EE105 – Spring 2008
Microelectronic Devices and Circuits

http://www-inst.eecs.berkeley.edu/~ee105

Prof. Ming C. Wu
wu@eecs.berkeley.edu
261M Cory Hall

Teaching Assistants

- Eudean Sun (eudeansun@berkeley.edu)
- Sung Hwan Kim (shpkim@eecs.berkeley.edu)
- Abhinav Gupta (agupta@eecs.berkeley.edu)

- Office Hours will be announced on the web

What is this class all about?

- Basic semiconductor device physics and analog integrated circuits.
- What will you learn?
  – Electrical behavior and applications of transistors
  – Analog integrated circuit analysis and design

Schedule

- Lectures:
  – TuTh 3:40-5:00 PM (102 Moffitt)

- Discussion Sections (beginning Monday 1/28):
  – Sec. 102 (293 Cory): Mon. 4-5PM, Eudean Sun
  – Sec. 103 (2305 Tolman):Wed. 10-11AM, Abhinav Gupta
  – Sec. 104 (293 Cory): Fri. 10-11AM, Sung Hwan Kim

Lab Schedule

- **Laboratory Sections (beginning Monday 1/28):**
  - Section 10 (353 Cory): Monday 9AM-12PM; Wilson Ko
  - Section 11 (353 Cory): Wednesday 5-8PM; Eudean Sun
  - Section 12 (353 Cory): Wednesday 2-5PM; Abhinav Gupta
  - Section 13 (353 Cory): Thursday 5-8PM; Sung Hwan Kim
- **Students must sign up for one lab section outside 353 Cory by 5PM Friday 1/25**, and regularly attend this lab section.
- Switching lab needs consent from both TAs
- All of the lab assignments (and tutorials) are posted online at

  http://inst.eecs.berkeley.edu/~ee105/sp08/#labs
- Each pre-lab assignment is due at the beginning of the corresponding lab session. Post-lab assignments are due at the beginning of the following lab section.

EE105 Spring 2008 Course Overview, Slide 5

Relation to Other Courses

- **Prerequisite:**
  - EECS40: KVL and KCL, Thevenin and Norton equivalent circuits, impedance, frequency response (Bode plots), semiconductor basics, simple pn-junction diode and MOSFET theory and circuit applications, analog vs. digital signals.
- **Relation to other courses:**
  - EE105 is a prerequisite for EE113 (Power Electronics) and EE140 (Linear Integrated Circuits).
  - It is also helpful (but not required) for EE141 (Introduction to Digital Integrated Circuits).

EE105 Spring 2008 Course Overview, Slide 6

Class Materials

- Textbook:
  - *Fundamentals of Microelectronics* by Behzad Razavi, Wiley Press, January 2008
- Lecture Notes will be posted on the class website, but it is important that you read the corresponding sections in the textbook
- Lectures will be recorded and webcasted, however, this is not intended to replace attendance

EE105 Spring 2008 Course Overview, Slide 7

Homework

- Weekly assignments will be posted online on Tuesdays
- Due the following Tuesday at 5:10 PM @EE105 Drop box in Undergraduate Lounge, Cory Hall).
- Late homework will not be accepted.
- Students are encouraged to discuss homework problems. However, <u>the work which you submit for grading must be your own</u>.

EE105 Spring 2008 Course Overview, Slide 8

Grading

- **Homework** (posted online) — 15%
  - *due Tu (5:10PM at Drop Box in Undergrad Lounge)*
  - *late homeworks not accepted*
- **Laboratory assignments** — 15%
  - *Prelab due at beginning of lab session*
  - *Report due at the beginning of the following lab*
- **2 midterm exams** — 30%
  - *80 minutes each*
  - *closed book (3 pages of notes allowed)*
- **Final exam** — 40%
  - *Th 5/22 from 12:30-3:30PM*
  - *closed book (7 pages of notes allowed)*
  - *bring calculator*

