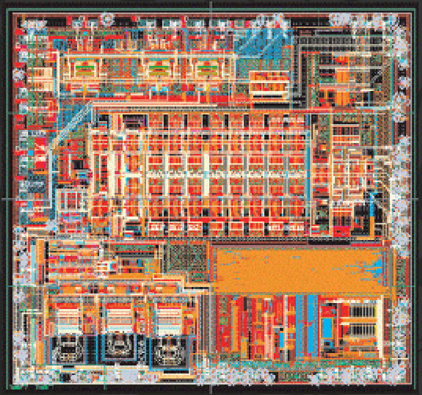
ECE 310 MICROELECTRONICS I

COURSE INTRODUCTION



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College of Engineering

COURSE OUTLINE

Instructor : Dr. Vishal Saxena

Office BEL 318

Email: vsaxena AT uidaho DOT edu

Time : MWF, 10:30-11:20 AM

Course dates : Jan 10 – May 4, 2018

Location : EP 205

Office Hours : MW 12:00 Noon-1:00 PM (or by appointment)

Website : http://lumerink.com/courses/ECE310/s18/ECE310.htm

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COURSE OBJECTIVES

- This course focuses on design and analysis of microelectronic circuits.
- At the end of the course, it is expected that you will be able to design, analyze and simulate basic microelectronic circuits with confidence.

COURSE TOPICS

- Basics of Semiconductor Physics
- Diode Models and Circuits
- MOS Transistors
- Bipolar Transistors
- MOS and Bipolar Amplifiers and Current Mirrors
- Operational Amplifiers
- Digital CMOS Circuits (if time permits)

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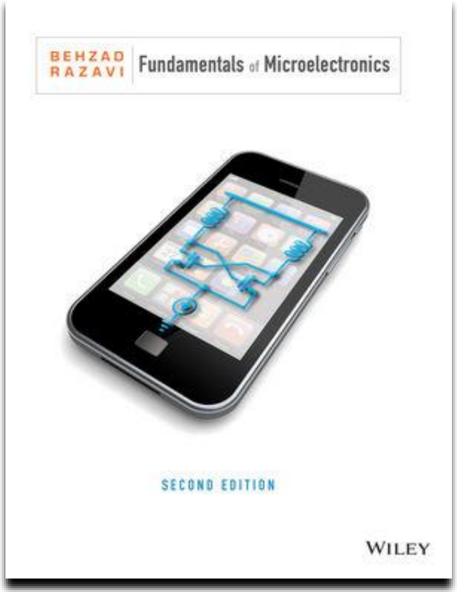
TEXTBOOK

- Fundamentals of Microelectronics –
  Behzad Razavi, 2nd Edition, Wiley, 2013. ISBN: 1118156323
- Homeworks will be assigned from the textbook
- Companion Site: http://goo.gl/LQRqOv



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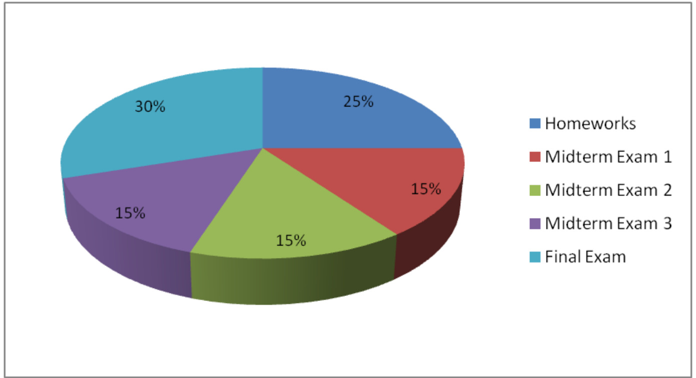
COURSE PEDAGOGY AND GRADING

Combination of lecture notes and slides

- Lecture notes/slides will be posted online at the end of the week
  - Take your own notes in class instead of listening passively

Workload (Grading)

- 25% Homework/In-Class Assignments
- 45% Exams (3) : Check syllabus for tentative exam dates
- 30% Final exam



