

# ECE 402

## APPLICATIONS OF ANALOG INTEGRATED CIRCUITS

SPRING 2009

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<b>COURSE:</b>	M W F	3:00 - 3:50 pm	Room 112 Bessey Hall
<b>PREREQ:</b>	ECE 302 & ECE 303		
<b>INSTRUCTOR:</b>	G.M. Wierzba	Room 3215 EB	355-5225; wierzba@msu.edu
<b>WEB SITE:</b>	www.egr.msu.edu/~wierzba		
<b>OFFICE HRS:</b>	Tu Th	4:15 - 5:15 pm	or by appointment
<b>TEXTS:</b>	G.M. Wierzba, <i>ECE 402 Course e-Notes &amp; Lab Manual, Spring 2009 Edition</i> , available at <a href="http://stores.lulu.com/willowepublishing">http://stores.lulu.com/willowepublishing</a>		
	Schubert & Kim, <i>Active and Non-Linear Electronics</i> , Wiley, 2004		
	M. Rashid, <i>Intro. To PSpice Using Orcad for Circuits and Electronics</i> , Pearson Prentice Hall, 2004		
<b>GRADING:</b>	Three one-hour exams	(2/11, 3/4, 4/15)	200 pts
	Final exam*	(Th. May 7, 3:00 - 5:00 pm)	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 laptop computers 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 have little or no partial credit. 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: Operational Amplifiers and Applications
  - 1.1 Basic Amplifier Characteristics
    - Ideal and Commercial Op-Amps.
  - 1.2 Modeling the Op-Amp
    - Inverting Amplifier, Zero Volt - Zero Current Property, Inverting Amplifier-  
Revisited, Modeling an Inverting Amplifier
  - 1.3 Applications
    - Stereo Pan-Pot Circuit, Microphone Mixer
  
- Chapter 2: First and Second Order Filters
  - 2.1 First Order Bode Plots
    - Audio Frequency Inverting Amplifier, Product of Terms, Decibel, First-  
Order Inspections Forms, Making Log Paper and Reading Points, Factoring  
Equations into Inspection Forms
  - 2.2 One Capacitor Circuits
    - One Capacitor Method, Audio Frequency Inverting Amplifier - Revisited, One  
Capacitor Approximation, National Association of Broadcasters Cassette  
Tape Preamplifier, Special Case: Pole Cancellation
  - 2.3 Tone Control Design
    - Treble Tone Control Design, Bass Tone Control Design, Shelving Equalizer
  - 2.4 Second Order Bode Plots
    - Second-Order Inspection Forms, Low-Pass, High-Pass, Band-Pass, Band-  
Stop, Low-Pass Notch, High-Pass Notch, Multiple Feedback Active Filter  
Design, Ten-Band Octave Room Equalizer, Notch-Filter Design
  - 2.5 Symbolic SPICE
    - Sspice program, Tone Controls - Revisited, Band-Pass Design - Revisited,  
Simulator Inductor - Revisited.
  
- Chapter 3: High Order Filters
  - 3.1 Low-Pass Butterworth Filters
    - Butterworth Approximation to an Ideal Low-Pass Filter, Butterworth  
Polynomials, Second Order Low-Pass Building Block, Normalized Response,  
Magnitude and Frequency Scaling, Third Order Low-Pass Building Block,  
Nth Order Low-Pass Synthesis, Normalized Low-Pass Design Table
  - 3.2 High-Pass Butterworth Filters
    - Butterworth High-Pass Approximation, Low-Pass to High-Pass  
Transformation
  - 3.3 Band-Pass Butterworth Filters
    - Cascaded low-pass and high-pass filters, Butterworth Band-Pass Filter
  - 3.4 Band-Stop Butterworth Filters
    - Summed low-pass and high-pass filters, Butterworth Band-Stop Filter
  - 3.5 Passive Low-Pass Butterworth Filters
    - Passive Butterworth Low-Pass Filters with Termination
  
- Chapter 4: Non-Ideal Op-amps
  - 4.1 Limitations Due to Gain-Bandwidth-Product
    - Voltage Gain and Phase Shift, Gain-Bandwidth-Product, Approximations for  
Dominant Pole and Non-Dominant Pole Op-Amps, Stability, Phase Margin,  
Rate of Closure, Stabilization Networks

- 4.2 Time Domain Response
  - Step Response Due to Bandwidth Limiting, Step Response Due to Slew Rate Limiting
- 4.3 DC Limitations
  - Output Swing, Short Circuit Current, Offset Voltages, Offset Adjustment, Input Bias and Input Offset Currents, Offset Minimization
- Chapter 5: SPICE Modeling of Non-Ideal Op-amps
  - 5.1 Macromodeling
    - MicroSim's NPN Input Stage Macromodel, MicroSim's JFET Input Stage Macromodel,
  - 5.2 Testing and Validation
    - Testing and Validating Data Sheet Parameters, Testing a Single Supply Amplifier
- Chapter 6: Voltage Comparators
  - 6.1 Crossing Detectors
    - Comparators, Open-collector Comparators, Noninverting Crossing Detector, Inverting Crossing Detector, Inverting Schmitt Trigger
  - 6.2 Astable Multivibrator
    - Analysis of a Relaxation Oscillator
  - 6.3 Comparator Macromodel
    - MicroSim's Macromodel for a Comparator, Simulation and Evaluation of Relaxation Oscillator
  - 6.4 Comparator Limitations
    - Voltage Gain, Output Current Sink, Saturation Voltage, Response Time, Input Overdrive, Model Testing and Validation
- Chapter 7: Timer Integrated Circuits
  - 7.1 555 Timer
    - 555 Functional Block Diagram, Monostable Multivibrator, Astable Multivibrator
  - 7.2 555 Timer SPICE Model
    - Transistor Level 555 Timer Model, Testing
  - 7.3 555 Timer Limitations
    - Threshold Voltage and Current, Trigger Voltage and Current, Reset Voltage and Current, Discharge Transistor Specifications, Output Specifications, Supply Current, Model Testing and Validation
  - 7.4 Timer Applications
    - Capacitance Meter Using a DC Voltmeter, Delay Wipers
- Chapter 8: Voltage Regulators
  - 8.1 3-Terminal Adjustable Regulator
    - LM117 Functional Block Diagram, Basic Regulator, Adjustable Regulator, Precision Current Limiter, Battery Charger, Current Limited Charger, Macromodel, Data Sheet Testing, Ripple Rejection, Output Impedance, Dropout Voltage, Current Limiting, Line and Load Response
  - 8.2 Switching Regulators (DC-DC Converters)
    - Step-Down Regulator (Buck Converter), Step-Down Regulator Using a 555 Timer, Inverting Regulator (Buck-Boost Converter), Inverting Regulator Using a 555 Timer, Step-Up Regulator (Boost Converter)

Chapter 9: Switching Amplifiers

9.1 Class D Amplifier

Pulse Width Modulation, Low-Pass Filtering, Lossy Components, Pspice Simulation, Energy Evaluation, Design Modifications