given by:
$$E = \frac{U}{d} = \frac{6.3 \text{ V}}{1 \cdot 10^{-6} \text{ m}}$$

Therefore, the formula is
$$C = \frac{\epsilon_0 \epsilon_r \{N \cdot l \cdot w\}}{d} \approx 8.854 \cdot 10^{-12} \frac{\text{As/Vm} \cdot 3 \cdot \{5 \cdot 1.5 \cdot 10^{-3} \text{ m} \cdot 0.7 \cdot 10^{-3} \text{ m}\}}{1 \cdot 10^{-6} \text{ m}}$$

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