EE105 - Spring 2007
Microelectronic Devices and Circuits

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What is this class all about?

- Introduction to semiconductor devices and integrated circuits.
  - Circuit analysis and design techniques. Time and frequency domain analysis. PN junctions and bipolar transistors. MOSFET physics and modeling. Integrated passives. Single stage amplifiers. Differential amplifiers. Introduction to feedback. Frequency response of amplifiers. Multistage Amps
- What will you learn?
  - Understanding, designing, and optimizing analog integrated circuits. Understanding the operation of semiconductor devices.

Practical Information

- Instructor
  - Prof. Ming C. Wu
    - 261M Cory Hall, 643-0808, wu@eecs
    - Office hours: Mon 2:30-3:30 pm, Thu 3:30-4:30 pm
- TAs:
  - Please see class website
- Web page:
  - http://www-inst.eecs.berkeley.edu/~ee105/sp07/

Your EE 105 Week

	Monday	Tuesday	Wednesday	Thursday	Friday
9					Lab-014 353 Cory
10			DIS-103 293 Cory	Lab-011 353 Cory (?)	
11					
12					
1					DIS-104 293 Cory
2	OH 261M Cory	Lecture 155 Donner	Lab-012 353 Cory	Lecture 155 Donner	
3				OH 261M Cory	
4	DIS-102 293 Cory				
5	Lab-010 353 Cory				
6					
7					

Class Organization

- 2 Lectures and 1 recitation per week
- ~ 10 HW assignments, 9 Labs / Reports
- 2 Midterms, 1 Final
  - Midterm 1: Thursday, February 22, 6:30-8:00 pm (room tba)
  - Midterm 2: Thursday, April 5, 6:30-8:00 pm (room tba)
  - Final: Friday, May 11, 12:30-3:30 pm
- Grading policy:
  - Homeworks: 15%
  - Labs: 15%
  - Midterm-1: 15%
  - Midterm-2: 15%
  - Final: 40%

Some Important Announcements

- Please don't bring food/drinks to 353 Cory
- Labs done in groups. But each person should do his/her own measurement, and turn in individual report
- Homework should be done individually
- Cheating will result in automatic Fail

Class Materials

- Textbook:
  - Behzad Razavi, *Fundamentals of Microelectronics, Preliminary Edition*, Wiley Press, May 2006
- Reference (on reserve at Bechtel Engineering Library):
  - R.T. Howe and C.G. Sodini, *Microelectronics: An Integrated Approach*, 1997
  - P. W. Tuinenga, SPICE, *A Guide to Circuit Simulation & Analysis using PSpice*, Prentice Hall, 1995.
- Lecture Notes will be posted on website, but it is important that you read the corresponding sections in the textbook
- Lectures will be recorded and webcasted, however, it is not meant to replace attendance

The Web Sites

- http://www-inst.eecs.berkeley.edu/~ee105/sp07/
  - Announcements
  - Lecture notes
  - Webcast
  - Assignments and solutions
  - Lab manual
  - Past exams, earlier class web pages
  - Many other goodies …
- bSpace (bspace.berkeley.edu) will be used *only* for
  - Posting grades of HW, Lab Reports
  - Chat Room

Software

- HSPICE
  - Industry standard
  - Online tutorials
- There are free versions of WinSpice and PSPICE that you can use at home

Getting Started

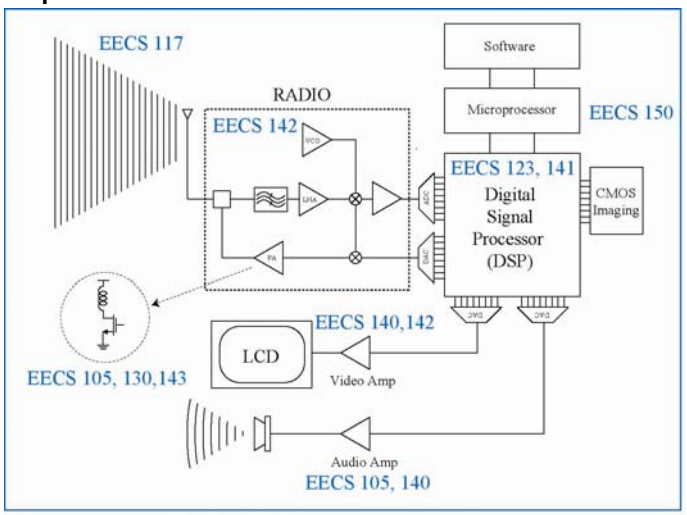
- Assignment 1:
  - Assigned next Tuesday, Due 1/30 (Tuesday), 5pm
- NO discussion sessions or labs this week.
- First discussion sessions in Week 2
- First lab in Week 3

