ECE 421 (423) - Microwave Circuits and Systems (with Laboratory)

Credits: 3, **Contact Hours:** Two 75 minute lecture sessions per week, ECE 421
Credits: 4, **Contact Hours:** Two 75 minute lecture sessions per week, one 160 minute laboratory session per week

Coordinator: T. Wong, Professor of ECE

Textbook: S. Ramo, J. Whinnery, and T. Van Duzer, *Fields and Waves in Communication Electronics*, 3rd Edition, Wiley, 1993.
ECE 423 Laboratory Manual

2019 Catalog Data: ECE 421: Microwave Circuits and Systems, Credit 3

Maxwell's equations, waves in free space, metallic and dielectric waveguides, microstrips, microwave cavity resonators and components, ultra-high frequency generation and amplification. Analysis and design of microwave circuits and systems. Credit will be given for either ECE 421 or ECE 423, but not for both. Lecture: 2

ECE 423 : Microwave Circuits and Systems with Laboratory, Credit 4

Maxwell's equations, waves in free space, metallic and dielectric waveguides, microstrips, microwave cavity resonators and components, ultra-high frequency generation and amplification. Analysis and design of microwave circuits and systems. Credit will be given for either ECE 421 or ECE 423, but not for both. Lecture:2 Lab:1

Enrollment: Elective course for EE majors

Prerequisites or co-requisites by topic: ECE 307 Engineering Electromagnetics

Specific outcomes of instruction:
Course contents and laboratory work will provide students with the experience of

1. Utilize Maxwell's equations and the appropriate boundary conditions to solve practical problems.
2. Determine plane wave propagation in homogeneous media and reflection and refraction of plane waves.
3. Determine TEM wave propagation in uniform transmission lines; compute characteristic impedance and wave velocities.
4. Calculate wave impedance, propagation constant, and estimate power dissipation in cylindrical metallic waveguides.
5. Determine quasi-TEM wave propagation in planar transmission lines and use empirical formulas to characterize these lines.
6. Determine equivalent voltage and current for guided waves; apply the scattering matrix for representation and analysis of microwave components.
7. Describe the construction of passive microwave components and their properties in terms of scattering matrices.
8. Acquainted with principles of active microwave devices.
9. Understanding the operation of microwave systems and measurement equipment at microwave frequencies.

Additional experience for ECE 423:

10. Be familiar with microwave sources, wavelength and power measurement.
11. Analyze wave transmission and reflection in transmission lines and waveguides.
12. Make measurements of properties of passive microwave components.
13. Use of network analyzer to measure S-parameters.
14. Design and test a microstrip circuit with the use of a CAD tool
15. Complete an engineering design incorporating engineering standards and realistic constraints.
16. Prepare an informative and organized design project report.

Relationship of ECE 421 specific outcomes of instruction to student outcomes:

	Student Outcomes	ECE 421 Course Goals	ECE 423 Course Goals
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9
2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	5,6,7	5,6,7,12,13,14,15
3	An ability to communicate effectively with a range of audiences		8
4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts		
5	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives		
6	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions		11,12,13,14,15 16
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies		

Topics:

- Electromagnetics (2 weeks)
- Transmission lines (1 week)
- Plane waves (2 weeks)
- Guided waves (3 weeks)
- Circuit theory for waveguiding systems (3 weeks)
- Microwave components (2 weeks)
- Active microwave circuits (2 weeks)

Laboratory topics (ECE 423):

- Students conduct microwave experiments on signal generation, power and frequency measurements.
- Transmission and reflection of waves, propagation characteristics of guided waves, and microwave components.
- The use of an automated network analyzer is introduced through scattering parameter measurement of passive elements.
- In the last six weeks of the semester, a design project on a simple microstrip circuit is implemented by each student.
- The circuit is first optimized with a commercial CAD package, followed by fabrication and testing with the network analyzer. A report on the design process and measured performance of the circuit is required.

Prepared by: T. Wong **Date:** February 28, 2020