

**MICROELECTRONIC CIRCUITS DESIGN - ELEC 310
2015 FALL**

Class Meeting Location	CASEZ48
Class Meeting Times	Mo We 16:00 - 17:15
Instructor	Şükrü Ekin Kocabaş
Office Hours	Wed 15:00 – 16:00 or by appointment
Office Location	ENG Z11
Office Phone	1776
Email	ekocabas@ku.edu.tr
Web Address	http://courses.ku.edu.tr/elec310/
Number of Credits	4
ETCS Credit	6
Prerequisites	ELEC. 202
Language	English
Lab Session 1	To be announced (3 hrs) (ENG 114)
Lab Session 2	To be announced (3 hrs) (ENG 114)
PS Session 1	To be announced (75 mins, same time as lab) To be announced
PS Session 2	To be announced (75 mins, same time as lab) To be announced

Assistants

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Course Description

Microelectronic Circuits Design aims to provide a basic understanding of analog integrated circuits, as well as an introduction to electronic devices. The course consists of two 75-minute lectures every week. In addition to the lectures, every week, there will either be one problem session at which the homework and lecture material will be reviewed, or one three-hour laboratory.

Course Objectives

This course aims to provide a basic introduction to, and an understanding of, semiconductor materials (silicon), semiconductor electronic devices (pn-junction diodes and metal-oxide-semiconductor-field effect and bipolar junction transistors, MOSFET and BJT) and the analysis techniques and design principles for analog integrated amplifier circuits.

Learning Outcomes

Students who have taken this course are expected to be able to:

- 1) Understand the basic physics of silicon crystal structure and pn-junction silicon diodes.
- 2) Understand the engineering of silicon based on doping with impurities.
- 3) Understand the basic electrostatics of, and basic current conduction mechanisms in, silicon.
- 4) Understand the theory of small-signal equivalent models and small-signal analysis.
- 5) Apply large and small-signal analysis to circuits containing diodes and passive elements.
- 6) Understand the basic physics and operation of BJT transistors, including structure and operational regimes (saturation, triode, etc.).
- 7) Understand and apply large and small-signal models of BJTs to solve for both bias points and small-signal gain, input/output impedances, and frequency response of canonical and multi-stage amplifier topologies.
- 8) Understand the basic physics and operation of the Metal Oxide Semiconductor Field Effect Transistor (MOSFET), including structure, operational regimes (depletion, inversion, etc.), current-voltage characteristics.

- 9) Understand and apply large and small-signal models of MOSFETs to solve for both bias points and small-signal gain, input/output impedances, and frequency response of canonical and multi-stage amplifier topologies.
- 10) Understand and apply frequency domain analysis to small-signal equivalent circuits based on Miller approximations and Open Circuit Time Constant (OCTC) analysis.

Teaching Methods

The duration of the course is 14 weeks. The course consists of two 75-minute lectures every week. In addition to the lectures, there are six 75-minute problem sessions, held every other week, at which the homework and lecture material will be reviewed, and there are six 150 minute laboratory sessions also held every other week alternating with the problem sessions. Every problem session is associated with a homework assignment handed out every other week. In addition to attending the lectures, the problem and laboratory sessions, students need to allocate self study time in order to review the lecture material, prepare for the problem sessions, laboratory sessions, written examinations, and work on the solution of the homework problems. There is one written midterm examination and a written final examination.

Lecture Attendance and Lecture Notes

Attendance to the lectures will not be monitored. However, you are strongly encouraged to attend the lectures. Most importantly, you are responsible for any announcement that will be made during lecture hours. Lecture notes will be made available on the website, and they reflect the material that will be covered during the lectures. A detailed list of chapter and section numbers for the textbook that will be covered during the course are also provided on the website. We make every effort so that this information and the lecture notes accurately reflect the material discussed in class. However, this information and the lecture notes on the website are for your convenience only. Ultimately, you are responsible for what is covered and *emphasized* during the actual lecture hours.

Problem Session and Laboratory Attendance

It is mandatory to attend the problem and laboratory sessions. Homeworks and laboratory assignments will involve using SPICE for electronic circuit simulation. For homework assignments that involve SPICE, no credit will be given unless the SPICE portions are completed. For this course on electronic devices and analog integrated circuit design, the execution of the homeworks and the laboratory assignments are extremely important and will play a major role in the final grade you receive. It will not be possible to receive a passing grade in this course with only midterm and final examination performance. The execution of the homeworks and laboratory assignments will be rigorously checked for any plagiarism. No late lab reports or homeworks will be accepted. The homeworks are due on the day of the problem session in which they will be reviewed, as shown in the schedule on the website. The pre-lab reports are due at the beginning of the laboratory session, as explained above. The post-lab reports are due at the next laboratory session as shown in the schedule on the website. Satisfactory completion of the laboratory is required in order to receive a grade in the course. If you miss more than one (1) laboratory session without any acceptable excuse, you will automatically receive an F grade for this course. You need to individually prepare the prelab and attend the lab section you are assigned to. If you come to the lab without having prepared the prelab, you will not be admitted to the lab, will receive zero credit, and moreover, you will be treated as if you have missed the lab without an excuse. This will count towards the number of labs (1) you are allowed to miss without an excuse. This policy will be strictly enforced, starting with the first lab.

Quizzes will be administered at the problem and laboratory sessions. Your performance on these quizzes will have a significant effect on the the lab and homework credits you will receive.

Assessment Methods

Type	Description	Final Grade %
Quiz	Homework assignments and quizzes during problem sessions.	10
Lab	6 lab sessions	20
Midterm Test		30
Final Exam		40
Total		100

Required Text Book

Microelectronic Circuits, 6th edition (international), Oxford, 2011, Sedra & Smith.

