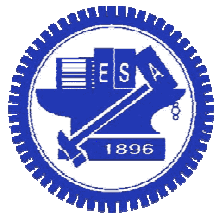


Introduction to Digital Circuit Design



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Outline of the Course[†]

- ☐ Binary Numbers
- ☐ Boolean Algebra and Logic Gates
- ☐ Gate-Level Minimization
- ☐ Combinational Logic

(midterm exam)

- ☐ Synchronous Sequential Logic
- ☐ Registers and Counters
- ☐ Memory and Programmable Logic
- ☐ Design at the Register Transfer Level

(Final exam)

[†]Textbook: M. M. Mano and M. D. Ciletti, "Digital Design," 5th Ed., Pearson Education Limited, 2013.

Grading Policy

- ❑ Grading is based on
 - Pop Quizzes (30%)
 - Mid-terms exam (35%)
 - Final exam (35%)

Software vs. Hardware

- ☐ Is it easier to write a software program or to design a hardware circuit?
- ☐ Are there “things” that can only be done in hardware or software?
- ☐ Can you become a master of digital circuit design after taking this class?

Are You Indispensable?

- ❑ If you plan to work in a big company ...
 - What's wrong with focusing your skill on either software or hardware alone?
 - Any other options?
- ❑ If you plan to start your own company ...
 - Selling crispy chicken breast?
 - Writing smart phone apps?
 - Any other options?

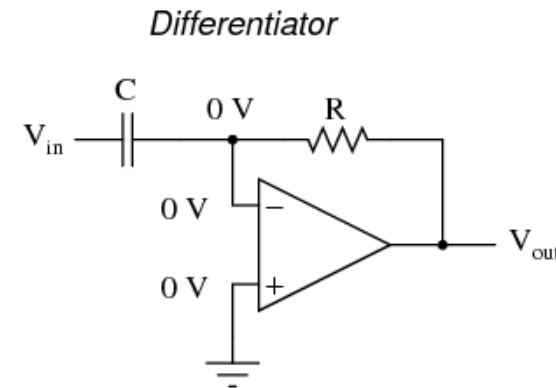
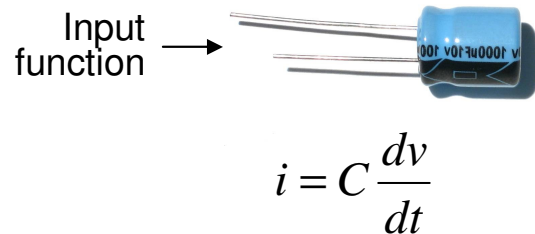
Digital Future Is Inevitable

- ❑ What do these things have in common: Smart Phones, Smart TVs, Smart Cameras, and Smart-Whatever?



Digital vs. Analog

- ❑ Analog circuits are considered more “natural” in early days (before 1940s) of technologies; why?
- ❑ How do we compute differentiation of a function using analog circuits?



- How do you read the output?
- ❑ How do you do that in digital circuits? What are the advantages and disadvantages?

