**Electrical Engineering: RF & Microwave Engineering**

**EERF 5305** Radio Frequency Engineering (3 semester credit hours) Introduction to generation, transmission, and radiation of electromagnetic waves. Microwave-frequency measurement techniques. Characteristics of guided-wave structures and impedance matching. Fundamentals of antennas and propagation. Prerequisite: EE 4301 or equivalent. (3-0) Y

**EERF 6311** RF and Microwave Circuits (3 semester credit hours) Analysis and design of RF and microwave circuits. Topics include impedance matching, network theory, S-parameters, transmission line media (waveguide, coax, microstrip, stripline, coplanar waveguide, etc.) and passive component design (power dividers, couplers, switches, attenuators, phase shifters, etc.). Industry-standard microwave CAD tools will be used. Prerequisite: EE 4368 or equivalent. (3-0) R

**EERF 6330** RF Integrated Circuit Design (3 semester credit hours) Introduction to RF and wireless systems; basic concepts of RF design: linearity, distortion, (P1dB, IIP3), sensitivity, noise figure; RF passives: Q-factors, impedance transformation, matching network; transceiver architectures: Receivers - Heterodyne, direct down-conversion, image reject receivers, direct conversion transmitter, two-step transmitter; low noise amplifier design; mixer design; oscillator design; basic architectures of power amplifiers. Industry-standard CAD tools will be used for design projects. Prerequisite: EE 4340. (3-0) Y

**EERF 6351** Computational Electromagnetics (3 semester credit hours) Review of Maxwell's equations; numerical propagation of scalar waves; finite-difference time-domain solutions of Maxwell's equations; numerical implementations of boundary conditions; numerical stability; numerical dispersion; absorbing boundary conditions for free space and waveguides; selected applications in telecommunications, antennas, microelectronics and digital systems. Prerequisite: EE 4301 or equivalent. (3-0) R

**EERF 6355** RF and Microwave Amplifier Design (3 semester credit hours) Design of narrow band, and broadband amplifiers. Study of stability on amplifiers. Study of noise figure, noise parameters and noise sources. Low noise amplifier design. Study of distortion on amplifiers. Introduction to power amplifiers. Microwave amplifier design in integrated circuits. Prerequisite: EERF 6311 or equivalent. (3-0) R

**EERF 6392** Millimeter Wave Integrated Circuit Design (3 semester credit hours) Millimeter wave applications, silicon integrated circuits technology trends, passive components in silicon IC's for millimeter wave operation, Drude model for silicon substrate, parasitic modeling, NQS transistor model, High frequency limit for thermal noise, chip interface including packaging and antenna, comparison between RF and mm-wave circuits, techniques for extending circuit operation frequency (injection locking and frequency multiplication), and diode circuits including a parametric amplifier. Prerequisites: EECT 6325 and EERF 6311 or equivalent. (3-0) T

**EERF 6393** Microwave Power Amplifiers (3 semester credit hours) RF/Microwave transistor power amplifier (PA) applications and fundamental linear and non-linear performance objectives are studied such as: output power, efficiency, and distortion. Key amplifier classes and design topologies are studied. Students will complete CAD design projects to demonstrate mastery of relevant techniques. Prerequisite: EERF 6311
or equivalent. Corequisite: **EERF 6355** or equivalent. (3-0) R

**EERF 6394** Antenna Engineering and Wave Propagation (3 semester credit hours) Operating principles for microwave antennas used in modern wireless communications and radar systems. Prerequisite: **EEGR 6316** or equivalent. (3-0) T

**EERF 6395** RF and Microwave Systems Engineering (3 semester credit hours) Review of RF and microwave systems, such as cellular, point-to-point radio, satellite, RFID and RADAR. Topics include: system architectures, noise and distortion, antennas and propagation, transmission lines and network analysis, active and passive components, modulation techniques and specification flowdown. Prerequisite: **EE 4368** or equivalent. (3-0) R

**EERF 6396** Microwave Design and Measurement (3 semester credit hours) This lecture and lab course covers the fundamentals of microwave component design and measurements, including vector impedance (scattering parameters), scalar measurements and spectrum analysis. Microwave components, such as filters, directional couplers, switches, amplifiers, and oscillators, will be designed and simulated with various CAD tools and then built and measured to compare performance with theory. Prerequisite: **EE 4368** or equivalent. (2-1) R

**EERF 7330** Advanced RF Integrated Circuit Design (3 semester credit hours) Power Amplifiers, different classes of linear (A, B, AB, C) and switching power amplifiers (E, G, H), CMOS Integrated power amplifiers, High Efficiency Power Amplifiers (Doherty Power Amplifier); Phase Locked Loops: Basic concepts of PLL, Charge pumps, Type-I and Type-II PLLs, Noise in PLLs, Phase Noise, Frequency multiplication, RF Synthesizer Architectures, Frequency Dividers, Fractional-N PLLs, Delta-Sigma based PLLs, ADPLL; Advanced RF transceivers; Wideband and multiband radio design; Complete link budget analysis for wireless systems. Design project will focus on design of the entire transmitter using Agilent ADS. Prerequisite: **EERF 6330**. (3-0) Y

**EERF 7V89** Special Topics in RF and Microwave Systems (1-6 semester credit hours) May be repeated for credit as topics vary (9 semester credit hours maximum). ([1-6]-[0-3]) R