EEC 216 - Low Power Digital Integrated Circuit Design

Lecture: MWF 12-1
Wellman 203

Instructor: Rajeevan Amirtharajah
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Web Page: Access course webpage through UC Davis SmartSite.

Office Hours: M 1-2:30

Prerequisites: EEC 118

Grading: Letter (A: 100-90%, B: 90-80%, C: 80-70%, D: 70-60%, F: below 60%)
Midterm 30%
Design Project #1 10%
Design Project #2 20%
Final Project 40%

There will be two design projects, one midterm exam, and one final project. The midterm exam will be held in class on Friday 2/8. Final project presentations will occur during the final exam period. There will be three or four homework assignments, but they will not be collected or graded.

Collaboration: You may collaborate on design projects (but not tests). Each student must turn in their own project writeup. If you choose to collaborate, each student must list all of his/her collaborators on the first page of their homework. Final projects will be done individually or in groups of at most two.

Late Design Projects: Design projects are due at the beginning of lecture. Twenty-five percent of the total points are deducted for each day the homework is late, until the assignment is worth 0 points four days after the official due date.

Curves: No curves on design projects. Exams will be graded on a curve if the class performance warrants it, and the curve will only improve your grade.

Extra Credit: No individual extra credit. Instructor might offer an extra credit assignment to the entire class, but only if absolutely necessary.

Course Description: IC design for low power and energy consumption. Low power architectures, logic styles, and circuit design. Variable supply and threshold voltages. Leakage management. Power estimation. Energy sources, power electronics, and energy recovery. Applications in portable electronics and sensors. Thermodynamic limits.

Course Outline:

I. Overview of Low Power Design

   A. CMOS Power Dissipation
   B. Power and Performance Tradeoffs
   C. Trends in IC Power Consumption

II. Low Power Architectures

   A. Clock Gating and Clock Management
   B. Pipelining to Reduce Supply Voltage
   C. Parallelization to Reduce Supply Voltage

III. Low Power Circuit Design

   A. Logic Power Estimation
   B. Power Minimization in Static CMOS
   C. Power Minimization in Dynamic CMOS
   D. Multiple-Threshold CMOS
   E. Variable Supply and Threshold Voltages
   F. Managing Leakage
   G. Subthreshold Circuit Design
   H. Silicon-on-Insulator (SOI) Technologies
   I. Energy Recovery
   J. Interconnect Power Estimation and Management

IV. Energy Sources and Power Electronics

   A. Batteries and Fuel Cells
   B. Energy Scavenging
   C. DC/DC Converters: Fundamentals
   D. DC/DC Converters: Optimization

V. Other Topics in Low Power Design

   A. Low Power Synthesis

B. Applications: Computing, Communication, and Multimedia

C. Applications: Sensors and Sensor Networks

D. Fundamental Limits and Thermodynamics of Computation

Reading:

1. Most material will be from classic and recent research papers on low power design.

Reference Material:

1. Roy, K. and Prasad, S., *Low Power CMOS VLSI: Circuit Design.*
2. Chandrakasan, A. and Broderson, R., eds., *Low-Power CMOS Design.*
3. Chandrakasan, A. and Broderson, R., *Low Power Digital CMOS Design.*
4. Rabaey, J., Chandrakasan, A., and Nikolic, B., *Digital Integrated Circuits: A Design Perspective*, 2nd ed.
5. Kassakian, J., Schlecht, M., and Verghese, G., *Principles of Power Electronics.*

Lecture	Date	Title	Reading
1	01/07/08	CMOS Power Dissipation and Trends	
2	01/09/08	Metrics and Logic Level Power Estimation	
3	01/11/08	High Level Power Estimation Interconnect Power	
4	01/14/08	Clock Gating and Power Down Modes	
5	01/16/08	Pipelining and Parallelization	
	01/18/08	Guest Lecture: TBD	
6	01/21/08	Martin Luther King, Jr. Day	
	01/23/08	Low Power Circuits 1	
7	01/25/08	Low Power Circuits 2	
8	01/28/08	Sizing for Low Power	
9	01/30/08	Clocking and Sequential Circuits	
10	02/01/08	Alternative Latch Styles and Self-Timed Design	
16	02/04/08	Guest Lecture: TBD	
17	02/06/08	Guest Lecture: TBD	
15	02/08/08	Midterm	
11	02/11/08	Low Power Interconnect 1	
12	02/13/08	Low Power Interconnect 2	
13	02/15/08	Leakage Mechanisms	
	02/18/08	President's Day	
14	02/20/08	Circuit Techniques for High Leakage	
18	02/22/08	Subthreshold Circuit Design 1	
19	02/25/08	Subthreshold Circuit Design 2	
20	02/27/08	Energy Recovery Techniques	
21	02/29/08	Batteries, Fuel Cells, and Power MEMS	
22	03/03/08	Energy Scavenging	
23	03/05/08	DC/DC Conversion 1	
24	03/07/08	DC/DC Conversion 2	
25	03/10/08	Low Power CMOS Applications: Ultra Low Power Sensor DSP	
26	03/12/07	Fundamental Limits and Thermodynamics of Computation	
27	03/14/07	Thermal Design	
28	03/17/07	Temperature Measurement Circuits	