Advantages of digital circuits

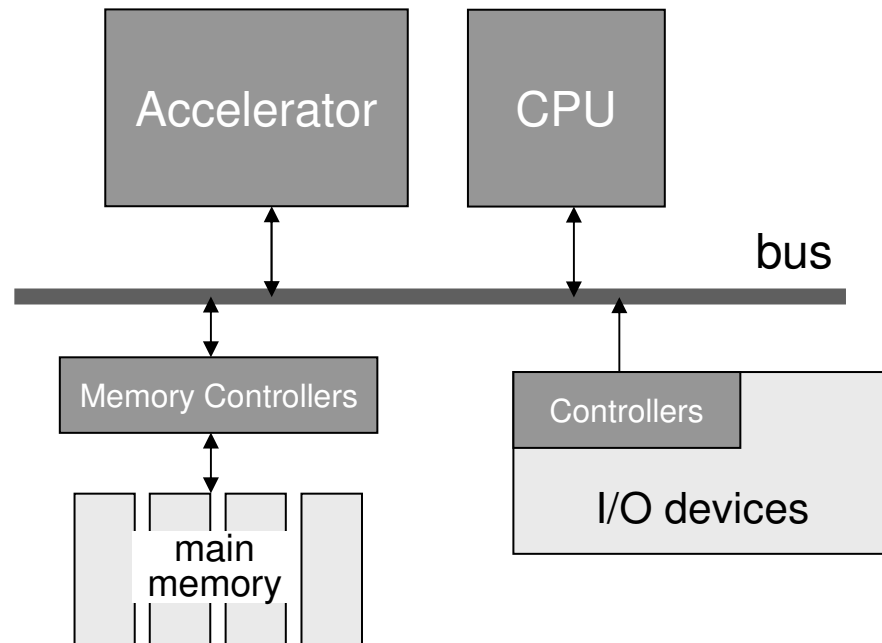
- ❑ Digital devices are programmable
 - Same manufacturing cost for different applications.
- ❑ Digital systems are more robust to errors
 - DVDs are one of the most successful digital storage devices that allow storage of information on **unreliable** cheap media using error correction code.
- ❑ Digital designs are easy for reuse and scale-up
 - This is the reason why Taiwan “hi-tech” companies only pay “banana salary” to digital engineers

Digital Systems

- ❑ A digital system is an interconnect of digital modules. To understand the operation of each digital module, it is necessary to have a basic knowledge of digital circuits and their logical function.
- ❑ A major trend in digital design methodology is the use of a HDL to describe and simulate the functionality of a digital circuit.

Best Known Digital Systems

- ❑ The general-purpose digital computer is the best known example of a digital system.
- ❑ Central Processing Unit (CPU) contains
 - Arithmetic/Logic Unit (ALU)
 - Control Unit
 - Registers
 - Cache Memory
- ❑ Bus
- ❑ Main Memory
- ❑ Accelerators
- ❑ I/O devices



Behavior, Dataflow, and Structure (1/2)

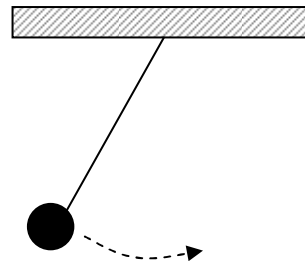
- ❑ *Behavior* description: a clock that counts 10 ticks per second; equivalently, the solution to

$$\frac{d^2x}{dt^2} + 2\lambda \frac{dx}{dt} + \omega_0^2 x = 0$$

- ❑ *Dataflow* description: a second-order dynamic equation can produce regular, repeated motion

$$x = \sin(20\pi \cdot t)$$

- ❑ *Structure* description:



Behavior, Dataflow, and Structure (2/2)

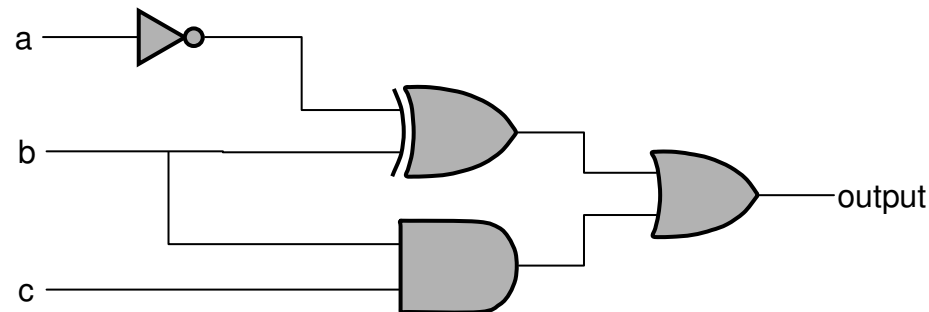
❑ Behavior:

