EE 382/382L: Applied Electromagnetics

CATALOG DATA:

EE 382/382L – Applied Electromagnetics (2.5-0.5) 3 Credits. Prerequisite: EE381. Field theory (e.g., Maxwell’s equations) for time-varying electromagnetic phenomena. Applications will include transmission lines, plane waves, and antennas. Students are introduced to typical laboratory equipment associated with applied electromagnetics (e.g., vector network analyzer).

TEXTBOOK:


COORDINATOR:

Dr. Thomas P. Montoya, Assistant Professor

GOALS:

The objective of this course is to provide students with a basic understanding of Maxwell’s equations for the time-varying case; analyzing uniform plane wave propagation, reflection, & transmission; analysis, applications, & theory of transmission lines in the frequency-domain and time-domain; transmission line impedance matching techniques using Smith charts; an introduction to antennas; and introduction to modern microwave & RF test equipment.

CLASS SCHEDULE:

Lecture: 3 hours per week.
Laboratory: no scheduled weekly lab; lab projects will be scheduled as required and/or dictated by equipment availability

Topics:

1. Time-varying Fields and Maxwell’s Equations:
   a. Faraday’s Law
   b. Ampere’s Law and displacement current
   c. Differential and integral forms of Maxwell’s equations for time-varying case
   d. Boundary conditions
   e. Wave equations
   f. Time-harmonic fields

2. Theory and Applications of Transmission Lines:
   a. Types of transmission lines
   b. Lossy transmission lines (frequency-domain)
   c. Lossy transmission line circuits (frequency-domain)
   d. Lossless transmission line circuits and transients (time-domain)
   e. Graphical analysis of lossless transmission lines using Smith charts
   f. Lossless transmission line impedance matching techniques

3. Antennas:
a. Fundamental concepts and definitions
b. Friis transmission equation
c. Radar range equation
d. Analysis/design of canonical antennas (e.g., linear dipoles/monopoles and loop wire antennas)
e. Design, construction, matching, and testing of a widely utilized antenna (e.g., log-periodic dipole arrays (LPDA))

4. Plane Electromagnetic Waves:
   a. Uniform plane wave (UPW) propagation in lossy and lossless media
   b. UPW polarization
   c. Group velocity
   d. Poynting vector and theorem
   e. Normal and oblique incidence of UPWs at conducting and dielectric boundaries

**COMPUTER USAGE:**

Students are encouraged to use PSpice to verify problems involving electrical circuits and transmission lines as well as computer programs for analysis, mathematics, and graphing (e.g., MS Excel, MathCad, MATLAB, ...).

**LABORATORY PROJECTS:**

Laboratory projects will include transmission line concepts (time-domain and frequency-domain) and the design, construction, and testing of an antenna. Students will use modern microwave & RF laboratory test equipment (e.g., vector network analyzer).

**OUTCOMES:**

Upon completion of this course, students should demonstrate the ability to:

1. Apply Maxwell’s equations to problems involving time-varying fields, particularly Faraday’s Law.
2. Calculate distributed parameters (i.e., $R$, $L$, $G$, and $C$) and dependent quantities (e.g., characteristic impedance, phase velocity, attenuation constant, and phase constant) for simple lossy transmission lines.
3. Solve frequency-domain problems (e.g., find impedances, reflection coefficients, currents, voltages, and powers) for lossy transmission line circuits.
4. Solve time-domain (transient) problems (i.e., find reflection coefficients, currents and voltages versus time at stationary points or versus position at a given time) for lossless transmission lines.
5. Use Smith charts to calculate or find reflection coefficients, impedances, the location of voltage maxima and minima, and VSWR on a lossless transmission line.
6. Solve lossless transmission line matching problems (e.g., single-stub and quarter-wave matching sections).
7. Apply or calculate fundamental antenna concepts, definitions, or quantities.
8. Apply or use the Friis transmission and Radar range equations.
9. Analyze and design a dipole/monopole or loop wire antenna.
10. Design, construct, match, and test a widely utilized antenna (e.g., LPDA).
11. Calculate UPW equations/parameters for propagation through lossy or lossless media.
12. Calculate the polarization of a UPW given the electric or magnetic fields.
13. Apply/calculate Poynting vector/theorem to UPWs given the electric or magnetic fields.
14. Take measurements with modern microwave & RF test equipment.

**RELATION OF COURSE TO PROGRAM OBJECTIVES:**

These course outcomes fulfill the following program objectives:

(a) An ability to apply knowledge of mathematics, science, and engineering.
(b) An ability to design and conduct experiments, as well as to analyze and interpret data.
(c) An ability to design a system, component, or process to meet desired needs.
(d) An ability to function on multi-disciplinary teams.
(e) An ability to identify, formulate, and solve engineering problems.
(f) An understanding of professional and ethical responsibility.
(g) An ability to communicate effectively.
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context.
(i) A recognition of the need for, and an ability to engage in life-long learning.
(j) A knowledge of contemporary issues.
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The following table indicates the relative strengths of each course outcome in addressing the program objectives listed above (on a scale of 1 to 4 where 4 indicates a strong emphasis).

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**PREPARED BY:**
Thomas P. Montoya, Date: May 1, 2002 (course numbered EE480)
Thomas P. Montoya, Date: January 7, 2004