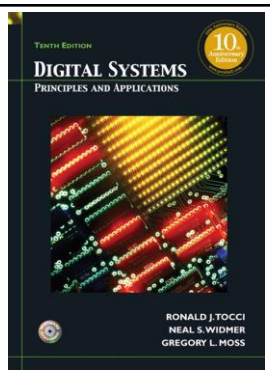
Digital Logic Design

Professor: Dinh Duc Anh Vu, PhD.
Office: A2.713
Email: ddavu@hcmiu.edu.vn

Digital Logic Design



- Code: IT67IU
- Credit: 3
- Prerequisite: None
- Co-requisite:
  Digital Logic Design Lab
- Textbook: **Digital Systems: Principles and Applications**, 10th edition, Pearson Edu. Intl., 2007, by Ronald J. Tocci and Neal S. Widmer, Gregory L. Moss
- Class and recitation notes

Class Time and Office Hour

- Class Time:
  - Thursdays
- Office Hours:
  - by appointment
  - office: A2.713
  - Email / Conversation (Teams)

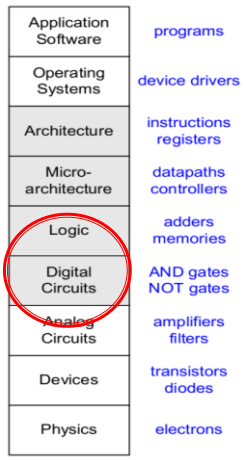
What is this course all about?

- Introduction to digital logic
  - Digital system fundamentals; number system; fundamentals of digital circuits and computer systems stressing general techniques for the analysis and synthesis of combinational and sequential logic systems.
- What will you learn?
  - To learn simple digital circuits in preparation for computer engineering and science
  - Understanding and designing digital logic circuits with respect to different quality metrics such as functionality, timing, power and area.

Agenda

- Chapter 1 (this chapter): Introduction
- Chapter 2: Number Systems
- Chapter 3: Logic Circuits
- Chapter 4: Boolean algebra & Combinational logic circuits
- Chapter 5: Flip-Flop and related devices
- Chapter 6: Counters and registers
- Chapter 7: MSI logic circuits

The position of the course



- Number representation: binary, decimal, hexadecimal …
- Logic gates: AND, OR, NOT, NAND, NOR …
- Flip-flop, latch, register …
- Combinational circuit: adder, comparator, multiplexer …
- Sequential circuit: asynchronous/synchronous counters, shifters …

Digital Logic Design

- Grade distribution:
  - Homework, quizzes, hourly exams: 30%
  - Midterm exam: 30%
  - Final exam: 40%
- Exams: open-book
- NO MAKE UP EXAM WILL BE GIVEN!!!

Homework

- You will have at least 4 sets of homework.
- The point is to give you practical experience with what you're learning.
- No problem if you want to work together.
- You need to write down your own solution.
- *You need to credit anybody you work with!*

Homework

- Homework assignments will be posted. All homework questions will be graded for correctness. Questions will come both from the textbook as well as created by the instructor.
- Solutions for homework assignments will be posted after the expiration of the grade period.
- Quiz solutions will be discussed in class and will only be posted online if they cannot be discussed before an exam.
- Exam solutions will only be discussed in class.

Unacceptable Collaboration

- Copying (program or assignment) files from another person or source, including retyping their files, changing variable names, copying code without explicit citation from previously published works (except the textbook), etc.
- Copying on quizzes or exams.
- Allowing someone else to copy your code or written assignment, either in draft or final form.
- Inappropriately obtaining course information from instructors and TAs.

Use of Laptops and Mobile Devices in Class

- As research on learning shows, unexpected noises and movement automatically divert and capture people's attention, which means you are affecting everyone's learning experience if your cell phone, pager, laptop, etc. makes noise or is visually distracting during class.
- For this reason,
  - You must turn off your mobile devices during class.
- - You can take notes on your laptop, but you must turn the sound off so that you do not disrupt other students' learning. If you are doing anything other than taking notes on your laptop, please sit in the back row so that other students are not distracted by your screen.

Recording of class

- Classroom activities may be recorded by a student for the personal, educational use of that student or for all students presently enrolled in the class only, and may not be further copied, distributed, published or otherwise used for any other purposes.
- All students are advised that classroom activities may be taped by students for this purpose.

