ELEN306 16

Course Summary

Course : ELEN306 **Title :** Analog Circuit Theory
Length of Course : 16
Prerequisites : ELEN305 **Credit Hours :** 4

Description

Course Description: This course presents basic elements in analog circuit design. Initially operational amplifiers will be discussed, including design and implementation of practical amplifier and feedback circuits. Other analog elements such as diodes and transistors will be introduced combined with previously discussed passive components to design DC power supplies, audio amplifiers, active filters and oscillators along with other applications. Students will gain a fundamental understanding of the key analog circuit components and the basic skills to create and implement practical designs. NOTE: This course requires the student to purchase additional materials that are not covered by the book grant. Please refer to the Course Materials section for additional details. Prerequisites: ELEN305

Course Scope:

This course introduces students to basic analog components and important concepts of design for more complicated operations. Lessons, assigned homework, quizzes and laboratory exercises will concentrate on building a fundamental and intuitive understanding of discrete devices such as operational amplifiers, diodes and transistors as well as building competency to design and analyze complex amplifiers, power supplies and other electronic devices. The discussion of discrete components will include the basic physics behind device operation as well as power and frequency limitations and how these can affect signal processing and overall performance.

The course work and exams will be cumulative, as each component learned is added to the design toolkit for use in the following lessons. Laboratories will be exercises to demonstrate the functionality presented in the lessons and will play an important role in developing design skills and intuition about circuit analysis and debugging. Laboratory reports will concentrate on developing data presentation skills and communication.

Objectives

After completing the course, the student should be able to accomplish these Learning Objectives (LO):

1. Describe the operation of operational amplifiers, diodes and transistor
2. Analyze analog circuit structures to predict DC and AC signal response
3. Produce designs for amplifier circuits to specified inputs, outputs and tolerances.

4. Produce designs for power converters to specified input and load tolerances.
5. Implement frequency filtering techniques in active circuit
6. Evaluate the role of analog components in practical application
7. Describe experimental results to a specified audience.

Outline

Week 1: Signals, Amplifiers and Transducers

Learning Objective(s)

1. Electronic signals and transducers
2. Thevenin and Norton equivalents of signal sources
3. Amplification and amplifiers of electronic signals
4. Types of signal amplifiers
5. Frequency response of an amplifier using Fourier and Laplace representations
6. Analyze signal sources and transducers

LO-2, LO-6

Readings

Microelectronic Circuits: Chapter 1 Signals and Amplifiers

(pgs 4-41)

Lessons in Electric Circuits Vol 1:

Chapter 9 Electrical Instrumentation Signals (pgs 301-328)

Assignment(s)

Week 1 Assessment

Laboratory hardware and software Setup

Introduction Forum

Tracing Signals Forum

Week 2: Ideal Operational Amplifiers

Learning Objective(s)

1. Ideal op-amp terminal characteristics
2. Analysis of op-amp circuits containing passive components
3. Closed-loop and open-loop gain
4. Inverting and non-inverting amplifier circuits
5. Input and output resistance of an amplifier

LO-1, LO-2, LO-3, LO-6

Readings

Microelectronic Circuits: Chapter 2 Operational Amplifiers

(pgs 53-71)

Assignment(s)

Week 2 Assessment

Laboratory 1: OpAmp Circuits

Exercises

Tracing Signals Forum

Week 3: Non-ideal Op-amps and Practical Circuits

Learning Objective(s)

1. Non-ideal Op-amp characteristics including offset, input bias currents, frequency response
2. Difference and instrumentation amplifiers
3. Integrators and differentiators
4. Saturation, slew rate and output limits of op-amps
5. Frequency response of op amps circuits

LO-1, LO-2, LO-3, LO-6

Readings

Microelectronic Circuits: Chapter 2 Operational Amplifiers

(pgs 71-107)

Assignment(s)

Week 3 Assessment

Laboratory 1: OpAmp Circuits

Exercises

History of Integrated Circuits Forum

Week 4: Semiconductors

Learning Objective(s)

1. Basic properties of semiconducting materials
2. Energy band gaps
3. Doping and charge carrier concentrations
4. Drift and diffusion currents in semiconductor devices
5. Basic operation of semiconductor interfaces, specifically PN junctions
6. Optical properties of semiconducting materials

LO-1, LO-6, LO-7

Readings

Microelectronic Circuits: Chapter 3 Semiconductors (pgs 124-160)

Microelectronic Circuits: Appendix A: VLSI Fabrication (pgs A1-A16)