Miscellany

- Special accommodations:
  - Students may request accommodation of religious creed, disabilities, and other special circumstances. Please make an appointment to discuss your request, in advance.
- Academic (dis)honesty
  - Departmental policy will be strictly followed
  - Collaboration (not cheating!) is encouraged
- Classroom etiquette:
  - Arrive in class on time!
  - Bring your own copy of the lecture notes.
  - Turn off cell phones, pagers, MP3 players, etc.
  - No distracting conversations

Some Important Announcements

- Please don't bring food/drinks to 353 Cory
- Lab experiments will be done in pairs. Each person should turn in his/her individual reports.
- Homework should be done individually.
- Cheating on an exam will result in an automatic F course grade.

Getting Started

- Assignment 1:
  - To be posted later today
  - Due 1/29 (Tuesday) at 5 PM
- NO discussion sessions, labs, or office hours this week.

Course Overview

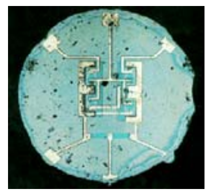
(refer to detailed syllabus)

EE105 Spring 2008 Course Overview, Slide 13

Introduction

The Integrated Circuit (IC)

- **An IC consists of interconnected electronic components in a single piece (“chip”) of semiconductor material.**
  - **In 1958, Jack S. Kilby (*Texas Instruments*) showed that it was possible to fabricate a simple IC in germanium.**
  - **In 1959, Robert Noyce (*Fairchild Semiconductor*) demonstrated an IC made in silicon using SiO_2 as the insulator and Al for the metallic interconnects.**



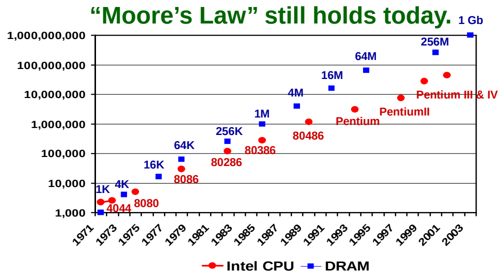
The first planar IC (actual size: 0.06 in. diameter)

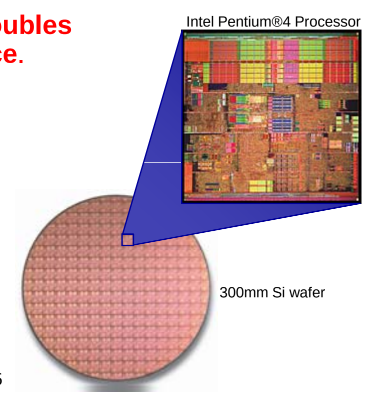
EE105 Spring 2008 Course Overview, Slide 15

From a Few, to Billions

- **By connecting a large number of components, each performing simple operations, an IC that performs very complex tasks can be built.**
- **The degree of integration has increased at an exponential pace over the past ~40 years.**
  - » **The number of devices on a chip doubles every ~18 months, for the same price.**

“Moore’s Law” still holds today.