Late Assignment Policy

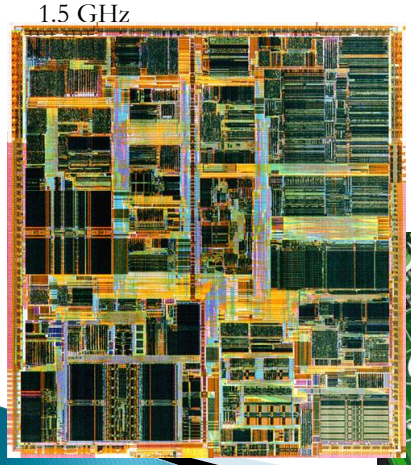
- All assignments are expected to be turned in during class on the due date unless otherwise noted.
- If an assignment is turned in after that time, I will accept it and assign a 25% penalty for each 24-hour period it is late.
  - Examples: A turns his assignment in at 8 AM the day after the due date. He loses 25%. B turns his in at 3 PM the next day. He loses 50%.
  - This will be calculated by simply multiplying your earned score by the appropriate penalty. Consider that A earned 30/40 points on his assignment. After his 25% late penalty, he would receive a final score of 23/40 (rounded up).
- Weekend days count as days too. An assignment due on Friday that is turned in on Monday is subject to a 50% penalty.
- If the solutions to an assignment are posted prior to the normal expiration of this period (to facilitate studying for an exam, for example), assignments will no longer be accepted.

Few Hints for Success

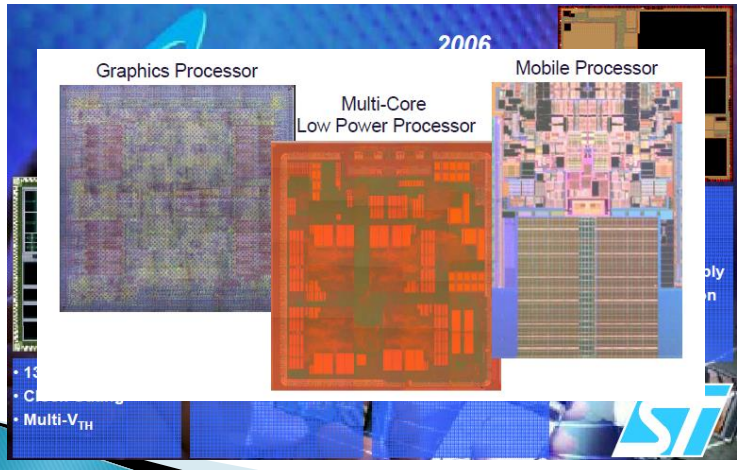
- I can expect you:
  - To come to class on time.
  - To be attentive and engaged in class.
  - To refrain from using laptops, cell phones and other electronic devices during class.
  - To spend an adequate amount of time on the assignments, making an effort to solve and understand each problem.
  - To engage with both the abstract and computational sides of the material.
  - To seek help when appropriate

Why is this course important?

2000
42 million transistors
1.5 GHz



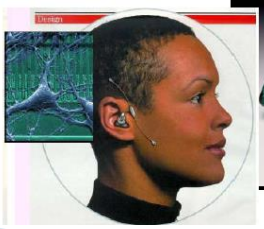
The base for modern circuit design



Many Chips

Industry Trends

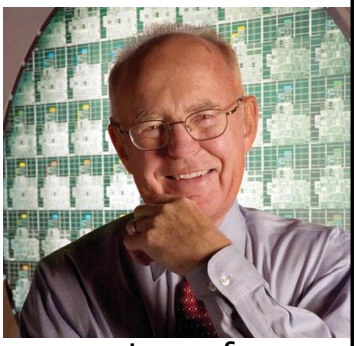
High performance
Low power dissipation
Wireless capability
etc…



Robert Noyce, 1927 – 1990

- Nicknamed “Mayor of Silicon Valley”
- Co-founded Fairchild Semiconductor in 1957
- Co-founded Intel Corporation in 1968 (with Gordon Moore)
- Co-inventor of integrated circuit (with Jack Kilby)

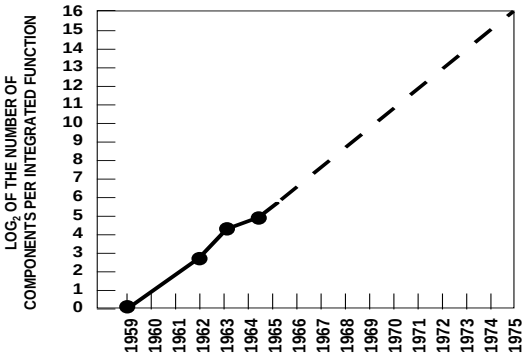
Gordon Moore, 1929 –



- the co-founder and chairman emeritus of Intel Corporation
- Author of Moore's law: the number of transistors in a dense integrated circuit (IC) doubles about every two years

