

ECE 831

ANALOG CIRCUIT THEORY

FALL 2010

COURSE:	M W F	1:50 pm - 2:40 pm	Room 2320 EB
PREREQ:	Undergraduate Course in Electric Circuits		
INSTRUCTOR:	G.M. Wierzba	Room 3215 EB	355-5225; wierzba@msu.edu
WEB SITE:	www.egr.msu.edu/~wierzba		
OFFICE HRS:	M W Th	4:15 - 5:15 pm	or by appointment
TEXTS:	G.M. Wierzba, <i>ECE 831 Course e-Notes, Fall 2010 Edition</i> , available at http://stores.lulu.com/willowepublishing		
REF:	W-K. Chen, <i>Passive and Active Filters: Theory and Implementations</i> , Wiley, 1986 (On reserve in the Engr. Library)		
	L. T. Bruton, <i>RC-Active Circuits Theory and Design</i> , Prentice-Hall, 1980 (On reserve in the Engr. Library)		
GRADING:	Three one-hour exams	(9/22, 10/20 and 11/17)	200 pts
	Final exam	(Tu., Dec.14 @ 12:45 - 2:45 pm)	200 pts
	Homework *	(normalized)	200 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. Copying of old assignments will be dealt with severely.		
OTHER:	Only simple scientific calculators are allowed for exams. There are NO MAKE UP EXAMS . One 1-hour exam 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: Fundamentals of Passive Circuit Theory

- A) Passive Network Nodal Analysis
Nodal Analysis Algorithm
- B) Source Transformations
Pushing a Voltage Source Through a Node
- C) Passive Network Mesh Analysis
Mesh Analysis Algorithm
- D) Source Transformations (revisited)
Moving a Current Source Around a Loop
- E) Duality
Inspection Transformation
- F) Linearity and Superposition
Proof using Node Equations, Proportionality
- G) Substitution Theorem
Voltage Substitution, Current Substitution
- H) Two Ports
Y-parameters, Z-parameters, Conversion, Transfer Functions, Reciprocity
- I) Interconnection of Two Ports
Series Combination, Parallel Combination
- J) Scaling Network Functions
Magnitude Scaling, Frequency Scaling
- K) Tellegen's Theorem
Application to the Conservation of Power

Chapter 2: Fundamentals of Active Circuit Theory

- A) Nullator and Norators
Independent Sources, Norator, Short Circuit, Open Circuit, Nullator, Ideal Op-Amp, Ideal BJT
- B) Nullator-Norator Nodal Analysis
Nodal Analysis Algorithm, Treble Tone Control, Simulated Impedance
- C) Equivalence Relationships
Nullator Series Equivalence, Norator Series Equivalence, Nullator Parallel Equivalence, Norator Parallel Equivalence, Open Circuit Equivalence, Short Circuit Equivalence,
- D) Controlled Source Models
VCCS, VCVS, CCCS, CCVS
- E) Symbolic SPICE
Simulated Voltage Source, Simulated Inductance, Software

Chapter 3: Op-Amp Circuit Synthesis

- A) Op-Amp Relocation
Pairing Property, Nullator Trees, Tree Generation Property, Relocation Theorem
- B) Ground Relocation
Norator Trees, Indefinite Admittance Matrix, Singular Property, Characteristic Equations, Ground Relocation Theorem, Interchange Theorem
- C) Transfer Function Synthesis
Source Insertion, Generating Active Filters

- D) Gain-Bandwidth-Product Errors
 $f_o - Q_o$ Errors, Error Approximation using Spice, High Frequency Stability
- E) Numeric Op-Amp Relocation Software
 Case Study - Tow-Thomas Active Filter

Chapter 4: Passive Circuit Synthesis

- A) LC One Port Synthesis
 Even and Odd Polynomials in s , Imaginary Axis Roots, Partial Fraction Expansion form of $Z(s)$, Reactance vs ω , First Foster Canonical Form, Duality, Second Foster Canonical Form, First Cauer Canonical Form, Continued Fraction Expansion, Second Cauer Canonical Form, Third Cauer Canonical Form
- B) RC One Port Synthesis
 LC - RC Transformation, Properties of RC Input Impedance, First and Second Foster Form Synthesis, First and Second Cauer Form Synthesis, Number of Elements, Internal Critical Frequencies, Third Cauer Form Synthesis
- C) Two Port Synthesis by Ladder Development
 Zeros of Transmission, LC Ladder Networks, Zero Shifting, Pole Removal
- D) RC Ladder Two Port Synthesis
 Zero Shifting, Case Study, Interpretation of Poles and Zeros

Chapter 5: Approximation Theory

- A) Butterworth Low-Pass Approximation
 Ideal Normalized Low-Pass Filter, Butterworth Approximation, Roots on a Unit Circle
- B) Butterworth Filter Sections
 Second Order Block, Normalized, Scaling, Third Order Block, Nth Order Block, Normalized Element Table
- C) Butterworth High-Pass Approximation
 Ideal Normalized High-Pass Filter, Low-Pass to High-Pass Transformation
- D) Butterworth Band-Pass Approximation
 Ideal Normalized Band-Pass Filter, Low-Pass and High-Pass Configuration
- E) Butterworth Band-Stop Approximation
 Ideal Normalized Notch Filter, Low-Pass and High-Pass Configuration
- F) Chebyshev Low-Pass Approximation
 Chebyshev Approximation,
- G) Chebyshev Polynomials
 Chebyshev Polynomials, Roots on an Ellipse
- H) Normalized Chebyshev Low-Pass Table
 Normalized Element Table for -1dB and -3dB Ripple
- I) Design Example
 Fifth Order Design
- J) Bessel-Thomson Low-Pass Approximation
 Delay Approximation, Bessel-Thomson Polynomials,
- K) Normalized Bessel-Thomson Low-Pass Table
 Normalized Element Table
- L) Step Response
 Approximating Delay Based on Bandwidth
- M) Delay Scaling
- N) Passive Butterworth Low-Pass Filters
- O) Passive Butterworth High-Pass Filters