ECE 404

RADIO FREQUENCY ELECTRONIC CIRCUITS

FALL 2019

COURSE:	M W F	9:10 - 10:00 am	Room 2243 EB
PREREQ:	ECE 302, 303 & 305		
INSTRUCTOR:	G.M. Wierzba	Room 3215 EB	355-5225; wierzba@msu.edu
WEB SITE:	www.egr.msu.edu/~wierzba		
OFFICE HRS:	M W Th	4:10 - 5:00 pm	or by appointment

TEXTS: G.M. Wierzba, *ECE 404 Class e-Notes and Lab Manual, Fall 2019 Edition,* (free for all registered students)

Guillermo Gonzalez, "Microwave Transistor Amplifiers: Analysis and Design", Prentice Hall, 1997, ISBN: 0-13-254335-4

Chris Bowick, "RF Circuit Design," Newnes, 1997, ISBN:0-7506-9946-9

GRADING:

Three one-hour exams	(9/16, 10/14 and 11/11)	200 pts
Final exam*	(Th., Dec. 12 @ 7:45 - 9:45 am)	200 pts
Homework*	(normalized)	50 pts
Lab Grade*		150 pts

**You must obtain a passing grade to pass the course.*

POLICIES: You are expected to arrive for class on time. No electronic devices or laptops are allowed during class. No student can wear earphones during class.

HOMEWORK: Homework is to be done on 8.5" x 11" paper using only one side. It must be stapled and ragged edges must be trimmed. Whenever possible, the correct answer is to be circled or boxed. You may **NOT** work with other students. The work you submit must be done by you. Assignments which are identical to any other student will all receive a grade of **zero**. You must type and run all of your own computer work.

OTHER: Only simple scientific calculators are allowed for exams. Exam questions may have little or no partial credit. There are NO MAKE UP EXAMS. Your lowest hourly exam grade will be dropped in computing your grade. Late homework WILL NOT be accepted. Your lowest homework grade will be dropped in computing your normalized homework grade.

An 85% attendance rate is required to pass the course, that is, you can miss 7 classes. Please keep your own record of absences.

DETAILED TOPICS:

Chapter 1: Resonant Circuits

1.1 Review of Phasors
Vector Representation of Sinusoids, Euler's Formula, Complex Numbers, Rectangular and Polar Form, Phasor Transform, Inverse Phasor Transform, Addition- Subtraction- Multiplication-Division of Complex Numbers, Impedance, Admittance, Phasor Circuit Analysis, SPICE, Resonant Frequency of an Impedance.

1.2 Review of Bode Diagrams
Product of Terms, Decibel, First-Order Inspections Forms, Making Log Paper and Reading Points, Audio Frequency Inverting Amplifier, Second-Order Inspection Forms, RLC Low-Pass Filter, Hiss Filter, RLC High-Pass Filter, RLC Band-Pass Filter, RLC Band-Stop Filter.

1.3 Series Resonance
Lossless Components.

1.4 Parallel Resonance
Lossless Components, Band-Pass Filter, Band-Pass Filter with Load.

1.5 Components
Resistivity of Wire, AWG, Wire Inductance, Equivalent Circuit of a Resistor, Equivalent Circuit of a Capacitor, Insulation Resistance, Dissipation Factor, Quality Factor, Self Resonance of a Capacitor, Equivalent Circuit of an Inductor, Effective Series Resistance, Self Resonance of an Inductor, Dissipation Factor, Quality Factor, Air-Core Inductor.

1.6 Series-to-Parallel Transformations
Series-to-Parallel Inspection Formulas.

1.7 Insertion Loss
Definition of Insertion Loss, Maximum Power Transfer.

1.8 Impedance Transformations
Ideal Transformer, Tapped Capacitor Circuit, Performance Analysis with Pspice, Goal Functions, Tapped Inductor Circuit, Mutual Inductance, Coefficient of Coupling, Reflected Impedance.

Chapter 2: Impedance Matching

2.1 Introduction
Complex Maximum Power Transfer, Impedance Matching.

2.2 The L Network
Low-Pass Configurations, High-Pass Configurations, Design Equations, Parasitic Effects.

2.3 Three-Element Matching
Pi-Network, Four Filter Configurations, T-Network, Four Filter Configurations.

2.4 Smith Chart
Impedance Properties, Plotting Impedance Values, Impedance Scaling, Impedance Manipulation, Admittance Properties, Admittance Manipulation, Conversion of Impedance to Admittance.

2.5 Impedance Matching on the Smith Chart
Two-Element Matching, Three-Element Matching, T-Networks, Pi-Networks.

Chapter 3: Small-Signal RF Amplifiers

3.1 BJT Equivalent Circuits
Giacoletto Model, Gain-Bandwidth-Product, SPICE, DC Results, AC - Mid-Band Results, AC - High Frequency Results, Miller Effect.

3.2 Two-Port Parameters
Y-Parameters, H-Parameters, Chain Parameters, Interconnection of Two-Ports, Parallel Input - Parallel Output, Chain-Connection.

3.3 Transmission Line Concepts
Distributed Circuit Model, Lossless Transmission Line, Characteristic Impedance, Wave Functions, Incident Wave, Reflected Wave, Reflection Coefficient, Voltate-Standing-Wave Ratio, Matched Transmission Line, Shorted Transmission Line, Open Transmission Line, Quarter-Wave Transmission Line, SPICE model, Lossy Transmission Line, Scattering Parameters, T-Parameters, Shifting of Reference Planes, Properties of Scattering Parameters, Stability, Transducer Power Gain, Two-Port Analysis.

3.4 Characteristics of Microwave Transistors
Scattering Parameter Analysis.

3.5 The Smith Chart
Derivation of the Smith Chart, Transmission Line Input Impedance, Load Reflection Coefficient and VSWR, Transistor Scattering Parameters with Ansoft Designer.

Chapter 4: Small-Signal RF Amplifier Design

4.1 Designing with Y-Parameters
Linvill Stability Factor, Stern Stability Test, Maximum Available Gain, Transducer Gain, Simultaneous Conjugate Matching, Designing with Potentially Unstable Transistors, Generating Two-Port Parameters with Ansoft Designer.

Chapter 5: Oscillator Circuits

5.1 Introduction to Sinusoidal Oscillators

5.2 Phase Shift Oscillator
Conditions for Oscillation

5.3 Wien Bridge Oscillator
Conditions for Oscillation, Stablizer

5.4 Colpitts Oscillator
Conditions for Oscillation, Biasing, Design