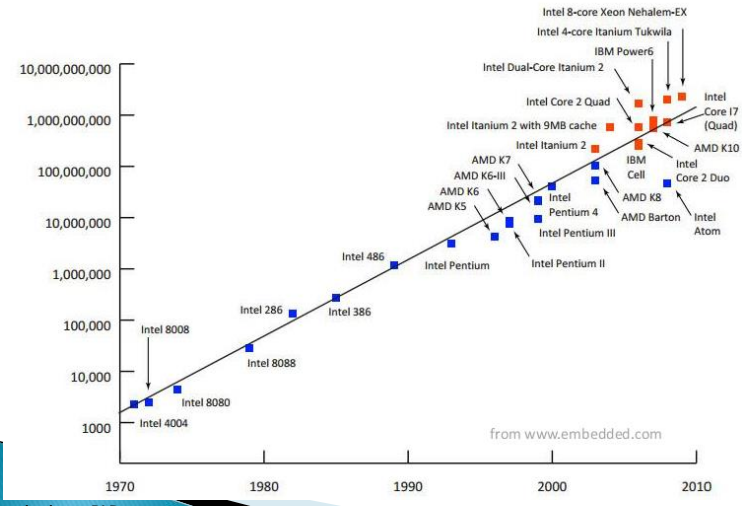
Moore's Law

Twice the number of transistors, approximately every two years



Electronics, April 19, 1965.

Moore's Law



Analog vs. Digital Representation

- Analog Representation
  - Analog signals can take any value across a continuous range of current, voltage, etc.
  - One quantity is represented by another which is proportional to the first
  - Examples: automobile speedometer, thermostat, …
  - Analog quantities have an important characteristic: they can vary over a continuous ranges of values
- Digital Representation
  - Quantities is represented not by proportional quantities but by symbols called digits.
  - Restrict themselves to two discrete values of 0 and 1, low and high, false and true
  - Examples: digital watch, …
  - Changes in discrete steps

- Analog: continuous
- Digital: discrete (step by step)

Examples

- Which of the following involve analog quantities and which involve digital quantities ?
  - Ten-position switch
  - Current meter
  - Temperature
  - Sand grains on the beach
  - Radio volume control
- Concisely describe the major difference between analog and digital quantities
  - Analog quantities can take on any value over continuous range; digital quantities can take on only discrete values

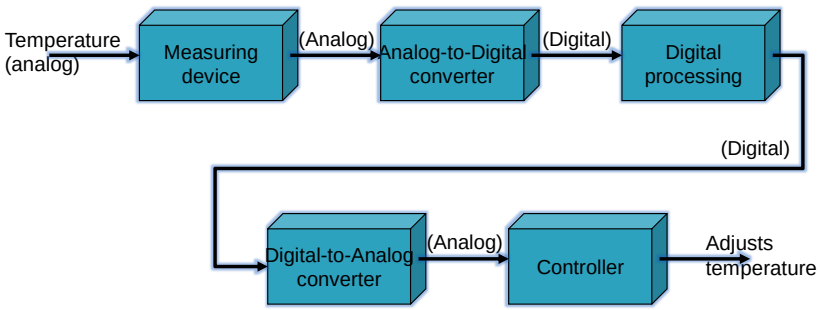
Digital and Analog Systems

- Digital Systems
  - a combination of devices designed to manipulate logical information or physical quantities that are represented in digital forms
  - Examples: computer processor, robot, …
- Analog Systems
  - Contains devices that manipulate physical quantities that are represented in analog form
  - Examples: TV, VCR, …

Digital Systems

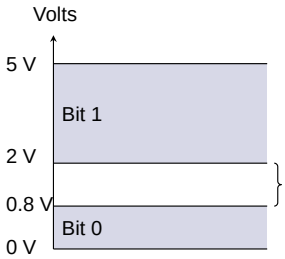
- Advantages of Digital Techniques
  - easier to design and store
  - accuracy and precision are greater
  - operation can be programmed
  - less effective by noise
  - more can be fabricated on IC chips
- Limitation of Digital Techniques
  - The real world is mainly ANALOG!!
  - To take advantages of digital techniques
    1. convert analog inputs to digital
    2. process the digital
    3. convert the digital outputs to analog

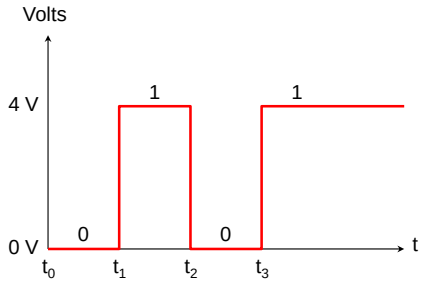
Digital Systems



- Block diagram of a temperature control system that requires analog/digital conversions in order to allow the use of digital processing techniques

