Lecture 36, Apr 14, 2023

Maxwell's Contribution – Displacement Current

- Ampere's law breaks down when we consider a simple circuit with a capacitor and a surface through the middle of the capacitor
- A new type of "current" has to be considered – the *displacement current*

Definition

The displacement current is defined as

$$\vec{J}_d = \frac{\partial \vec{D}}{\partial t}$$

with Ampere's law becoming

$$\vec{\nabla} \times \vec{H} = \vec{J} + \vec{J}_d$$

or in the integral form:

$$\oint_C \vec{H} \cdot \mathrm{d}\vec{l} = \iint_S \left(\vec{J} + \frac{\partial \vec{D}}{\partial t} \right) \cdot \mathrm{d}\vec{s} = I_c + I_d$$

- The displacement current was initially an educated guess by Maxwell which was experimentally verified later
- Unlike $\vec{J}$, the displacement current $\vec{J}_d$ is not due to the movement of charges
- This now allows the existence of electromagnetic waves – a change in $\vec{D}$ induces a change in $\vec{H}$ by Ampere's law, and a change in $\vec{H}$ induces a change in $\vec{D}$ by Faraday's law