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EE1101: Circuits and Network Analysis

Lecture 01: Overview

Topics :

1. General Overview - Maxwell's Equations
2. From Physics domain to Circuits domain

General Overview - Maxwell's Equations

Basis for studying electrical systems → Maxwell's Equations

a) describe $\vec{E}$ and $\vec{B}$ fields associated with the system

$\vec{E}$ → elec field intensity

$\vec{B}$ → mag. flux density

Integral form | Differential form

Gauss law: $\oint_S \vec{D}\cdot\vec{ds} = Q_{enc}$; $\underbrace{\nabla\cdot\vec{D}}_{\text{divergence}} = \rho_v$ ← volume charge density

Faraday's law: $\underbrace{\oint_C \vec{E}\cdot\vec{dl}}_{\text{Potential in a closed loop}} = -\frac{d\lambda}{dt}$ ← flux linkage ; $\underbrace{\nabla\times\vec{E}}_{\text{Curl}} = \frac{-d\vec{B}}{dt}$

Gauss law for $\vec{B}$-fields: $\oint_S \vec{B}\cdot\vec{ds} = 0$; $\nabla\cdot\vec{B} = 0$

Ampere - Maxwell Equation: $\oint_C \vec{H}\cdot\vec{dl} = I_{enc} + I_d$ (↑ displacement Current) ; $\nabla\times\vec{H} = \vec{J} + \vec{J}_d$

b) 2 more related fields

$\vec{H}$ → mag. field intensity

$\vec{D}$ → elec. flux density

$\vec{B} = \mu\vec{H}$ and $\vec{D} = \varepsilon\vec{E}$

c) $\vec{J}$ → Current density

In addition to Maxwell's Eqn, we have

Continuity Eqn: $\oint_S \vec{J}\cdot\vec{ds} = -\frac{dQ_{enc}}{dt}$

can be obtained from Ampere-maxwell Eqn.

Analysis vs Design

given an electrical system

Study its prop (or) response to particular set of inputs.

To Analyze: Solve Maxwell's Equations

integral form (used when symmetry is associated)

Differential form

used for numerical solution

Not practical for all scenarios

Develop Simplified Models

- Simple mathematical relationship.
- accurate enough
- easily realizable.

Objective: To design a system that meets the requirements

Maxwell's Equations may not be a nice starting point

one solution (circuit domain approach)

a) design the system based on circuit principles

b) Study its EM properties (EMI/EMC)