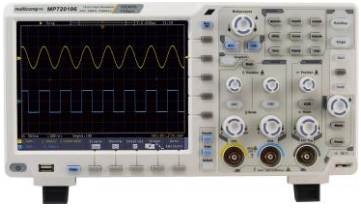
Representing Binary Quantities





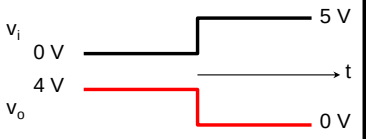
Typical voltage assignments in digital systems

Typical digital signal timing diagram

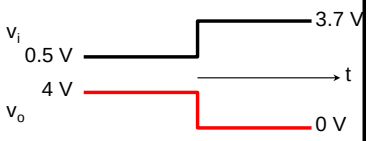


Digital Circuits/Logic Circuits

- Digital Circuits = Logic Circuits
- Digital IC
  - TTL, CMOS, NMOS, and ECL

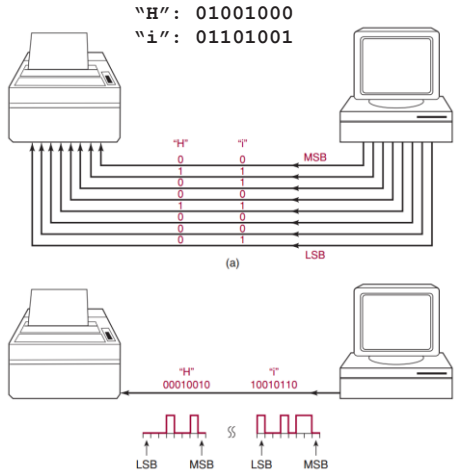


A digital circuit responds to an input's binary level (0 or 1) and not to its actual voltage



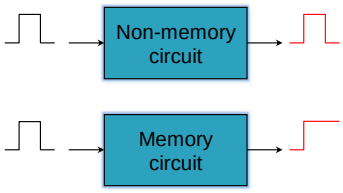
Parallel / Serial Transmission

- Parallel transmission
  - uses one connecting line per bit
  - and all bits are transmitted simultaneously
- Serial transmission
  - uses only one signal line
  - and the individual bits are transmitted serially (one at a time)



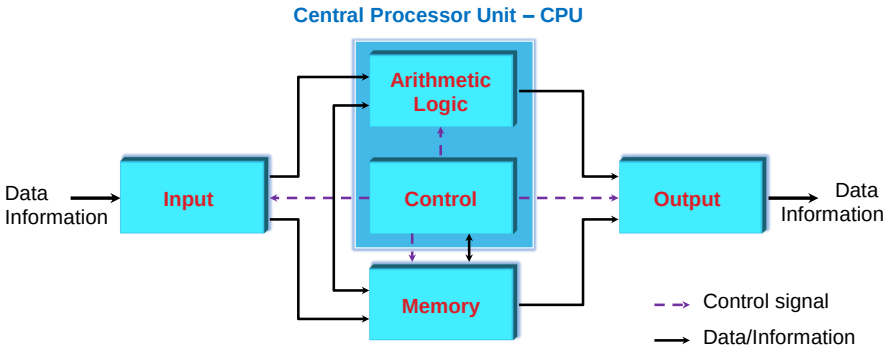
Memory

- When an input is applied to a circuit, the output will change its state, but it will remain in the new state even after the input is removed. This property of retaining its response to a momentary input is called memory.



Comparison of non-memory and memory operation

Digital Computers

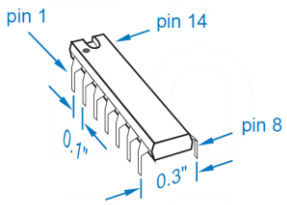


Functional diagram of a digital computer

Digital Computers

- Type of Computers
  - microcomputer, minicomputer (workstation), and mainframe.
- Microcomputer
  - the smallest type of computer
  - consists of several IC chips: microprocessor, memory, and I/O interface
- Microcontroller
  - a more specialized type of microcomputer
  - designed to be used as a dedicated or embedded controller

Integrated Circuits (IC)



- Lots of gates on a chip are called Integrated Circuits.
- Initially part of a wafer, then sliced and diced up.
- Classified by scale of integration:
  - 1-20 Gates: Small Scale Integration
  - 20-200 Gates: Medium Scale Integration
  - 200-1,000,000 Gates: Large Scale Integration
  - > 1,000,000 Gates: Very Large Scale Integration (VLSI)

Summary

- Digital design is ubiquitous and pervasive.
- There is a lot to talk about the digital system.