ELECTRICAL, COMPUTER, AND SYSTEMS ENGINEERING DEPARTMENT

ABET COURSE SYLLABUS

ECSE-4040 Digital Electronics

Course Catalog Description:

Analysis and design of switching-mode circuits: NMOS, CMOS, RTL, DTL, TTL, and ECL digital-logic families. Topics include: basic logic gates (voltage-transfer characteristics, noise margin, fan out, propagation delay, power dissipation), flip flops, Schmitt triggers, oscillators, timers, memories, A/D and D/A converters, and optional advanced topics. Spring term annually. *3 credit hour, 5 contact hours*

Pre-Requisite Courses:

ECSE-2050 Introduction to Electronics, ECSE-2610 Computer Components and Operations

Co-Requisite Courses:

None

Prerequisites by Topic:

1. Calculus, linear algebra, differential equations
2. Linear-circuit analysis (node and loop equations, steady state and transients, first-order *RC* networks, power)
3. Introductory electronics: including diode, MOSFET, and BJT devices.
4. Boolean logic and primitives (gates)

Textbook & Materials:

1. *Microelectronics: Circuit Analysis and Design*, 3rd Ed., D.A. Neamen
2. *B^2 Spice* Circuit Simulation Software, Beige Bag Software

References:

1. *Digital Course Notes*, Y.L. Le Coz, K. Rose, and T.P. Chow (required)
2. *D/A and A/D Converters*, Presentation Slides, D.A. Mercer, Analog Devices (supplemental)
3. *The SPICE BOOK*, A. Vladimirescu (optional)
4. *Semiconductor Device Fundamentals*, R.F. Pierret (optional)

Course Coordinator:

Yannick L. Le Coz

Overall Educational Objective:

We wish to teach students how to analyze and understand basic digital integrated circuits (ICs). The ability to perform both "*Hand*" circuit calculations and *Spice* circuit simulations is stressed. Particular emphasis is placed on MOS and BJT switching circuits. We treat, in some depth, advanced digital circuits—including regenerative circuits, IC memories, and digital converters. We expect, of note, that students will become familiar with the meaning of common terms and acronyms, and critical issues associated with modern digital-IC technology.

Course Learning Outcomes:

1. Develop skills for *Hand* circuit analysis of basic MOS digital gates: voltage-transfer characteristic (VTC), propagation delay time.
2. Develop skills for *Hand* circuit analysis of basic BJT digital gates: voltage-transfer characteristic (VTC), fan out, and average power dissipation, propagation delay time.
3. Achieve competency in setting *Spice* Level-1 model MOS and BJT parameters for both dc and transient computer simulation of digital circuits.
4. Show an ability to verify the results of *Hand* digital-circuit calculations by constructing appropriate network topologies and simulating them in *Spice*.

How Course Outcomes are Assessed:

40 Studio Problems (35%)
Mid-Term Exam (25%)
Final Exam (40%)

Relation to EE/CSE/EPE Outcomes:

N = none
M = moderate
H = high

Outcome	Level	Demonstrate Proficiency
	N, M, H	e.g. Exams, projects, HW
Mathematics, science and engineering	M	Studio Problems, Exams
Basic disciplines in Electrical Engineering	M	Studio Problems, Exams
Depth in Electrical Engineering	H	Studio Problems, Exams
Basic disciplines in Computer & Sys. Eng.	M	Studio Problems, Exams
Depth in Computer and Systems Eng.	M	Studio Problems, Exams
Electromagnetics, electromechanics, power semiconductors	N	
Power system behavior	N	
Electrical energy conversion	N	
Conduct experiments and interpret data	N	
Identify, formulate and solve problems	H	Studio Problems, Exams
Design a system, component or process	N	
Communicate in written and oral form	N	
Function as part of a multi-disciplinary team	N	
Preparation for life-long learning	M	Take-Home Mid-Term Exam
Ethical issues; safety, health, public welfare	N	
Humanities and social sciences	N	
Laboratory equipment and software tools	H	Studio Problems, Mid-Term Exam
Variety of instruction formats	M	Lecture, Studio

Topics Covered:

1. Introduction—1 Lectures, 1 Studio
2. MOSFETs—3 Lectures, 1 Studio
3. MOS Gates—4 Lectures, 2 Studios
4. Shockely Diode & Transients—2 Lectures, 1 Studio
5. Ebers-Moll Model & BJT Transients—2 Lectures, 1 Studio
6. BJT Inverters—4 Lectures, 2 Studios
7. BJT Gates—6 Lectures, 3 Studios
8. Regenerative Circuits —1 Lecture, 1 Studio
9. Memories—1 Lecture
10. A/D & D/A Converters—1 Lecture, 1 Studio, PowerPoint Presentation (for additional self-study).
11. GaAs Digital Circuits—Web links (provided for self-study).

Computer Usage:

Students use the computer circuit-simulation program *Spice* during each weekly three-hour Studio.

Laboratory Experiences:
(Computer Studio)

1. MOSFET Model and Body-Effect
2. NMOS & CMOS Digital Circuits, and Switching Transients
3. Shockley Diode Model, BJT Ebers-Moll Model, Diode & BJT Switching Transients
4. RTL Voltage Transfer Characteristic, Fan Out, and Switching Transients
5. DTL, TTL, and ECL Voltage Transfer Characteristic, Fan Out, and Average Power Dissipation
6. CMOS *RC* Oscillator
7. *R-2R* Ladder Digital-to-Analog Converter

Design Experiences:

None

Independent Learning Experiences:

1. Take-Home Mid-Term Exam requires independent thought and analysis, particularly in regard to the required *Spice* computer verifications of all *Hand* analyses.

Class/Lab Schedule:

M Th Lecture, 10:00am–11:20am; W Studio, 2:00pm–4:50pm

Contribution to the Professional Component:	(a) College-level mathematics and basic sciences:	0 credit hours
	(b) Engineering Topics (Science and/or Design):	3 credit hours
	(c) General Education:	0 credit hours

Prepared by:	Yannick L. Le Coz
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