Reference Book

Fundamentals of Microelectronics, 2nd edition, Wiley, 2014. B. Razavi
The first edition of the book is just as well

Modern Semiconductor Devices for Integrated Circuits, Prentice Hall, 2010, C. C. Hu

This book is available online. It will be used in the device physics oriented parts of the course.
<http://www.eecs.berkeley.edu/~hu/Book-Chapters-and-Lecture-Slides-download.html>

Microelectronics: an Integrated Approach , Prentice-Hall, 1997. R. T. Howe and C. G. Sodini
This is an out of print book, available from the instructor upon request.

Academic Dishonesty

Academic dishonesty, including cheating on exams, quizzes and homework is a serious offense and will not be tolerated. University policies regarding this matter will be strictly enforced. Please read the section on academic dishonesty in the university catalog.

<http://vpaa.ku.edu.tr/tr/rules-and-regulations/student-discipline-regulations>

<http://dos.ku.edu.tr/tr/regulations-undergrad>

<http://vpaa.ku.edu.tr/tr/academic/student-code-of-conduct>

[http://vpaa.ku.edu.tr/sites/vpaa.ku.edu.tr/files/Misc_Documents/Statement on Academic Honesty.pdf](http://vpaa.ku.edu.tr/sites/vpaa.ku.edu.tr/files/Misc_Documents/Statement_on_Academic_Honesty.pdf)

Policy on Makeups

If you miss any lab or exam with a valid excuse, you can take the relevant make-up for that part. Quizzes do not have makeups, instead, those you missed with a valid excuse will not be counted with the remaining ones weighing a greater amount. For health related issues you need to get your excuse approved by the health center. For other emergencies, you should get in touch with the instructor as early as possible. Regardless of your excuse, fill out the form on the course website to get your excuse processed.

<http://courses.ku.edu.tr/elec310/>

Lab Rules

- There will be 6 *laboratory sessions* throughout the semester. Each laboratory session needs to be completed in 2:45 hours.
- *If you miss two lab sessions* without an approved excuse (e.g. medical report or instructor's consent), you will automatically get an *F* from the course. There will be a single make-up session for all the labs during the finals week for all those with an approved excuse.

- No one is allowed to *change lab sessions* without prior approval from TAs and the instructor.
- Each student will have *one partner* during the experiments to be selected during the first lab session. The students are not allowed to change partner or the lab bench throughout the semester without TAs consent.
- Every student is *individually* required to prepare and submit a *preliminary report* before the experiment. Preliminary report questions will be posted on the course web site prior to the experiments. The purpose of the preliminary report is to get the student acquainted with the procedure that will be followed during the experiment. You will not be allowed in the lab without a preliminary report.
- Before each experiment, there will be a *quiz* that is similar to the preliminary report questions. The quizzes will start at the very beginning of the lab session and all students have to return the quiz papers at the same time. Those who come in late will have to miss the quiz.
- If you are *late for more than 30 minutes*, you will not be allowed to join the lab. Please make sure you are on time.
- In order to receive full credit, you have to show the TA that each setup in the experiment is completed and *receive a check mark* before you proceed with the experiment.
- After each laboratory session each group is required to *keep the bench clean and organized*, i.e. each component used should be returned to relevant box, the devices should be turned off etc. Leaving the bench with a mess after the laboratory session will result in a 20% decrease in the overall lab grade.
- You will need to prepare *a lab report* for each lab. The structure of the report is outlined in the following section. Lab reports will be due the next lab session, unless noted otherwise.
- If you took this class before, you may be *exempt from the lab section* based on your lab performance the last time you took the class. Please get in touch with the instructor to be exempt from labs.

Lab Report Guidelines

Two partners should *turn in a joint report*, which should be prepared collectively by both partners.

Below are the parts of the lab report.

Title Page

Full Names of both students
Student Numbers
Lab Section
Experiment Number

Question 1, 2, 3...

Answer the questions under the section called "Procedure" or "Measurements" in the order given in the lab manual. Clearly specify which section of the lab manual you are referring to while answering questions. This section should include PSPICE results, data taken during the experiments, associated figures as required, and relevant discussion sections.

Conclusion

Add your comments about the experiment and the difficulties you encountered in your conclusions section.

Appendix

You need to add the PSpice schematic print outs (or netlists) that you have analyzed in your preliminary work to your lab report.

Notes

- Specify the name of the axes and units in all your plots
- For your PSpice and oscilloscope screen outputs, clearly specify voltage levels, time divisions, etc (Do not forget to include the units of your measurements.)
- Instead of a single figure, you can easily fit 2-4 figures on a single page to save paper.
- If there is a change in the value of any components during experiment with respect to the manual sheet, please point out that change in your report.
- If you take material from an external source, you need to properly cite the source. Use footnotes for citations and make sure you read the following material on academic writing.
 - http://vpaa.ku.edu.tr/sites/vpaa.ku.edu.tr/files/Misc_Documents/Statement_on_Academic_Honesty.pdf

Tentative Schedule

- Basics of semiconductor physics (2 lectures)
- PN junction electrostatics and I-V relationships (3 lectures)
- Diode circuits (1 lecture)
- BJT device physics (2 lectures)
- BJT amplifiers (2 lectures)
- MOS device physics (2 lectures)
- MOS transistors (2 lectures)
- MOS amplifiers (2 lectures)
- Amplifier stages, cascodes, current sources, current mirrors (4 lectures)
- Frequency response of amplifiers (4 lectures)

These topics correspond to Chapters 1, 3, 4, 5, 6, 8 of Sedra & Smith as well as selections from Chapters 1, 2, 4, 5, 6, 8 of Hu.