Spring 2024

ECE 271-HM1: Electronic Circuits I

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ECE 271 ELECTRONIC CIRCUITS I
Spring 2024 Course Outline

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Office Hours (ECEC 203)**:** Wednesdays 1-4 PM, and by appointment (email).
Teaching assistant: None

Course description: Electronic devices, junction diodes, bipolar transistors, and field-effect transistors are introduced and studied based on semiconductor physics models. The study then continues with the analysis and design of main digital electronic circuits (NMOS and CMOS inverters and logic gates, MOS memory and storage circuits) and an introduction to analog electronic circuits such as simple one-transistor amplifiers.
Prerequisite: ECE 231, Co-requisite ECE 232
Main text: Microelectronic Circuit Design / Richard Jaeger & Travis Blalock, 5th Edition, McGraw Hill. ISBN 978-0-07-352960-8
Reference text (optional): Microelectronic Circuits / Sedra & Smith, 6th edition, Oxford University Press. ISBN 978-0-19532203-0

Specific course learning outcomes

By the end of the course students are supposed to being able to perform the following tasks.

#	Topic	Outcome
1	2	Calculate the major physical parameters in doped semiconductors and pn-junctions.
2	3	Analyze (calculate voltages and currents) simple diode circuits using different diode models. [1]
3	3	Analyze (find voltages and currents and sketch their time graphs) and design different types of rectifier circuits. [1]
4	4	Demonstrate the knowledge of MOSFET (JFET) region models and their IV-characteristics. Draw the IV-characteristics of a MOSFET from its parameters and find parameters using the IV-characteristics. [1]
5	4	Analyze (calculate voltages and currents) a simple MOSFET (JFET) bias circuit and find its Q-point.
6	4	Design a simple MOSFET (JFET) bias circuit for a given specification.
7	5	Identify different models of BJT, regions of operations, and their IV-characteristics. [1]
8	5	Analyze (calculate voltages and currents) a simple BJT circuit and find its Q-point. [1]
9	5	Design a simple BJT bias circuit for a given specification..
10	6	Formulate the concept of ideal operational amplifier; identify its major properties and main types of op-amps circuits.
11	6	Analyze the simple circuits that include op-amps (find voltages and currents using op-amps properties and circuit laws). [1]
12	6	Analyze one transistor (MOSFET, BJIT) amplifier circuit (draw DC, AC, small signal model equivalent circuits, find their parameters and parameters of amplifier).
13	7	Identify different types of NMOS logic inverter gates and list their major benefits and deficiencies.
14	7	Analyze (find logic voltage levels and currents) and design 5 types of NMOS inverter gates
15	7	Determine the logic function of an arbitrary complex NMOS logic gate and design it for a given logic function and specifications.
16	8	Draw a CMOS inverter gate voltage transfer characteristic from I-V characteristics of a NMOS and PMOS transistors. Identify and explain its regions.
17	8	Determine the logic function of an arbitrary complex CMOS logic gate; design it a CMOS logic gate for a given logic function and time response specifications..
18	9	Draw the circuit of a static (6T) and dynamic (1T) memory cell and explain in details the process of reading and writing a bit of information in it.
19	9	Draw the circuit of a typical sense amplifier and explain how it works
20	9	Draw a circuit of a simple (2-3 bit) NOR/NAND NMOS address decoder and explain how it decodes a given address.
		[1] Includes use of Multisim simulation.

The exams questions will be mostly based on the course outcomes items.