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COURSE POLICIES

- Late work is highly discouraged (see policy on the course page)
- All assigned work is due at the beginning of class on due date
- Final exam will not be returned at the end of the semester
- Avoid internet surfing in class on any device
- Plagiarism and outsourcing (!) of work is not acceptable
  - See UI Student Code of Conduct http://www.webs.uidaho.edu/fsh/2300.html
- Detailed policies are available on the course site

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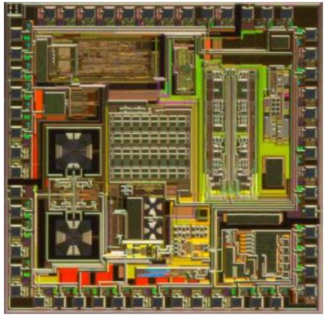
SOME DEFINITIONS

- A semiconductor is a substance that conducts electricity under some but not all circumstances.



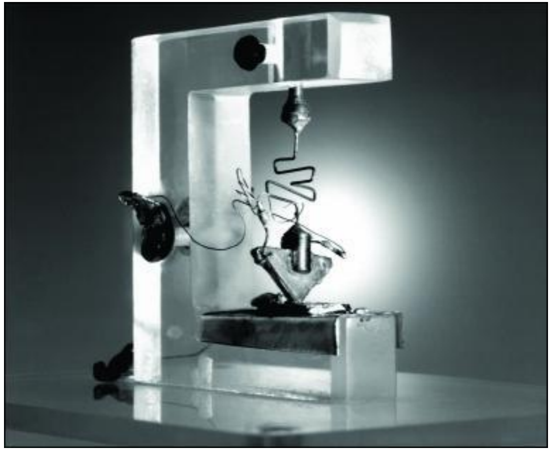
- Solid-State Electronics (SSE)
  - Solid-state electronics are those circuits or devices built entirely from solid semiconducting materials and in which the electrons, or other charge carriers, are confined entirely within the solid material

SSCS IEEE SOLID-STATE CIRCUITS SOCIETY
Where ICs are in IEEE

  - This distinguishes SSE from devices that use charge carriers not confined with a solid (i.e. plasmas, vacuum).
  - The most common SSE are based on pure silicon substrates.

THE START OF THE MODERN ELECTRONICS ERA

Bardeen, Shockley, and Brattain at Bell Labs - Brattain and Bardeen invented the bipolar transistor in 1947.



The first germanium bipolar transistor. Roughly 50 years later, electronics account for 10% (4 trillion dollars) of the world GDP.