Lessons in Electric Circuits Vol III: Chapter 2 Solid State Device Theory (pgs 28-55)

Assignment(s)

Microelectronic Circuits: Chapter 3 Semiconductors (pgs 124-160)

Microelectronic Circuits: Appendix A: VLSI Fabrication (pgs A1-A16)

Lessons in Electric Circuits Vol III: Chapter 2 Solid State Device Theory (pgs 28-55)

Week 5: Exam 1

Learning Objective(s)

1. Signals, amplifiers and transducers
2. Operational amplifier ideal characteristics
3. Operational amplifier practical circuits and non-ideal performance
4. Semiconductors

LO-1, LO-2, LO-3, LO-5

Readings

None

Assignment(s)

Exam 1

Week 6: Diodes

Learning Objective(s)

1. Characteristics of an ideal diode
2. Bias regions of a junction diode: forward, reverse and breakdown
3. Practical diode circuit models
4. Special purpose diodes
5. Optical devices based on pn junctions

LO-1, LO-4, LO-7

Readings

Microelectronic Circuits: Chapter 4 Diodes (pgs 164-194)

Lessons in Electric Circuits Vol III: Chapter 3.12 – Special Purpose Diodes (pgs 143-159)

Assignment(s)

Week 6 Assessment

Laboratory 2: Diodes – Exercises

Explaining the Diode Forum

Week 7: Diodes and Rectifying Circuits

Learning Objective(s)

1. Half-wave, full-wave and bridge rectifiers
2. Filtering stages
3. Limiting circuits
4. Varactors

LO-1, LO-4, LO-5, LO-7

Readings

Microelectronic Circuits: Chapter 4 Diodes (pgs 194-215)

Assignment(s)

Week 7 Assessment

Laboratory 2: Diodes – Exercises

Explaining the Diode Forum

Week 8: Bipolar Junction Transistors

Learning Objective(s)

1. Physical structure of a bipolar junction transistor (BJT)
2. Current-voltage characteristics of a BJT (NPN and PNP)
3. Current gain in NPN and PNP devices
4. Graphical representation of BJT characteristics
5. DC operation of BJT circuits

LO-1, LO-2, LO-6, LO-7

Readings

Microelectronic Circuits: Chapter 6 Bipolar Junction Transistors (pgs 350-396)

Assignment(s)

Week 8 Assessment

Laboratory 2: Diodes – Report

Laboratory 3: BJT Circuits - Exercises

Nanotechnology Forum

Week 9: BJT Amplifiers

Learning Objective(s)

1. Amplifier circuits using BJT as the active component
2. Small signal models of BJT
3. Common-emitter, common-collector and common-base amplifier configurations
4. DC biasing of BJT amplifier circuits
5. BJT constant current source
6. Frequency response of amplifiers

LO-2, LO-3, LO-5, LO-6

Readings

Microelectronic Circuits: Chapter 6 Bipolar Junction Transistors (pgs 396-466)

Assignment(s)

Week 8 Assessment

Laboratory 3: BJT Circuits - Exercises

Nanotechnology Forum

Week 10: Exam 2

Learning Objective(s)

1. Diode characteristics and operation
2. Rectifying circuits
3. BJT characteristics and current-voltage relationships
4. DC biasing of BJT circuits
5. BJT amplifiers

LO-1, LO-2, LO-3, LO-4, LO-5

Readings

None

Assignment(s)

Exam 2

Laboratory 3: BJT Circuits - Report

Week 11: Metal-Oxide-Semiconductor Field Effect Transistors

Learning Objective(s)

1. Physical structure of a metal-oxide-semiconductor field effect transistor (MOSFET)
2. Current-voltage characteristics of a MOSFET (NMOS and PMOS)
3. Complementary MOS (CMOS)
4. MOSFET regions of operation
5. DC operation of MOSFET circuits

LO-1, LO-2, LO-6

Readings

Microelectronic Circuits: Chapter 5 MOSFETs (pgs 230-267)

Assignment(s)

Week 11 Assessment

Laboratory 4: MOSFET Circuits - Exercises

Complexity of Systems Forum

Week 12: MOSFET Circuits and Amplifiers

Learning Objective(s)

1. MOSFET amplifier design
2. Small signal models
3. Common-source, common-gate and common-drain configurations
4. Gate leakage and input resistance
5. DC biasing in MOSFET circuits
6. CMOS inverter operation

LO-1, LO-2, LO-3

Readings

Microelectronic Circuits: Chapter 5 MOSFETs (pgs 268-328)

Microelectronic Circuits: Chapter 5 MOSFETs (pgs 268-328)