EECS 105: Course Overview

- Semiconductor physics (1 week)
- PN Junction / BJT Physics/Model (1.5 weeks)
- MOSFET Physics/Model (1 week)
- Integrated Passives (R, C, L) (1 week)
- Circuit analysis techniques (2 weeks)
- Single Stage Amplifiers (2 weeks)
- Feedback and Diff Amps (1 week)
- Freq Resp of Single Stage Amps (1 week)
- Multistage Amps (2.5 weeks)
- Freq Resp of Multistage Amps (1 week)

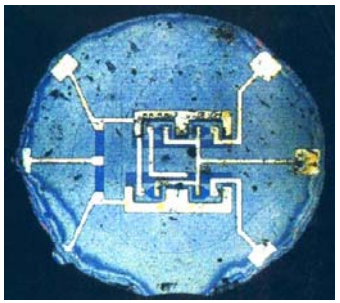
EECS 105 in the Grand Scheme

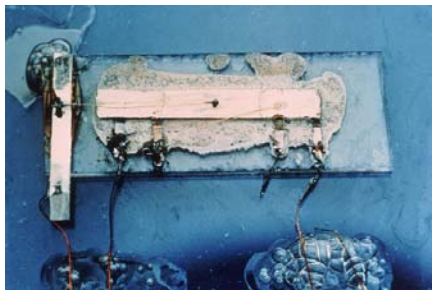
- Example: Cell Phone



ENTIRE SYSTEM: EECS 120, 126, 121

The First Integrated Circuits - 1958





R. N. Noyce
Fairchild Semiconductor
Co-Founder of both
Fairchild and Intel
(deceased 1990)

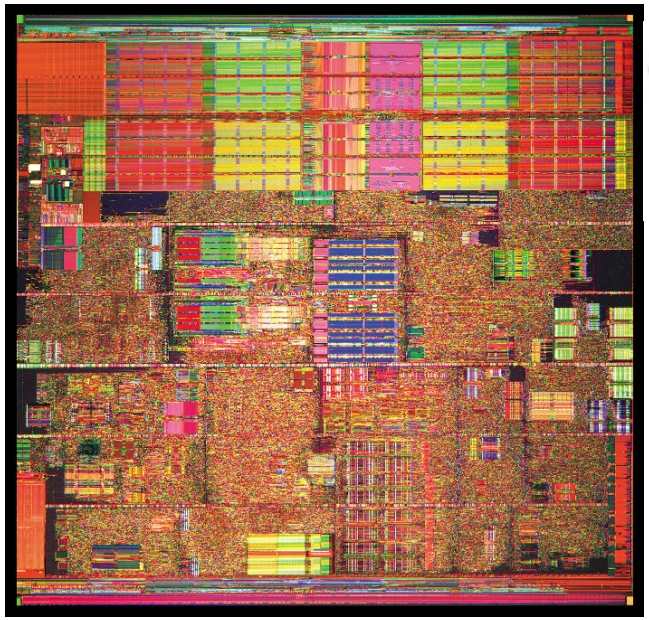
"Unitary Circuit" made of Si

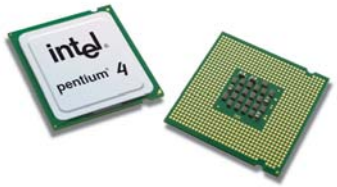
Jack Kilby
Texas Instruments
Invented IC during his first year at TI

(Nobel Prize 2000)