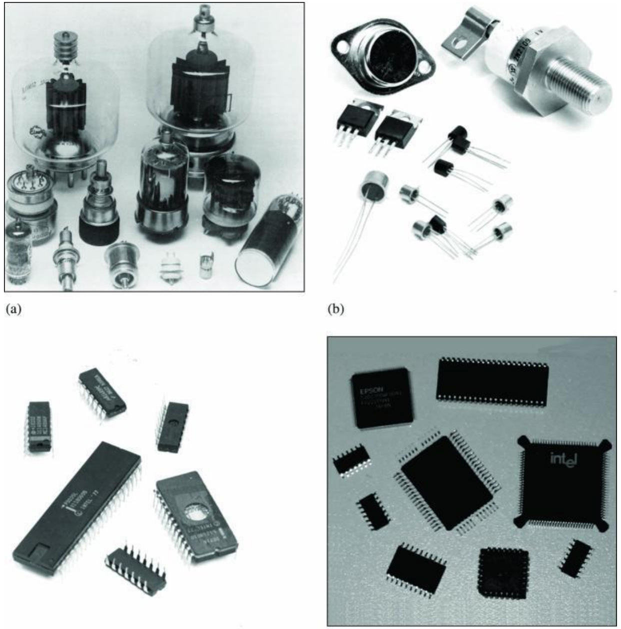
EVOLUTION OF ELECTRONIC DEVICES

Vacuum Tubes

Discrete Transistors

SSI and MSI Integrated Circuits

VLSI Surface-Mount Circuits



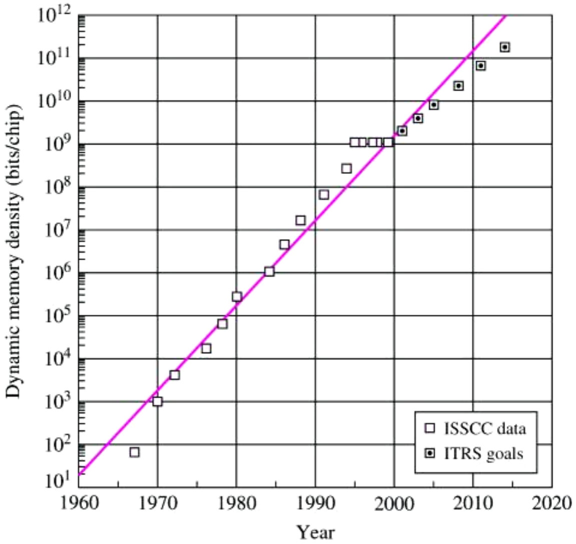
(a) (b) (c) (d)

MICROELECTRONICS PROLIFERATION

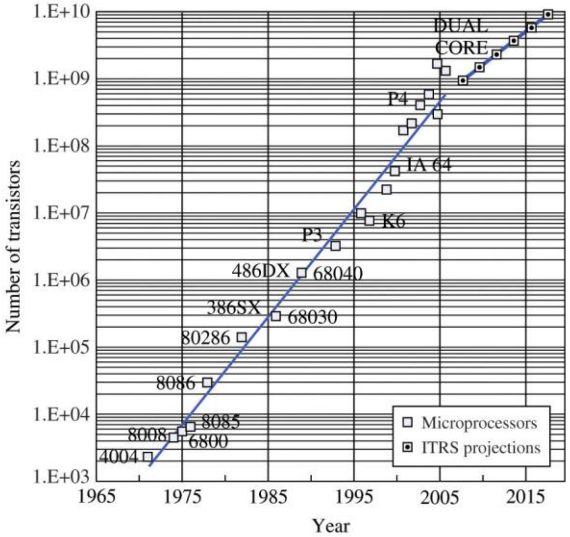
- The integrated circuit was invented in 1958.
- World transistor production has more than doubled every year for the past twenty years.
- Every year, more transistors are produced than in all previous years combined.
- Approximately 10^{18} transistors were produced in a recent year.
- Roughly 50 transistors for every ant in the world.

*Source: Gordon Moore's Plenary address at the 2003 International Solid State Circuits Conference.

RAPID INCREASE IN DENSITY OF MICROELECTRONICS

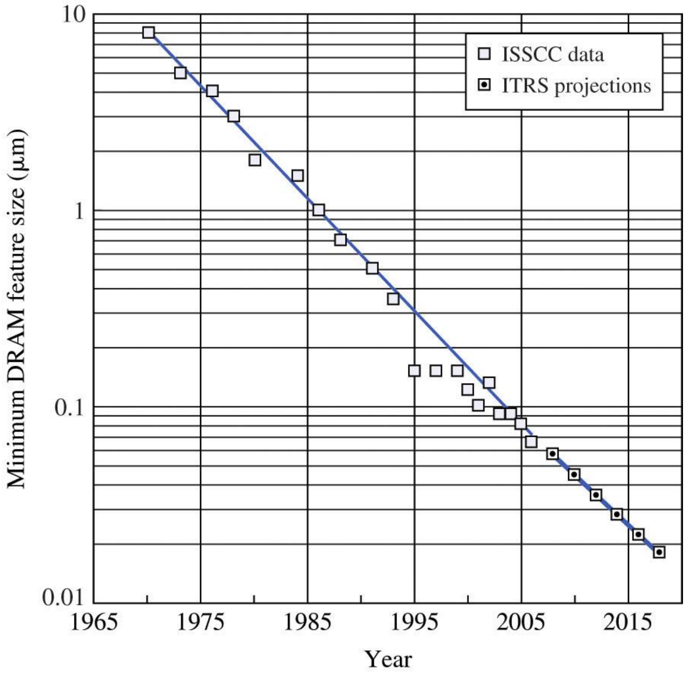


Memory chip density versus time.



