

Answer on Question #79549, Physics / Electric Circuits

Question. State and explain the boundary condition for the displacement vector \vec{D} at the boundary separating two dielectric media.

Answer. In a dielectric material, the presence of an electric field \vec{E} causes the bound charges in the material (atomic nuclei and their electrons) to slightly separate, inducing a local electric dipole moment. The electric displacement field \vec{D} is defined as

$$\vec{D} = \epsilon_0 \vec{E} + \vec{P} = \epsilon \epsilon_0 \vec{E}$$

where: ϵ_0 is the vacuum permittivity (also called permittivity of free space), and \vec{P} is the (macroscopic) density of the permanent and induced electric dipole moments in the material, called the polarization density.

The displacement field satisfies Gauss's law in a dielectric:

$$\nabla \cdot \vec{D} = \rho - \rho_b = \rho_f$$

At a boundary,

$$(\vec{D}_1 - \vec{D}_2) \cdot \vec{n} = D_{1n} - D_{2n} = \sigma_f$$

where σ_f is the free charge density on the surface and the unit normal \vec{n} points in the direction from medium 2 to medium 1. If $\sigma_f = 0$ then

$$D_{1n} = D_{2n}.$$

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