Assignment(s)

Week 12 Assessment

Laboratory 4: MOSFET Circuits – Exercises

Complexity of Systems Forum

Week 13: Integrated Circuit Amplifier Building Blocks

Learning Objective(s)

1. Basic IC design philosophies
2. Basic gain cells
3. Cascoded amplifiers
4. Current sources and current mirrors
5. Basic multi-transistor circuits

LO-2, LO-3, LO-6

Readings

Microelectronic Circuits: Chapter 7 Building Blocks of Integrated- Circuit Amplifiers (pgs 491-553)

Assignment(s)

Week 13 Assessment

Laboratory 4: MOSFET Circuits - Report

Laboratory 5: Amplifier Circuits - Exercises

Energy Forum

Week 14: Differential and Power Amplifiers

Learning Objective(s)

1. MOS and BJT differential pairs
2. Differential input operation of amplifiers
3. Common-mode gain and common-mode rejection
4. Amplifier output stage classification
5. Output stage distortion and efficiency

LO-2, LO-3, LO-6

Readings

Microelectronic Circuits: Chapter 8 Differential and Multistage Amplifiers (pgs 587-628)

Chapter 11 – Output Stages and Power Amplifiers (pgs 911-933)

Assignment(s)

Week 14 Assessment

Laboratory 5: Amplifier Circuits - Exercises

Energy Forum

Week 15: Frequency Response and Feedback

Learning Objective(s)

1. Filtering of amplifier gain using coupling and bypass capacitors
2. Modeling the frequency effects of internal capacitance on MOSFET and BJT amplifiers
3. High-frequency limitations of devices
4. Negative feedback in circuit operation
5. Feedback topologies

LO-2, LO-3, LO-5, LO-7

Readings

Microelectronic Circuits: Chapter 9 Frequency Response (pgs 687-720)

Microelectronic Circuits: Chapter 10 – Feedback (pgs 803-822)

Assignment(s)

Week 15 Assessment

Laboratory 5:

Amplifier Circuits – Report

Week 16: Final Exam

Learning Objective(s)

1. All Material from course

LO-1, LO-2, LO-3, LO-4, LO-5

Readings

None

Assignment(s)

Final Exam

Evaluation

Instructor announcements: Weekly announcements will appear on Monday of each week in the online classroom. The announcement will discuss the assignments for the week along with any other pertinent information for the week.

This is a junior level course; all students' work is to be presented as such in terms of quality and content. The grading system will be based on your participation in the forums (120 points or ~10% of your total grade), weekly assessments (390 points or ~30% of your grade), laboratory reports (375 points or ~25 % of your grade) and three exams (450 points or ~35% of your grade).

Reading Assignments: Please refer to the Course Outline section of this syllabus for the weekly reading assignments.

Week 1 Introductions: Each student must log into the classroom and introduce themselves to the class. This is a required assignment and introductions are due by Sunday of Week 1. Your response must be 250-300 words (a requirement) and include the following information.

a. Your name
b. Your university major or program
c. Where you are in the program of study
d. Your academic goals, to include why you are taking this class
e. Information that you would like to share about yourself

Weekly Forums: The weekly discussion forum is for students to post their questions on course content for that week. This forum should not be used to discuss specific test questions prior to receiving feedback from the instructor (after the test is graded). If there is a question on a specific item, find a similar problem in the book and ask a question on that. Asking specific questions on test questions creates an unfair advantage and defeats the purpose of the assessment tool.

Weekly Assignments: There will be thirteen weekly assessments during the course worth approximately 30% of your total grade. Each weekly assignment will cover material from the textbook used in this course as well as additional materials discussed in the lesson.

Exams: There will be three exams, two worth 15% of your final grade and a final exam worth 20%. Exams will be open book, open note tests. Exams will be administered without a proctor. Students must complete the numbered exam by the end of the week indicated in the schedule.

Grading:

Name	Grade %

Materials

Book Title: Additional required items are available to order from the APUS Bookstore. If you buy these items from other vendors, you may not receive all the parts you need for your course. These items (as noted)

are not covered by the APUS Book Grant.

Author: N/A

Publication Info: N/A

ISBN: N/A

Book Title: Microelectronic Circuits, 7th ed.