Course Topics

Day	Topic	Topic details	Textbook section	Assignments
1	1. Introduction	Intro and history Analog and digital signals. AC-DC converters Review of circuit analysis Elements parameter variation in circuit design	1.1 1.2 1.5 1.8	See Canvas
1,2	2. Intro to semi-conductor physics	Semiconductor materials. Covalent bonds Drift current, mobility, resistivity of intrinsic silicon Doping and its effects Diffusion and total currents PN junction physics	2.1, 2.2 2.3, 2.4 2.5-2.7 2.8-2.9 3.1	
2,3	3. Diodes	I-V characteristics and equation. Reverse and forward bias. Reverse breakdown. Diode models and diode circuit analysis Diode analysis in breakdown region. Diode rectifier circuits and other applications	3.2-3.4 3.6 3.10, 3.11 3.12 3.13-3.16	
		Test 1		
4,5,6	4. MOSFET	MOS transistor physics NMOSFET analysis PMOS transistor MOSFET circuit analysis and biasing JFET Transistors	4.1-4.2.0 4.2.1-4.2.9 4.3 4.9-4.10 4.11	
6,7	5. BJT	BJT physics and models (npn) Pnp BJT I-V characteristics Simplified circuit models Biasing and circuit design	5.1, 5.2.1, 5.2.2 5.3 5.5 5.6, 5.7 5.11	
		Test 2		
8,9	6. Intro to analog circuits a) OpAmps (Amp. as a system) b) Single transistor amplifier (Amp. as a circuit)	Amplifiers and two port models Op amp intro. Ideal op amp. Circuit analysis with op amps Transistor as an amplifier DC, AC equiv. models Small signal BJT model Common emitter amplifier Small signal MOSFET model Common source amplifier	10.2, 10.3 10.5, 10.7, 10.8, 10.9 13.1, 13.2 13.3 13.4,13.5 13.6, 13.7 13.8, 13.9 13.10, 13.11	
		Test 3		
10,11	7. Intro to digital circuits. NMOS inverters and gates	Logical gates: concept and definitions NMOS inverter, resistive load NMOS inverter, transistor load NMOS NAND and NOR gates Complex NMOS logic design Power dissipation Dynamic behavior of NMOS gates	6.1, 6.2, 6.3 6.5 6.6, 6.7 6.8.1, 6.8.2 6.9 6.10 6.11(1,2,3)	
12,13	8. CMOS circuit design	CMOS inverter basics and Voltage Transfer Characteristic CMOS inverter dynamic behavior Power dissipation NAND and NOR gates CMOS complex gates Domino CMOS logic	7.1, 7.2 7.3.1, 2, 3 7.4 7.5 7.6, 7.7 7.8	
13,14	9. MOS memory	Static memory cells Dynamic memory cells Sense amplifiers Memory architecture and address decoders Read-only memory, flash memory Flip-flops	8.2 8.3.1, 8.3.2 8.4.1, 8.4.2 8.1(1,2), 8.5(1,2,4) 8.6 8.7	
15		**FINAL EXAM**		

Changes in the course outline are possible and will be announced in the class and on Canvas.

Homework Policy
Homework assignments will be assigned and worth 10 points each. The six highest will count toward your final grade.. Solutions will be posted on Canvas after all submissions are received.

The textbook and slides contain numerous examples with solutions. Students are encouraged to study these examples and practice on the suggested problems for each module. **This is the best way to learn how to solve problems and prepare for the exam.**

Circuit simulations
Circuit simulation is very important part of the course. Many topics will be accompanied by Multisim modeling. The suggested problems also include simulation problems. Students are required to purchase the student version of Multisim and use it for active experiments to better understand circuits. **There will be five graded simulation assignments during the course.** Each will be graded at 10 points. At the end of the course, I will use all except the lowest score in your final grade. The top two simulation assignments will then be scaled out of 15 pts. **The submitted assignments should represent the original student's work. Attempts of plagiarism, compilation, and borrowing from other students will result in a grade of 0.** The simulations should be submitted to Canvas on time. Late submissions (6h – 5 days late) will be graded at 50%. Submissions more 5 days late will not be accepted.

A Multisim **simulation project** will be offered at the end of semester as an ***extra credit*** of up to 30 points. (except for honors students). The project topics will be assigned randomly and are strictly individual. **Attempts of plagiarism and/or borrowing part of a solution from other students will result in 0 point grade.**

Grading Policy
The course grade will be based on tests quizzes and simulation assignments:

3 Exams @ 100 points	300
Homework	60
Simulation assignments	50
Final examination	100
Total	510

Honors students will also have the Honors Project (100 pts), which will be their honors credit. This will be assigned at the same time as the extra credit project.

Exams
All exams are closed books and notes. You can create your own formula sheets based on the instruction given in class and on Canvas. Exams are based on the lecture, homework, and suggested problems.

Test grading: Full credit — for detailed correct solution showing all steps. Partial credit — for partially correct answers. Answers with no work/explanation (even if correct) will receive minimal credit. Critical errors (circuit labeling, Kirchoff's and Ohm's law) typically will have significantly bigger weight.

The grade improvement policy: students are allowed to retake **one** (the lowest grade) exam during the final.

Make-up exams are possible only under extenuating circumstances confirmed by the Dean of Students. In all other cases the grade improvement policy can be used.

NJIT Honor Code

"Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that you are working on. As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. ***Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university.*** *If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu"*