MODULE 2.5

2. Review of electromagnetic principles

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Outline of this Chapter

2.1 Maxwell's Equations (MODULE 1)

Faraday's Law, Ampere's Law, Gauss' law, Boundary conditions

2.2. Uniform plane waves (TEM waves) in different media (MODULE 2)

- Wave equations, Intrinsic impedance of the medium
- Lossless Media (Pure dielectric), Lossy Media (finite conductivity)
- Skin depth

2.3. Transmission lines (MODULE 3)

- Travelling waves on transmission lines
- Termination in load, Termination in another line
- Transmission line (TL) impedance in front of a boundary (load)

2.4. Electric and magnetic fields from dipoles (MODULE 4)

- Electric dipole, Magnetic dipole (loop)
- Wave impedance
- Maximum possible radiated field

2.5 Exercises (MODULE 5)

Exercises

1. Determine the speed of propagation, wavelength, phase constant, and intrinsic impedance of a uniform plane wave at 500 MHz in glass-epoxy used to make printed-circuit boards.
2. Determine the skin depth, speed of propagation, wavelength, phase constant, and intrinsic impedance of a metal with following properties at 1 kHz and 1 GHz. a) Copper with conductivity $\sigma = 5.8\text{x}10^7$ S/m, magnetic permeability $\mu = 4\pi\text{x}10^{-7}$ H/m. b) Iron with conductivity $\sigma = 0.58\text{x}10^7$ S/m and relative magnetic permeability 500.
3. Determine the divergence and curl of a magnetic vector field

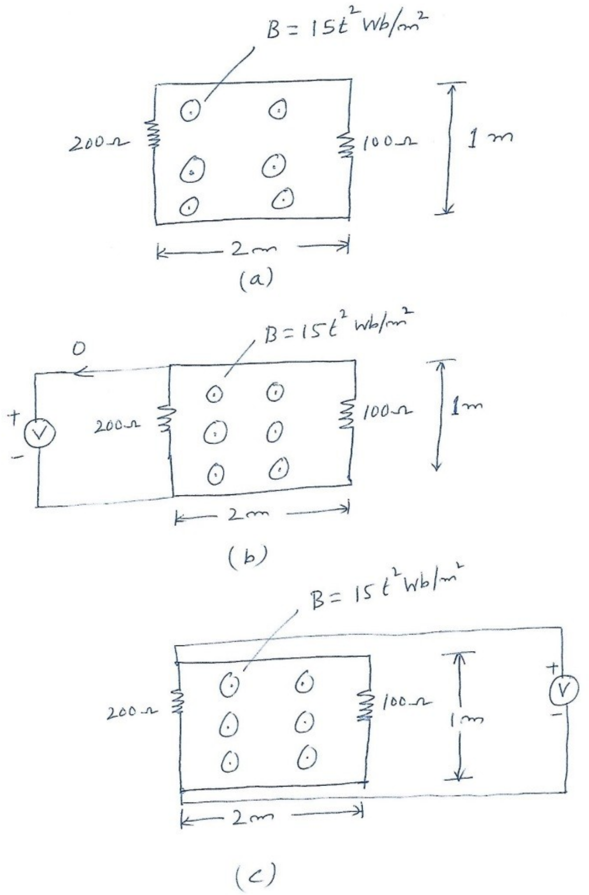
$$\bar{B} = B_{max} \cos x \sin t \; \hat{z}$$

4. A high-impedance voltmeter that draws negligible current is used to measure voltage across a resistor, which is part of a circuit subjected to a magnetic field as shown. Circuit has the physical dimension 2x1 m as shown. It is assumed that magnetic field is confined to the area of the loop formed by the circuit, and no magnetic field is present outside the circuit. Voltmeter is connected always at the same two points across the 200 ohm resistor, but the leads of the voltmeter can be routed differently.

a) Draw the equivalent circuit that can represent the magnetic field interaction and calculate the voltage across the 200 ohm and 100 ohm resistors. (refer Fig a)

b) Refer Fig b and find the voltage that would be measured by the voltmeter.

c) Refer Fig c and notice the new routing of the voltmeter leads. Circuit and voltmeter are in the same plane. Draw the equivalent circuit with voltage sources representing the new situation. Find the voltage meaured by the voltment and compare it to that measured in b). Explain the observation.



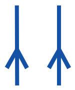
5. Find the reflection coefficient, and transmission coefficient for current, voltage and power for a long transmission line shown with characteristic impedance 100 ohm (A) and 50 ohm (B).

a) Surge travels from A to B

b) Surge travels from B to A

6. Find the maximum possible field at 50 m distance from a pair of electric dipoles with length 0.8 cm and carrying a current of 2 mA (peak) at a frequency of 400 MHz. Separation distance between dipoles 0.5 cm.

a) Two parallel dipoles with currents in phase and same direction.



b) Two parallel dipoles with currents in phase and opposite same direction.