

## **EE 483/483L: *Antennas for Wireless Communications***

### **CATALOG DATA:**

**EE 483/483L Antennas for Wireless Communications** (3-1) 4 credits. Prerequisite: EE 382/382L. Introduction to antenna design, measurement, and theory for wireless communications including fundamental antenna concepts and parameters (directivity, gain, patterns, etc.), matching techniques, and signal propagation. Theory and design of linear, loop, and patch antennas, antenna arrays, and other commonly used antennas. Students will design, model, build, and test antenna(s). Students enrolled in EE 583/583L will be held to a higher standard than those enrolled in EE 483/483L.

### **TEXTBOOK:**

*Antenna Theory: Analysis and Design* (Third Edition), Balanis, Wiley, 2005, ISBN 0-471-66782-X

### **COORDINATOR:**

Dr. Thomas P. Montoya, Associate Professor

### **GOALS:**

The objective of this course is to introduce students to the basic concepts of antenna design, measurement, and theory. In particular, they are introduced to fundamental antenna concepts and parameters (directivity, gain, patterns, etc.), the theory and design of some common antennas (e.g., linear, loop, patch, linear arrays, Yagi-Uda), matching techniques, and signal propagation. By the end of the course, the students should be able to design, model, build, and test simple antennas.

### **CLASS SCHEDULE:**

Lecture: 3 hours per week.

Laboratory: no scheduled weekly lab; lab projects will be scheduled as required.

### **TOPICS:**

1. Antennas
  - a. Types of antennas
  - b. Radiation mechanism
  - c. Describe some methods of analysis
  - d. History of antenna development
2. Fundamental Parameters of Antennas
  - a. Radiation patterns
  - b. Radiation power density
  - c. Radiation intensity, directivity, and gain
  - d. Antenna radiation efficiency

- e. Bandwidth and beamwidth
  - f. Polarization
  - g. Input impedance
  - h. Effective length and area
  - i. Friis Transmission Equation
  - j. Radar Range Equation
3. Numerical Electromagnetics Code (NEC)
    - a. Introduction
    - b. Modeling rules (e.g., segmentation)
    - c. Usage- input commands and input file structure
    - d. Interpreting output data
  4. Radiation Integrals and Auxiliary Potential Functions
    - a. Magnetic vector potential  $\bar{A}$  for electric current density  $\bar{J}$
    - b. Electric vector potential  $\bar{F}$  for magnetic current density  $\bar{M}$
    - c. Far-field electric and magnetic fields from  $\bar{A}$  or  $\bar{F}$
  5. Linear Wire Antennas
    - a. Infinitesimal dipole (fields, gain, radiation resistance, ...)
    - b. Small dipole (fields, gain, radiation resistance, ...)
    - c. Finite-length dipole (fields, gain, radiation resistance, ...)
    - d. Half-wavelength dipole (fields, gain, radiation resistance, ...)
  6. Loop Antennas
    - a. Small circular loops (fields, gain, radiation resistance, ...)
    - b. Circular loop with constant current (fields, gain, radiation resistance, ...)
    - c. Circular loop with nonuniform current (fields, gain, radiation resistance, ...)
  7. Yagi-Uda Dipole Arrays
    - a. design
    - b. feeding/matching techniques- folded dipole, T-Match, modified T-Match, Gamma match, Modified Gamma, ...
  8. Microstrip Antennas (patches)
    - a. Theory and design of rectangular patches- transmission line model
    - b. Theory and design of rectangular patches- cavity model
    - c. Quality factor, Bandwidth, efficiency, and input impedance
  9. Arrays: Linear, ...
    - a. Two-element array
    - b. Design of  $N$ -element linear arrays with uniform amplitude and spacing- broadside, end-fire, phased/scanning, and Hansen-Woodyard end-fire
    - c. Directivity of  $N$ -element linear arrays with uniform amplitude and spacing

**COMPUTER USAGE:**

Students use the computer program called the Numerical Electromagnetics Code (NEC) to model/simulate and analyze antennas. Also, computer mathematical packages such as MATLAB, MathCad, MS Excel, ... are used to analyze, design, and present results for antennas and related data and/or measurements.

**OUTCOMES:**

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

1. Apply, calculate, or produce fundamental parameters or quantities of antennas (e.g., radiation patterns, radiation intensity, directivity, ...).
2. Apply or use the Friis Transmission Equation and Radar Range Equation.
3. Use EM software to design and model antennas.
4. Know how to calculate the magnetic and electric vector potentials given the electric or magnetic current densities, respectively, for simple problems.
5. Calculate the far-field electric and magnetic fields from the magnetic and/or electric vector potentials.
6. Analyze and calculate antenna quantities and parameters for commonly used antennas (e.g., linear dipole, loop, microstrip, and Yagi-Uda).
7. Design, match, and test commonly used antennas (e.g., linear dipole, loop, microstrip, and Yagi-Uda).
8. Design and analyze linear antenna arrays with uniform spacing and amplitude.
9. Measure important antenna parameters (e.g., impedance, reflection coefficient, VSWR, radiation pattern, ...) using modern test equipment (e.g., vector network analyzer).

**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).

		Course Outcomes								
		1	2	3	4	5	6	7	8	9
ABET Objectives	(a)	4	4	3	4	4	4	4	4	4
	(b)							3		3
	(c)	2	2	2			3	4	3	3
	(d)									
	(e)	2	3	3	2	2	3	4	4	2
	(f)									
	(g)									
	(h)									
	(i)			2				2	2	2
	(j)									
	(k)			4				4	3	4

**PREPARED BY:**

Thomas P. Montoya, Date: January 15, 2004

Last revised June 17, 2016.

Revised by January 9, 2017 by Thomas P. Montoya and approved January 11, 2017 at ECE department meeting.