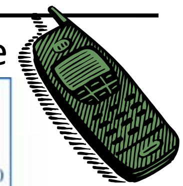


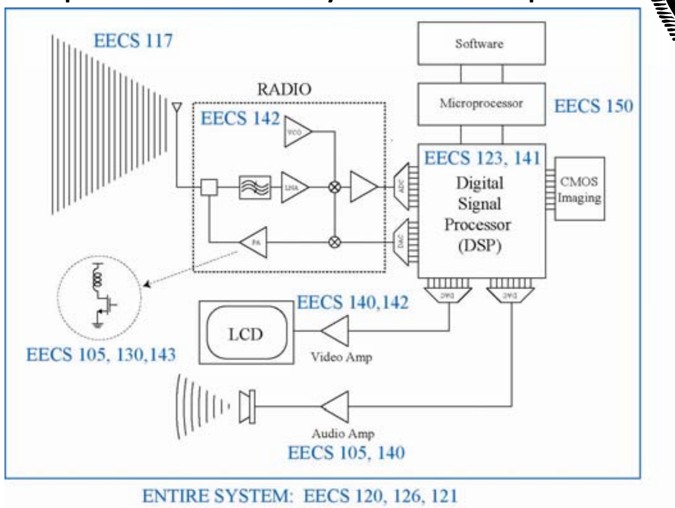


EE105 Spring 2008 Course Overview, Slide 16

EECS 105 in the Grand Scheme

- Example electronic system: cell phone

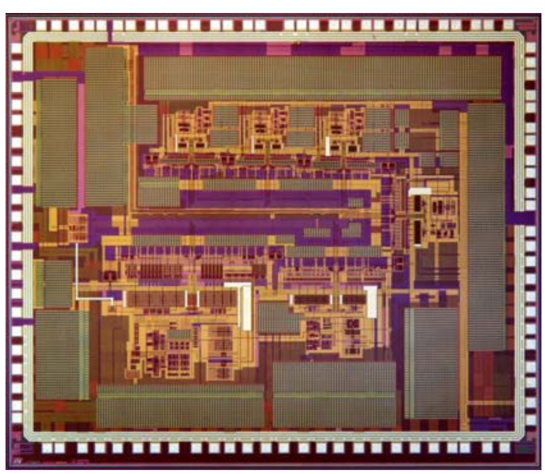




EE105 Spring 2008 Course Overview, Slide 17

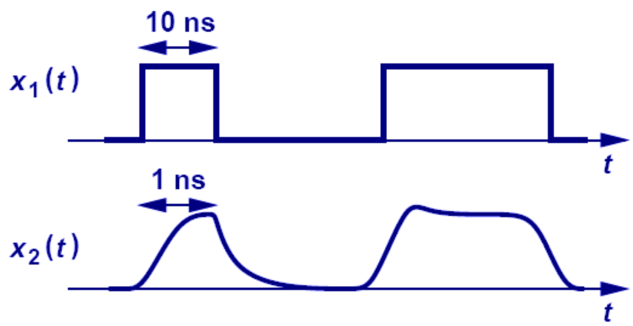
EECS 105: Emphasis on Analog IC's

- Example: 14-bit analog-to-digital converter
  - Y. Chiu, *IEEE Int'l Solid-State Circuits Conference*, 2004.



EE105 Spring 2008 Course Overview, Slide 18

Digital or Analog Signal?

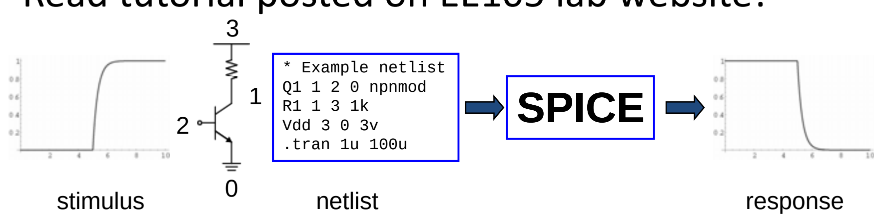


- $X_1(t)$ is operating at 100Mb/s and $X_2(t)$ is operating at 1Gb/s.
- A digital signal operating at very high frequency is very "analog".

EE105 Spring 2008 Course Overview, Slide 19

Circuit Simulation using SPICE

- Read tutorial posted on EE105 lab website!



- SPICE = Simulation Program with IC Emphasis
- Invented at Berkeley (released in 1972)
- .DC: Find the DC operating point of a circuit
- .TRAN: Solve the *tran*sient response of a circuit (solve a system of generally non-linear ordinary differential equations via adaptive time-step solver)
- .AC: Find steady-state response of circuit to a sinusoidal excitation

EE105 Spring 2008 Course Overview, Slide 20