Microprocessor complexity versus time.

DEVICE FEATURE SIZE

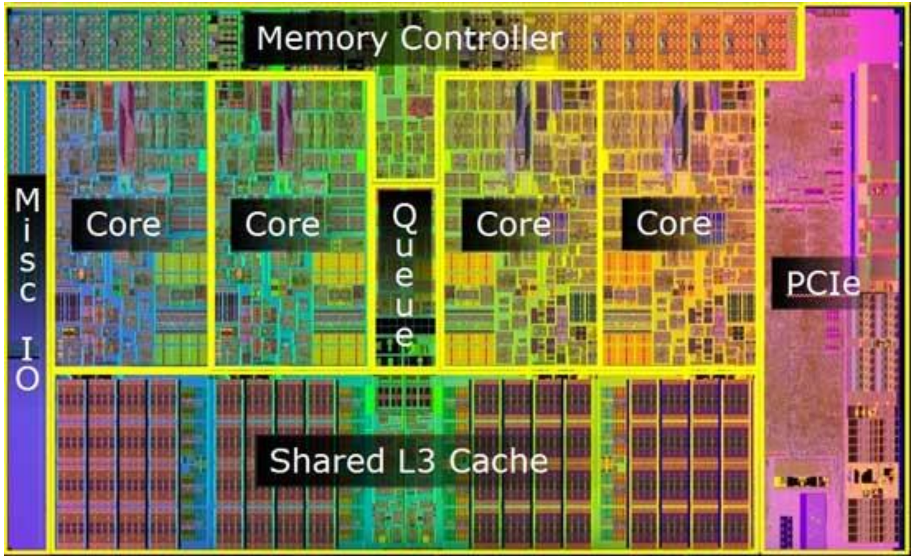


- Feature size reductions enabled by process technology innovations.
- Smaller features lead to more transistors per unit area and therefore higher density.

ECONOMIC IMPACT

- Key driver of global and US economy
  - >$400B in annual revenue
  - $166B of US semiconductor industry revenue
  - 20 year annual average growth of 13%
  - Highly innovative field that impacts all other sectors of economy
- Idaho's top export is Semiconductors (Memory Chips) - $2.4B in 2013
- Micron, Intel, Nvidia, Apple, etc. are key players
- Computing and smartphones key consumer products
- Internet-of-things and AI-based applications to sustain future growth

MICROELECTRONIC ICS IN ACTION

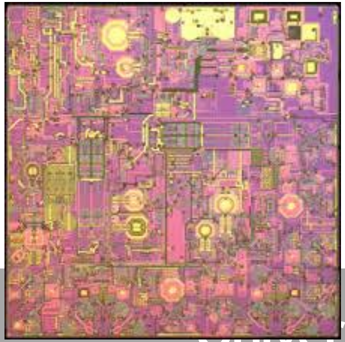


Intel Quad-core Processor (2012)

~1.2 Billion Transistors

MICROELECTRONIC ICS IN ACTION

- Back side of the logic board:
  - SanDisk SDMFLBCB2 128 Gb (16 GB) NAND Flash
  - Murata 339S0228 Wi-Fi Module
  - Apple/Dialog 338S1251-AZ Power Management IC
  - Broadcom BCM5976 Touchscreen Controller
  - NXP LPC18B1UK ARM Cortex-M3 Microcontroller (also known as the M8 motion coprocessor)
  - NXP 65V10 NFC module + Secure Element (likely contains an NXP PN544 NFC controller inside)
  - Qualcomm WTR1625L RF Transceiver



