University of California, Santa Cruz
ECE Department
EE-173 & 173L, Fall 2018

High-Speed Digital Design

Lecture Room: Soc Sci 2 159 (T TH 3:20pm – 4:55pm)
Laboratory Room: BE161
Instructor: S.C. Petersen (petersen@soe.ucsc.edu)
Office: JBE 251

Course Description:

This course discusses the design and construction of discrete digital circuits meant to operate at high speeds. Unlike low-speed digital circuits, where we can largely neglect the effects of passive circuit elements, high-speed design requires that special attention be paid to them. Our vocabulary must now include large-signal behavior of analog devices, a unified understanding of the alternate perspectives between the time and frequency domains, and application of field and waves to clearly understand transmission lines, propagation delay and radiation.

Hence, our general system-level perspective will emphasize practical applications built on solid theoretical foundations. Thus, we will survey topics from linear systems, device theory (active and passive) and the relationship between lumped and distributed circuit theory. A solid foundation of the terminal behavior of high-frequency analog circuits implemented as logic families will be discussed. Treatment of selected advanced high-speed families, in particular, LVDS (low voltage differential signaling) and ECL (emitter coupled logic) logic will be covered. Field theory will be presented at a level suitable to clearly understand how to interconnect active and passive components using transmission lines and to understand the phenomenon of radiation and its effects. Essentially, we will examine both the theoretical concepts and practical techniques to gain some experimental expertise, including the parasitic effects of test-equipment on circuit behavior and measurement accuracy. Mixed signal power, ground and data routing will be discussed in the context of ADC / DAC circuit blocks.

Students are expected to possess a working knowledge of basic electrical engineering network analysis (EE101), including an introduction to op-amps, diodes and bipolar junction transistors (EE-171 recommended). With the background from EE174, we will be able to more fully develop advanced topics in high-speed PCB design, especially multi-layer boards and simulation.

A related topic, designing for manufacture, will include electromagnetic compatibility (EMC) and electromagnetic interference (EMI).

References:

Required: Johnson and Graham, High-Speed Digital Design, A Handbook of Black Magic, PTR 1993
Optional and recommended: Tom Granberg, Handbook of Digital Techniques for High-Speed Design, PTR 2004
Lecture notes (handed out in class)
Supplementary references will be discussed in lecture and posted to our website.

Homework:

Homework in this class is important. It will be assigned and collected during class sessions and will generally follow a weekly sequence. Material will consist of problems from our text, supplementary and extra-credit problems. To receive full credit, your work must be college level: well organized, final draft quality, readable and show evidence of thoughtful attention to each problem.

Evidence of copying between students will result in an NC for that assignment for all students involved – regardless of who actually "worked" the problem(s). Note that I do not object to students studying together; I do object to plagiarism. Indicate on your homework any students you collaborated with and explain the degree of their contribution to your work.

Examinations:

Evaluation: Letter grades will be assigned for all work. Averaging will follow the usual 4.0 point scale to determine a final grade point and associated letter grade.

Homework	30%
Midterm	35%
Final	35%

Unless otherwise stated, the following grading rubric will be employed for homework and examinations:

Conceptual Understanding:
were relevant concepts understood?

Mathematical Completeness:
was relevant math expressed and used correctly, reinforcing and justifying expressed concepts?

Exposition:
was the writing clear and at college level? Did it support the concepts and mathematics?

Percentage weights may vary between problems and overall assignments, but this will be indicated where it applies. Unless otherwise stated, Conceptual = 40%; Math = 40% and Exposition=20%. A uniformly distributed mapping will be employed to equate percentages to letter grades:

A+ >= 95; A >= 85; A- >=80; B+ >=75; B >=60; B- >=55; C+ >=50; C >=35; C- >=30; D+ >=25; D >=10; D- >= 5

Citizenship in the laboratory:
Unlimited and unsupervised use of laboratory equipment (computers, printers etc.) and resources (web-access, email, ftp etc.) is a *privilege* not a right. Any abuse of equipment or misuse of resources will result in the immediate loss of these privileges, and may result in disciplinary action by the University. Note too that all food and beverages are expressly prohibited in lab, and the door should never be left propped open. We enjoy competent and professional support from the Baskin Engineering Lab Support Group (bels@soe.ucsc.edu). Immediately report any problems pertaining to the laboratory to them; they can also be consulted for parts you may need.

Academic Integrity:
The student-instructor relationship is based on imputed trust. Violations of this trust by deceptively offering the work of others as your own, cheating on examinations etc. will result in formal charges of academic dishonesty being brought against you.