ECE 5321: Microwave Engineering II

Credits and Contact Hours: 3.0 Credit Hours
15 weeks: Two 80-minute lectures per week

Instructor’s Name: Jeffrey S. Walling

Text Book(s) and/or Required Material:

Catalog Description: Nonlinear and active microwave devices including diodes, mixers, transistors, and negative resistance devices; compressed Smith Chart; balanced and double-balanced mixer design; transistor amplifier theory and design for best gain, stability, and noise performance. Oscillator theory and design using transistors, tunnel diodes, IMPATTs, and Gunn diodes. PIN diode switching circuits and phase shifters. Survey of design and performance of microwave systems and auxiliary components; antennas, signal modulation and multiplexing, transceiver and radar systems, signal-to-noise ratios, atmospheric effects, microwave heating, biological effects and safety. Course includes biweekly laboratory assignments using microstrip-integrated circuits with professional-level design and test equipment. Demonstrations of other active components such as traveling wave tubes, klystrons, and backward oscillators are also provided.

Prerequisites:
- C- or better in: ECE 5320: Microwave Engineering I; and
- Full major status in Computer Engineering

Designation: Elective

Contribution of Course to Meeting the Requirements of ABET Criterion 5: This course teaches electrical engineering design and some electrical engineering science.

Specific Outcomes of Instruction: In this course, students will be prepared to:
1. Apply fundamental concepts learned in earlier courses.
2. Develop techniques for designing solid-state active devices using bipolar junction transistors (BJT) and field effect transistors (FET) in amplifier and oscillator applications.
3. Design procedures to obtain amplifier stability, power gain relationships, constant gain circles for unilateral and bilateral devices, gain and VSWR trade-offs, bias networks, low-noise amplifiers, broadband amplifiers, power amplifiers, feedback oscillators, negative resistance oscillators, and the design of devices making one of these various design considerations.
4. Understand the concept of the speed of change of the technologies of the devices that will affect the future.

Relationship of the Course to the Program Outcomes:
(a) An ability to apply knowledge of mathematics, science, and engineering. Students apply fundamental concepts learned in earlier courses, including microwaves, electromagnetic field theory, and circuit theory and electronic background. Students apply this background in class and in the homework problems.
(b) An ability to design and conduct experiments, to analyze and interpret data, and to debug and analyze software. Two laboratories require the complete design of the circuit math used to build the amplifier and oscillator before the complete circuit could be built and tested.

(c) An ability to design a system, component, process or software package to meet desired needs. Students learn how to apply fundamental concepts learned earlier, including solid-state materials, general electronic devices, circuit theory to analyze transistor-circuit problems, transmission line theory, and evaluating device performance. Students use this background in understanding and applying this knowledge to the development of this microwave device application in both laboratory experiments and homework problems.

(d) An ability to function on multidisciplinary teams. Students work in teams for the laboratories, but they are not necessarily multidisciplinary.

(e) An ability to identify, formulate, and solve engineering problems. There is considerable opportunity in this class to learn how to identify, formulate, and solve electrical engineering problems.

(i) A recognition of the need for, and an ability to engage in life-long learning. The course incorporates readings from IEEE papers and demonstrates how to extract information from state of the art research and apply it to design problems and future research.

(j) A knowledge of contemporary issues. Taking a class of this kind when the field is developing rapidly gives the students a concept of the speed of change of the technologies of the devices that will affect the future.

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. The students increase their knowledge by solving the homework and utilizing necessary equipment to make the appropriate measurement of performance. The students also gain an appreciation of the rapid development of the solid-state device field when progress in this field continues to be made with the ability to build devices at higher power levels.

**Topics Covered in the Course:**

- RF basics: impedance matching networks, Smith chart
- Two-port network parameters: S-parameters
- Passive planar components: spiral inductors, MiM and MoM capacitors
- QAM, TPSK, ODFM: signal constellations, fidelity metrics
- Linear PA basics: Class A operation and PA characteristics, Class B, AB power amplifiers, energy efficiency, output power, linearity, push-pull configuration
- Switching PA basics: Class D,E,F power amplifiers, theory of operation, efficiency, output power, constant envelope modulation
- PA linearization: envelope elimination and restoration, polar loops
- Supply modulators: linear voltage regulators, switching regulators, PWM modulators, Δ−Σ modulators
- Digital power amplifiers: current cell based DPAs, switched capacitor PAs
- PA linearization: envelope tracking, saturated linear Pas
- Low noise amplifiers
- Bandpass pulse-width modulation
- Oscillator circuits
- Chireix/Outphasing/LINC
- Doherty amplifiers: load modulation techniques, class-C PA operation
- Low power techniques: class-C Pas for bio applications, sub-threshold switching amplifiers