https://www.ifixit.com/Teardown/iPhone+6+Teardown/29213

ANALOG VS DIGITAL: THE MYTH

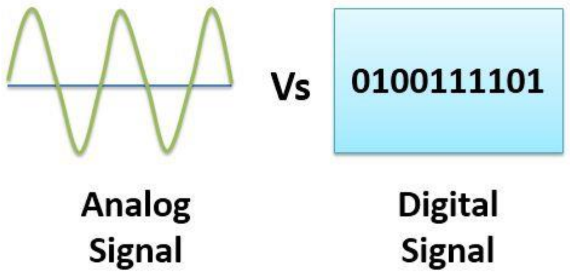
Analog

Digital

CHARACTERISTICS OF SIGNALS

Analog Signals

- Infinite number of possible signal levels (values)
- Can change at any instant to any other value
  - Bandwidth is potentially infinite
- Analog signals are *continuous* in both time and value



Digital Signals

- Signal level (value) only representable in fixed steps within a finite range
- Only know the signals value at distinct instants in time
- Digital signals are *discrete* in time and value
- Signal can be exactly identified in the presence of some amount of noise

WHY USE DIGITAL SIGNALS?

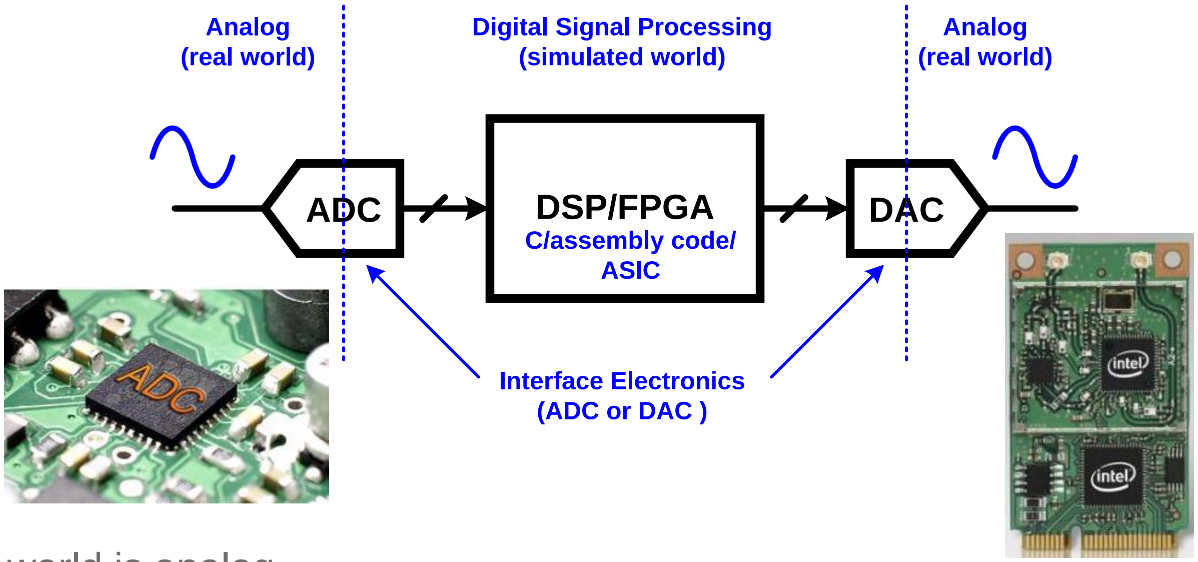
Pros

- Digital signals can be faithfully stored and copied
- Allows for numeric processing by digital computers (digital signal processing - DSP)
- Lossy and lossless data compression possible
- Can mathematically represent physically unrealizable systems

Cons

- Cannot exactly represent or reconstruct the original analog signal
- Requires greater bandwidth

WHY ANALOG CIRCUITS?



- Real world is analog.
- Digital world: Discrete-time, discrete-amplitude signal representation.
  - Interface circuits: ADC and DACs.
- High speed signal processing circuits are analog (Serial IOs, 60 GHz RF)

YOUR TO-DO LIST

- Read Chapter 1