"Solid Circuit" made of Ge

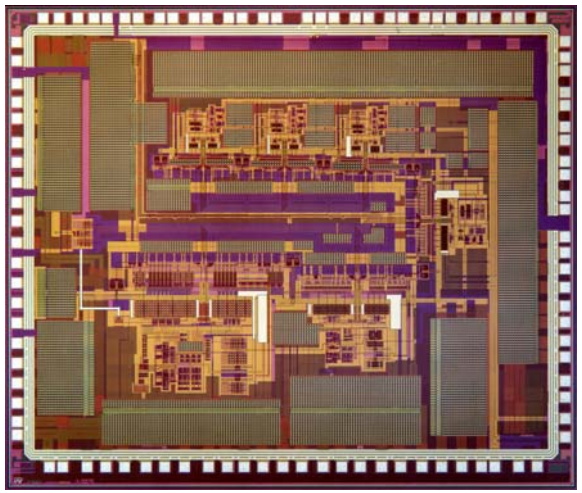
Intel Pentium 4 Microprocessor





90nm CMOS technology

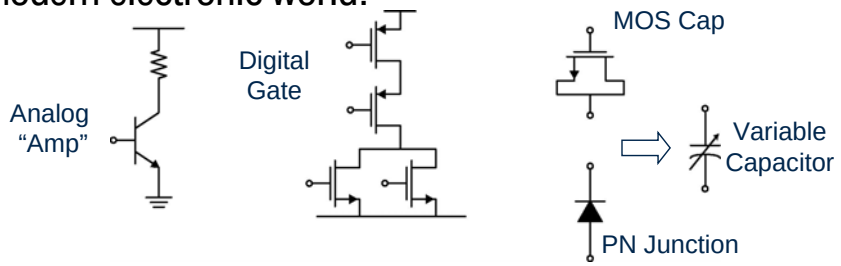
EECS 105: Emphasis in Analog



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

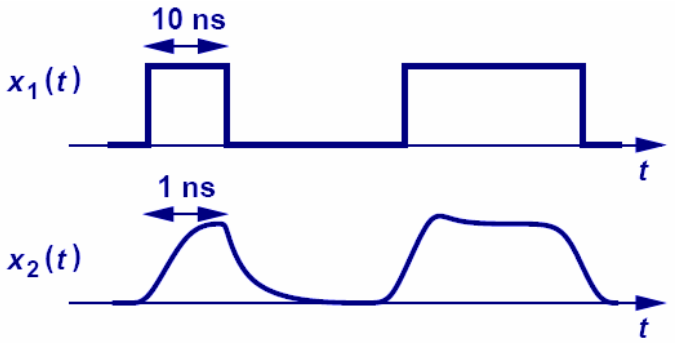
Transistors are Bricks

- Transistors are the building blocks (bricks) of the modern electronic world:



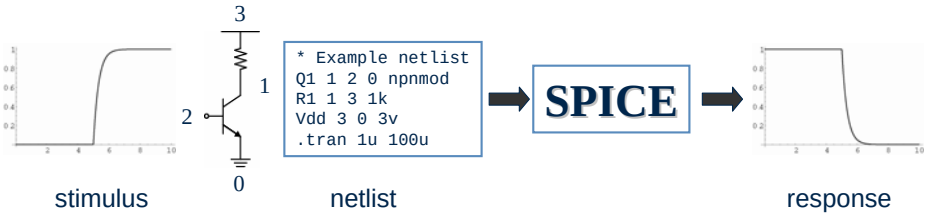
- Focus of course:
  - Understand device physics
  - Build analog circuits
  - Learn electronic prototyping and measurement
  - Learn simulations tools such as SPICE

Digital or Analog?



- $X_1(t)$ 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”.

SPICE



- 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

BSIM

- Transistors are complicated. Accurate sim requires 2D or 3D numerical sim (TCAD) to solve coupled PDEs (quantum effects, electromagnetics, etc)
- This is *slow* … a circuit with one transistor will take hours to simulation
- How do you simulate large circuits (100s-1000s of transistors)?
- Use compact models. In EECS 105 we will derive the so called “level 1” model for a MOSFET.
- The BSIM family of models are the industry standard models for circuit simulation of advanced process transistors.
- BSIM = Berkeley Short Channel IGFET Model