Input a, b, c	Output
000	1
001	1
010	0
011	1
100	0
101	0
110	1
111	1

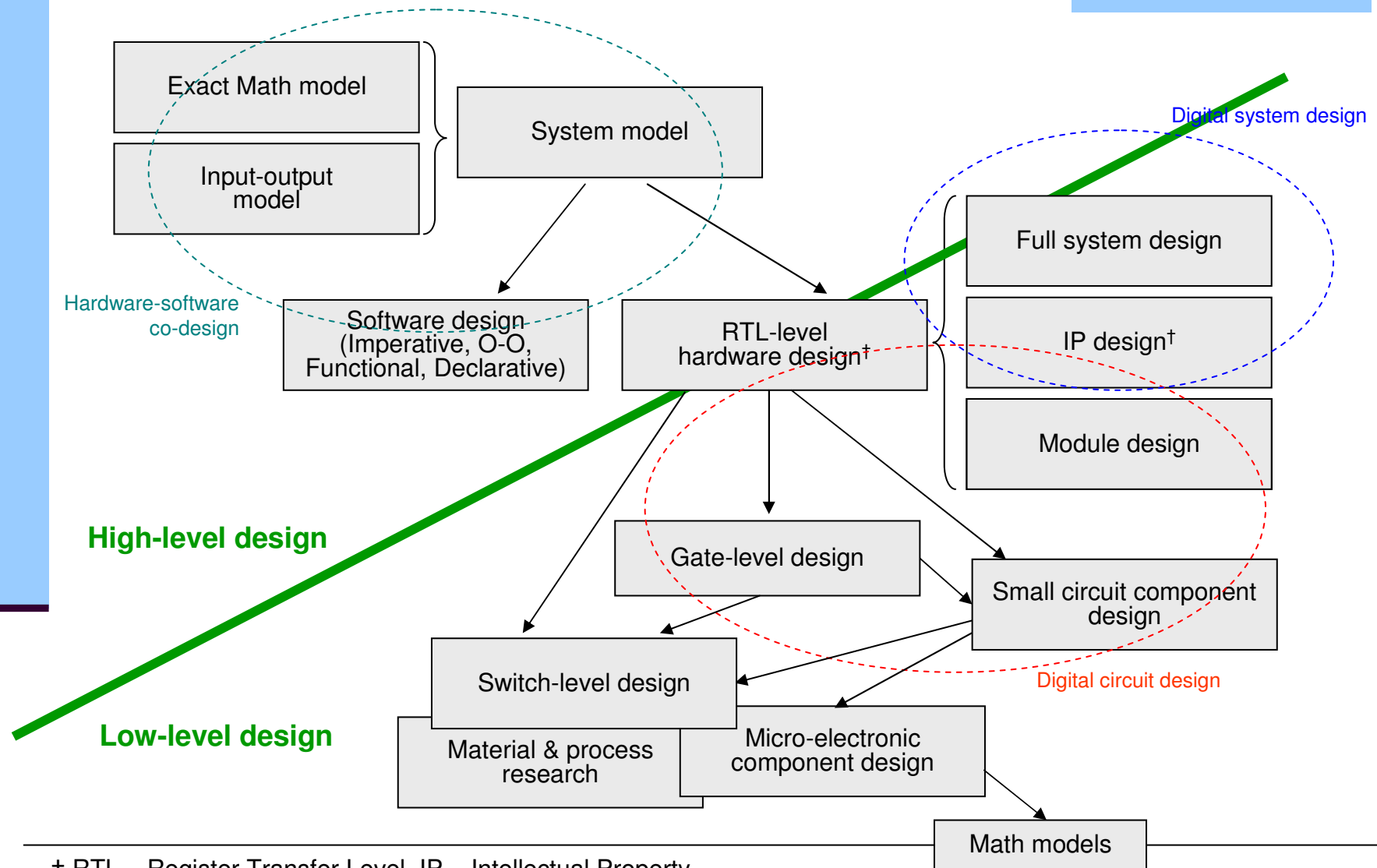
❑ Dataflow:

`output = ((not a) xor b) or
 (b and c)`

❑ Structure:



Global View of Digital System Design



[†] RTL – Register Transfer Level, IP – Intellectual Property