PROGRAM OF ELECTROMAGNETIC FIELDS
Academic Year 2016-2017
Prof. Roberto Vescovo

Theory of elementary cells for transmission lines involving harmonic fields. Propagation constant and characteristic impedance. Fundamental parameters. Voltage and current waves. Phase velocity and wavelength. Reflection coefficient and impedance. Matched load, Short circuit, open circuit, reactive load. Sections with resistive impedance. Standing Wave Ratio (SWR). Coaxial cable. Power flow in a transmission line. Quarter-wave adapters. Single, double and triple-stub adapters. Smith chart. Transmission lines in the time-domain. Equations for voltage and current.
Mathematics for the electromagnetism: line, surface and volume integrals; flux of a vector through a surface and a line; complex vector, modulus, scalar and vector product, orthogonality; gradient, divergence and curl operators; divergence theorem, Stokes theorem, gradient theorem and curl theorem. Orthogonal curvilinear coordinates. Circular cylindrical coordinates and spherical coordinates.
Electric charge, electric current, charge density and current density. Electric field and Coulomb law. Field of a charge distribution. Electrostatic potential. Gauss's law. Magnetism. The magnetic induction vector. Lorentz force. Magnetic force acting on a current wire. Gauss's law of magnetism. Faraday law and Lenz law. Ampère's law. Biot-Savart law. Electric charge conservation law.
Maxwell's equations in the vacuum, in both integral and differential form. Sinusoidal vector. Linear, circular and elliptical polarisation. Vector phasor. Maxwell's equations in the vacuum, in the frequency domain, in both integral and differential forms.
Electric polarisation vector, magnetisation vector, electric displacement vector and magnetic field vector. Maxwell's equations in the matter, in both integral and differential forms, in the time domain and in the frequency domain.
Electric and magnetic current sources of the electromagnetic fields. Constitutive relations: linear, isotropic, homogeneous media. Definition of anisotropic medium.
Boundary conditions for the electromagnetic fields. Perfect conductors. Poynting's theorem in the time domain and in the frequency domain. Power and energy stored in a space region. Unicity theorem in the time domain and in the frequency domain. Resonant field.
Helmholtz equation. Plane wave solution of the homogeneous Helmholtz equation. Separability condition and zero-divergence condition for plane waves. On the concept of wave. Equiphase and equi-amplitude surfaces. Phase velocity. Uniform, evanescent and dissociated plane waves. Relation between electric field and magnetic field for a plane wave. Polarisation properties of electric and magnetic fields for a plane wave.
Reflection of uniform plane wave on planar surface of perfect electric conductor. Reflection and refraction of uniform plane wave on a plane surface separating two half-spaces of perfect dielectric materials.
Reflection law and Snell law. Total reflection. TE e TM polarisations. Frésnel formulas. Decomposition of a plane wave in the sum of TE and TM plane waves. Fermat principle.
Brewster angle.
The course includes exercises on the covered topics.

REFERENCES
[1] C. A. Balanis, Advanced Engineering Electromagnetics, John Wiley and Sons, New York, 1989
[2] G. Franceschetti, Campi elettromagnetici, Boringhieri, Torino, 1983.
[3] G. Gerosa e P. Lampariello, Lezioni di Campi elettromagnetici, Edizioni Ingegneria 2000, Roma, 1995.
[4] J. D. Jackson, Classical Electrodynamics, Wiley, 1962.
[5] C. G. Someda, Onde elettromagnetiche, UTET, Torino, 1986.