ECE 402
APPLICATIONS OF ANALOG INTEGRATED CIRCUITS
SPRING 2012

COURSE: M W F 3:00 - 3:50 pm Room 112 Bessey Hall

PREREQ: ECE 302 & ECE 303

INSTRUCTOR: G.M. Wierzba Room 3215 EB 355-5225; wierzba@msu.edu

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OFFICE HRS: Tu Th 5:00 - 6:00 pm or by appointment


GRADING: Three one-hour exams (2/8, 2/29, 4/4) 200 pts
Final exam* (Tu. May 1, 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
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
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