

4.53 Dielectric breakdown occurs in a material whenever the magnitude of the field \mathbf{E} exceeds the dielectric strength anywhere in that material. In the coaxial capacitor of Example 4-12,

- (a) At what value of r is $|E|$ maximum?
- (b) What is the breakdown voltage if $a = 1$ cm, $b = 2$ cm, and the dielectric material is mica with $\epsilon_r = 6$?

Solution:

(a) From Eq. (4.114), $\mathbf{E} = -\hat{\mathbf{r}}\rho_l/2\pi\epsilon r$ for $a < r < b$. Thus, it is evident that $|\mathbf{E}|$ is maximum at $r = a$.

(b) The dielectric breaks down when $|\mathbf{E}| > 200$ (MV/m) (see Table 4-2), or

$$|\mathbf{E}| = \frac{\rho_l}{2\pi\epsilon r} = \frac{\rho_l}{2\pi(6\epsilon_0)(10^{-2})} = 200 \quad (\text{MV/m}),$$

which gives $\rho_l = (200 \text{ MV/m})(2\pi)6(8.854 \times 10^{-12})(0.01) = 667.6 \text{ } (\mu\text{C/m})$.

From Eq. (4.115), we can find the voltage corresponding to that charge density,

$$V = \frac{\rho_l}{2\pi\epsilon} \ln\left(\frac{b}{a}\right) = \frac{(667.6 \mu\text{C/m})}{12\pi(8.854 \times 10^{-12} \text{ F/m})} \ln(2) = 1.39 \quad (\text{MV}).$$

Thus, $V = 1.39$ (MV) is the breakdown voltage for this capacitor.