Author: Sedra/Smith

Publication Info: Oxford University Press

ISBN: 9780199339136

Book Title: NI Student Software Suite - access instructions provided inside the classroom

Author: National Instruments

Publication Info: National Instruments

ISBN: 779252-3501

Book Title: NI myRIO Starter Accessory Kit - this item is not covered by the APUS Book Grant

Author: National Instruments

Publication Info: National Instruments

ISBN: 783068-01

Book Title: myParts Kit from Texas Instruments - this item is not covered by the APUS Book Grant

Author: National Instruments

Publication Info: National Instruments

ISBN: 783752-01

Book Title: NI Elvis Kit - this item is not covered by the APUS Book Grant

Author: National Instruments

Publication Info: National Instruments

ISBN: 780381-02

Book Title: You must validate your cart to get access to your hard copy materials. If needed, instructions are available here - http://apus.libguides.com/bookstore/undergraduate

Author: N/A

Publication Info: N/A

ISBN: N/A

Websites

Site Name- ELEN306 Resources

Website URL/Address- http://development.mumechanical.com/apus/ENGR309

Course Guidelines

Citation and Reference Style

- Attention Please: Students will follow the APA Format as the sole citation and reference style used in written work submitted as part of coursework to the University. Assignments completed in a narrative essay or composition format must follow the citation style cited in the APA Format.

Tutoring

- Tutor.com offers online homework help and learning resources by connecting students to certified tutors for one-on-one help. AMU and APU students are eligible for 10 free hours* of tutoring provided by APUS. Tutors are available 24/7 unless otherwise noted. Tutor.com also has a SkillCenter Resource Library offering educational resources, worksheets, videos, websites and career help. Accessing these resources does not count against tutoring hours and is also available 24/7. Please visit the APUS Library and search for 'Tutor' to create an account.

Late Assignments

- Students are expected to submit classroom assignments by the posted due date and to complete the course according to the published class schedule. The due date for each assignment is listed under each Assignment.
- Generally speaking, late work may result in a deduction up to 15% of the grade for each day late, not to exceed 5 days.
- As a working adult I know your time is limited and often out of your control. Faculty may be more flexible if they know ahead of time of any potential late assignments.

Turn It In

- Faculty may require assignments be submitted to Turnitin.com. Turnitin.com will analyze a paper and report instances of potential plagiarism for the student to edit before submitting it for a grade. In some cases professors may require students to use Turnitin.com. This is automatically processed through the Assignments area of the course.

Academic Dishonesty

- Academic Dishonesty incorporates more than plagiarism, which is using the work of others without citation. Academic dishonesty includes any use of content purchased or retrieved from web services such as CourseHero.com. Additionally, allowing your work to be placed on such web services is academic dishonesty, as it is enabling the dishonesty of others. The copy and pasting of content from any web page, without citation as a direct quote, is academic dishonesty. When in doubt, do not copy/paste, and always cite.

Submission Guidelines

- Some assignments may have very specific requirements for formatting (such as font, margins, etc) and submission file type (such as .docx, .pdf, etc) See the assignment instructions for details. In general, standard file types such as those associated with Microsoft Office are preferred, unless otherwise specified.

Disclaimer Statement

- Course content may vary from the outline to meet the needs of this particular group.

Communicating on the Forum

- Forums are the heart of the interaction in this course. The more engaged and lively the exchanges, the more interesting and fun the course will be. Only substantive comments will receive credit. Although there is a final posting time after which the instructor will grade comments, it is not sufficient to wait until the last day to contribute your comments/questions on the forum. The purpose of the forums is to actively participate in an on-going discussion about the assigned content.
- “Substantive” means comments that contribute something new and hopefully important to the discussion. Thus a message that simply says “I agree” is not substantive. A substantive comment

contributes a new idea or perspective, a good follow-up question to a point made, offers a response to a question, provides an example or illustration of a key point, points out an inconsistency in an argument, etc.
- As a class, if we run into conflicting view points, we must respect each individual's own opinion. Hateful and hurtful comments towards other individuals, students, groups, peoples, and/or societies will not be tolerated.

Identity Verification & Live Proctoring

- Faculty may require students to provide proof of identity when submitting assignments or completing assessments in this course. Verification may be in the form of a photograph and/or video of the student's face together with a valid photo ID, depending on the assignment format.
- Faculty may require live proctoring when completing assessments in this course. Proctoring may include identity verification and continuous monitoring of the student by webcam and microphone during testing.

University Policies

Student Handbook

- Drop/Withdrawal policy
- Extension Requests
- Academic Probation
- Appeals
- Disability Accommodations

The mission of American Public University System is to provide high quality higher education with emphasis on educating the nation's military and public service communities by offering respected, relevant, accessible, affordable, and student-focused online programs that prepare students for service and leadership in a diverse, global society.