

**Helen and John C. Hartmann Department of Electrical and Computer Engineering  
New Jersey Institute of Technology**

**ECE 271 Electronic Circuits I. 3 credits**

**Instructor:** Dr. Serhiy Levkov. **E-mail:** [levkov@njit.edu](mailto:levkov@njit.edu) **WEB:** <http://web.njit.edu/~levkov/> **Phone:** 973 642 7676.

**Text** Microelectronic Circuit Design / Jaeger & Blalock, 5th Edition, McGraw Hill, 2011. ISBN 978-0-07-338045-8

**Course description:** The electronic devices, junction diodes, bipolar transistors and field-effect transistors, are introduced and studied based on semiconductor physics models. The study then continues with analysis and design of main digital electronic circuits (NMOS and CMOS inverters and logic gates, MOS memory and storage circuits), and with introduction to analog electronic circuits such as simple one transistor amplifiers.

**Required course. Prerequisite** ECE 231. **Corequisite** ECE232.

**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. <sup>1</sup>
3	3	Design different types of rectifier circuits and analyze them (find voltages, currents and sketch their time graphs) <sup>1</sup>
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. <sup>1</sup>
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. <sup>1</sup>
8	5	Analyze (calculate voltages and currents) a simple BJT circuit and find its Q-point. <sup>1</sup>
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) . <sup>1</sup>
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 the different types of NMOS logic inverter gates and list their major benefits and deficiencies.
14	7	Design and analyze (find logic voltage levels and currents) 5 types of NMOS inverter gates
15	7	Design the NMOS logic gate circuit for a given logic function and specifications. Determine the logic function of a complex NMOS logic gate.
16	8	Draw a CMOS inverter gate voltage transfer characteristic from IV-characteristics of a NMOST and PMOST. Identify and explain its regions.
17	8	Design the CMOS logic gate circuit for a given logic function and time response specifications. Determine the logic function of an arbitrary complex CMOS logic gate.
18	9	Draw the schematic 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 schematic of a typical sense amplifier and explain how it works
20	9	Draw a schematic of a simple (2-3 bit) NOR/NAND NMOS address decoder and explain how it decodes a given address.
		<sup>1</sup> Includes use of Multisim simulation.

**Student outcomes addressed by the course**

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (CLO 2, 5, 7, 8, 11, 12, 14, 15,16).
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (CLO 3, 6, 9, 14,15, 17).
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions (CLO 2,3,4,7,8,11).
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.. (CLOs 1, 4, 18, 19, 20)

## Course Topics

Week	Topic	Topic details	Text section
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
1,2	2. Semi-conductors	Semiconductor materials. Covalent bonds Drift current and mobility Doping. Diffusion and total currents PN junction physics	2.1, 2.2 2.3 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 4.2.1-4.2.8. 4.3 4.9-4.10 4.11
6,7	5. BJT	BJT physics and models (npn-pnp) I/V characteristics. Circuit models simplification Biasing and circuit design	5.1, 5.2, 5.3 5.5. 5.4-5.7 5.11
		Test 2	
8,9	6. Intro to OpAmps (Ampl. as a system) Single transistor amplifier (Ampl. 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
10,11	7. Intro to digital circuits	Logical gates and definitions, Boolean algebra review 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, 6.4 6.5. 6.6, 6.7 6.8.1, 6.8.2. 6.9 6.10. 6.11.1,2,3
12		Test 3	
12,13	8. CMOS circuit design	CMOS inverter basics and Voltage Transfer Characteristic CMOS inverter dynamic behavior. Power dissipation CMOS NAND and NOR gates. CMOS complex gates	7.1, 7.2 7.3.1, 2, 3. 7.4 7.5. 7.6, 7.7
13,14	9. MOS memory	Static memory cells Dynamic memory cells Sense amplifiers. Memory architecture and address decoders Read-only memory (ROM). Flip-flops	8.2 8.3.1, 8.3.2. 8.4.1, 8.4.2 8.1.1,2; 8.5.1,2 8.6. 8.7
15		<b>FINAL EXAM</b>	

### Homework Policy

The list of the assignment is on the course website and in Canvas. A significant number of homework problems will be assigned for each topic. The homework will not be graded (solutions will be posted on the web); instead, short quizzes (10p.each) will be conducted every week. 5 best results will be counted toward your quiz grade of 50.

### Circuits simulation

Circuit simulation is very important part of the project. There will be five graded simulation assignments during the course. A Multisim simulation project will be offered at the end of the course as an extra credit of up to 30p.

### Grading Policy

The course grade will be based on tests and quizzes (and on the project for honors students):

3 Tests @100 points	300
Short Quizzes	50
Simulation assignments	50
Final examination (all inclusive)	100
Project (honors students only)	(100)
<b>Total</b>	<b>500</b>

Tests and final exam are closed books and notes. A list of formulas will be provided by instructor.

### NJIT Honor Code

NJIT Honor Code will be strongly upheld. Violation will be brought to the immediate attention of the Dean of Students.