Answer on Question 73805, Physics, Electric Circuits

Question:

A parallel plate capacitor is made of two rectangular aluminum sheets of lateral dimensions $500\,mm$ and $20\,mm$. The space between the plates is filled with polystyrene and the separation between plates is $0.15\,mm$. Calculate the capacitance of the capacitor and the value of the maximum potential difference that can be applied across the capacitor without dielectric breakdown. Take the dielectric constant of polystyrene as 2.6 and the value of the maximum electric field that polystyrene can withstand as $25 \cdot 10^6\ V/m$.

Solution:

a) The capacitance of the parallel plate capacitor filled with dielectric between its plates can be calculated from the formula:

$$C = \kappa\varepsilon_0 \frac{A}{d},$$

here, κ is the dielectric constant of polystyrene, ε_0 is the permittivity of free space, A is the area of overlap of the rectangular aluminum sheets, d is the plate separation.

Then, we get:

$$C = 2.6 \cdot 8.854 \cdot 10^{-12}\ \frac{F}{m} \cdot \frac{500 \cdot 10^{-3}\ m \cdot 20 \cdot 10^{-3}\ m}{0.15 \cdot 10^{-3}\ m} = 1.53 \cdot 10^{-9}\ F.$$

b) We can find the value of the maximum potential difference that can be applied across the capacitor without dielectric breakdown from the formula:

$$V_{max} = Ed,$$

here, V_{max} is the maximum potential difference that can be applied across the capacitor without dielectric breakdown, E is the maximum electric field that polystyrene can withstand, d is the plate separation. Then, we get:

$$V_{max} = Ed = 25 \cdot 10^6\ \frac{V}{m} \cdot 0.15 \cdot 10^{-3}\ m = 3750\,V.$$

Answer:

a) $C = 1.53 \cdot 10^{-9}\ F.$

b) $V_{max} = 3750\,V.$