TRANSMISSION LINES AND ELECTROMAGNETIC WAVES

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INTENDED AUDIENCE : M.Tech. 1st years and B.Tech. 3rd or 4th years
INDUSTRIES APPLICABLE TO : BEL, ISRO, Comsol, HFSS

COURSE OUTLINE :
Bridge course to practical aspects of engineering electromagnetics for entering Graduate students and senior undergraduate students. The course will involve hands on programming to visualize most aspects of electromagnetics and transmission lines.

ABOUT INSTRUCTOR :
Prof. Ananth Krishnan is a faculty member at the Department of Electrical Engineering in IIT-Madras. His specialization is Photonics and specifically Plasmonics.

COURSE PLAN :

Week 1**:** Transmission Lines-Circuit model of a lossless transmission line
- a) Introducing space coordinate in circuit diagram
- b) The notion of delay in a lossless interconnect
- c) LC ladder equivalent
- d) The spatial derivative in equations for V and I
- e) Telegraphers equations
- f) Decoupling to wave equation
- g) Meaning of the analytical solution to wave equation - The existence of voltage and current waves

Week 2 : Programmatic approach to solving partial differential equations - Finite differences
- a) Taylor's series approximation to first and second derivatives
- b) Partial derivatives
- c) Octave/Matlab based solution to voltage in a capacitor (Laplace solver)
- d) Meaning of Dirichlet and Neumann boundary conditions and the voltage in parallel plate capacitor
- e) Octave/Matlab to solve wave equation
- f) Octave/Matlab to solve Telegrapher's equations
- g) Implication of short circuit or open circuit in a transmission line
- h) The reflection coefficient
- i) Time domain reflectometry
- j) Time of flight based inferences
- k) Bounce diagrams and time evolution of voltage

Week 3 : Non-idealities in the transmission line circuit model
- a) Resistor and conductor in circuit equivalent
- b) Steady state AC in transmission line
- c) The propagation constant and characteristic impedance
- d) Impedance in the transmission line
- e) Standing Wave and Voltage Standing Wave Ratio
- f) Power in transmission line

Week 4 : Impedance matching
- a) Quarter wavelength transformer
- b) Stub based matching

Week 5 : Equivalence of Maxwell's equations and telegraphers equations

Week 6 : Programmatic solutions to Maxwell's equations using Octave/Matlab

Week 7 : Power and Poynting vector

Week 8 : Losses in propagation and propagation constant, Polarization (the only difference from transmission lines)
- a) Linear, circular, elliptical

Week 9 : Reflection and transmission at interfaces (analogous to transmission lines)
- a) Reflection coefficient and transmission coefficient
- b) Standing waves

Effect of reflection and transmission on Polarization (different from transmission lines)

Week 10 : Dielectric-Dielectric and Dielectric-Metal interfaces, Fresnel coefficients,Brewsters angle,Total internal reflection

Week 11 : Parallel plate and rectangular waveguides, Modes of parallel plate and rectangular waveguides

Week 12 : The cut-off frequency, Dispersion