APPLIED ELECTROMAGNETICS FOR ENGINEERS

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PRE-REQUISITES : Electricity and magnetism at the level of high-school, Vector analysis, Differential and integral calculus, programming using Matlab (preferable)

INTENDED AUDIENCE : UG 2nd,3rd Year

INDUSTRIES APPLICABLE TO : Core UG course that is necessary for follow up courses on high speed digital design, RF and microwave, fiber optics, antennas. Companies/Industry such as Sterlite, Analog Devices, GE, Comsol India, Matlab, Texas Instruments, Defense labs etc will be interested

COURSE OUTLINE :

Applied electromagnetics for engineers is designed to be an application oriented course while covering all the theoretical concepts of modern electromagnetics. It begins by an in-depth study of transmission lines which play an important role in high-speed digital design and signal integrity of PCBs. After a brief review of necessary mathematics (coordinate systems, vector analysis, and vector fields), the course covers analytical and numerical solution of Laplace's and Poisson's equations, quasi-static analysis of capacitors and skin effect, inductance calculations, and Maxwell equations. Wave propagation in free-space, ferrites, and peroidic media are covered along with waveguides (rectangular, planar dielectric, and optical fibers) and antennas. The course includes a balance between theory, programming, and applications. Several case studies will be discussed.

ABOUT INSTRUCTOR :

Prof. Pradeep Kumar K. obtained his PhD from IIT Madras specializing in quantum cryptography. He joined the Department of Electrical Engineering at IIT Kanpur in 2009. He is also associated with the Centre for Lasers & Photonics. At IIT Kanpur he and his students work in the fields of quantum key distribution, nonlinear fiber optics for signal processing, mitigation of linear and nonlinear impairments in coherent optical communications, mode locked fiber lasers and chaos, fiber-optic sensors for undersea applications, and fiber-optic modeling. He is also actively involved in the LIGO-India effort under IndiGO umbrella. His lab develops single-photon detectors, single- and subcarrier RF transceivers, and is currently working on true random number generators. He has published over 40 papers in peer reviewed journals and conferences. He also holds three patents (one granted and two pending). His MOOC courses on NPTEL has been very popular with more than 15000 enrollments from across the country.

COURSE PLAN:

Week 1:

- Introduction to Applied EM theory
- Lossless Transmission line equations
- Frequency-domain behavior: Characteristic impedance of T-line
- Reflection and transmission coefficients
- Complete solution for sinusoidal propagation

Week 2:

- More general T-lines
- Attenuation and propagation coefficients
- Transmission line techniques: Standing wave ratio (SWR) and line impedance
- Visual aid: Smith Chart derivation
- Smith chart applications: Impedance to admittance conversion, SWR and impedance calculation

Week 3:

- Impedance matching techniques - Part 1
- Impedance matching techniques - Part 2
- T-lines in time-domain: Reflection from mismatched loads
- Lattice diagram calculations
- Pulse propagation on T-lines

Week 4:

- Case study: High-speed digital signals on PCBs
- Transients with reactive termination
- Application: Time-domain reflectometry
- Review of Coordinate Systems
- Review of Vector analysis -1

Week 5:

- Review of Vector analysis -2
- Vector fields -Part 1
- Vector fields - Part 2
- Overview and importance of Maxwell's equations
- Boundary conditions between two media

Week 6:

- Solution of Laplace's and Poisson's equation -- Analytical techniques
- Solution of Laplace's and Poisson's equation in two dimensions
- Numerical solution of Laplace's equation: Finite difference method
- Numerical technique: Method of moments
- Quasi-statics: Does an ideal capacitor exist?

Week 7:

- Magnetostatic fields: Biot Savart and Ampere's laws
- Magnetic field calculations
- Inductance and inductance calculation
- Quasi-statics: Fields of a wire
- Quasi-static analysis of skin effect

Week 8:

- Uniform plane waves - one dimensional wave equation
- Uniform plane waves: propagation in arbitrary direction, phase velocity, polarization
- Plane waves in conductors an dielectric media
- Reflection and transmission of plane waves at a planar interface
- Oblique incidence and reflection of plane waves - s and p polarization

Week 9:

- Total internal reflection and Snell's laws
- Application: Multilayer thin films
- Application: Fabry-Perot cavity
- Waveguides - General introduction
- Rectangular metallic waveguide modes

Week 10:

- Dispersion and attenuation
- Dielectric planar waveguides
- Case study: Optical fibers
- Application: Fiber-optic communications
- WDM optical components

Week 11:

- Wave propagation in crystals and index ellipsoid
- Wave propagation in Ferrites
- Wave propagation in periodic structures: Diffraction
- Vector potential and wave equation
- Radiation by dipole

Week 12:

- Fundamental Antenna parameters
- Half-wave dipole
- Antenna array and diffraction
- Application: RFID
- Looking ahead