LE242: Digital Circuit Design

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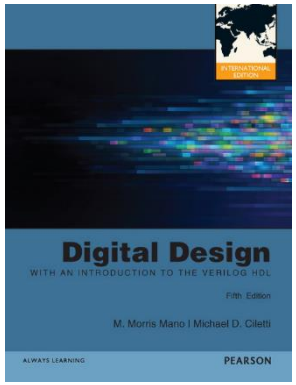
Course Information

- Instructor: Dr. Songyot Nakariyakul
  - E-mail: nsongyot@engr.tu.ac.th
  - Office Hours: by appointment via e-mail
  - Office Room: L 420-2
- Web site: http://songyot.ece.engr.tu.ac.th/LE242
  - All course materials will be posted on the web site.
  - Download the materials before attending class.

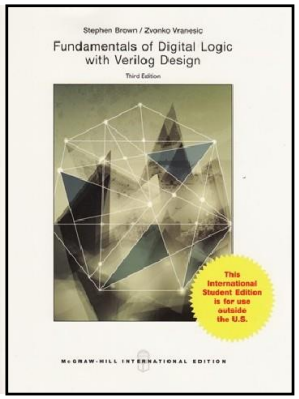
- Textbooks:

  - ทรงยศ นาคอริยกุล, *การวิเคราะห์และออกแบบวงจรดิจิทัล*, สำนักพิมพ์แห่งจุฬาลงกรณ์มหาวิทยาลัย, 2560.

  - M. Morris Mano and Michael D. Ciletti, *Digital Design*, 5th Ed., Pearson, 2013.



  - Stephen Brown and Zvonko Vranesic, *Fundamentals of Digital Logic with Verilog Design*, 3rd Ed., McGraw-Hill, 2013.



- Grading:
  - Class attendance: 5%
  - In-class exercises: 20%
  - Mid-term exam: 35%
  - Final exam: 40%
- In-class Exercise Policy:
  - 8 exercises. Copying other people's work is strictly prohibited.
- Problem Sets:
  - Problem sets will be provided on the course webpage. You are encouraged to do them to reinforce what you learn in lecture, but they will not be graded.

Course Outline

Week	Topic	Reading
1	Introduction, Number systems	M&C ch. 1.1-1.7
2	Boolean algebra	M&C ch. 2, 3.7-3.9
3	Karnaugh map	M&C ch. 3.1-3.6
4	Karnaugh map (cont'd)	M&C ch. 3.1-3.6
5	Design problems	M&C ch. 4.1-4.4
6	Combinational circuits I	M&C ch. 4.9-4.11
7	Combinational circuits II, PLD	M&C ch. 4.5-4.7
8	Midterm	

Week	Topic	Reading
9	Latches and flip-flops	M&C ch. 5.3-5.4
10	Synchronous sequential circuits	M&C ch. 5.5-5.8
11	Synchronous sequential circuits (cont'd)	M&C ch. 5.5-5.8
12	Synchronous sequential circuits (cont'd)	M&C ch. 5.5-5.8
13	Registers and counters	M&C ch. 6
14	Asynchronous sequential circuits	B&V ch. 9.1-9.3
15	Asynchronous sequential circuits (cont'd)	B&V ch. 9.6
16	Final	

Numerical Representations

- We are dealing with *quantities* in everyday life.
- Quantities are measured, monitored, recorded, manipulated arithmetically, observed, or in some other way utilized in most physical systems.
- We must represent these quantities efficiently and accurately.
- There are two ways of representing the numerical value of quantities: analog and digital.

Analog Representations

- An analog representation displays information or a quantity in a continuous way. Examples include automobile speedometers, thermometers, etc.
- In electrical analog systems, the physical quantity that is being measured or processed is converted to a proportional voltage or current (electrical signal). This voltage or current is then used by the system for display, processing, or control purposes.
- A microphone is a device that generates an output voltage that is proportional to the amplitude of the sound waves (analog signal) that strike it.

Digital Representations

- A digital representation displays information or a quantity in a discrete or discontinuous way. Examples include digital clocks, calculators, etc.
- The digital representation changes in discrete steps. There is no ambiguity when we read the value of a digital quantity, whereas the value of an analog quantity is often open to interpretation.
- The digital quantities are often represented by symbols called *digits*.

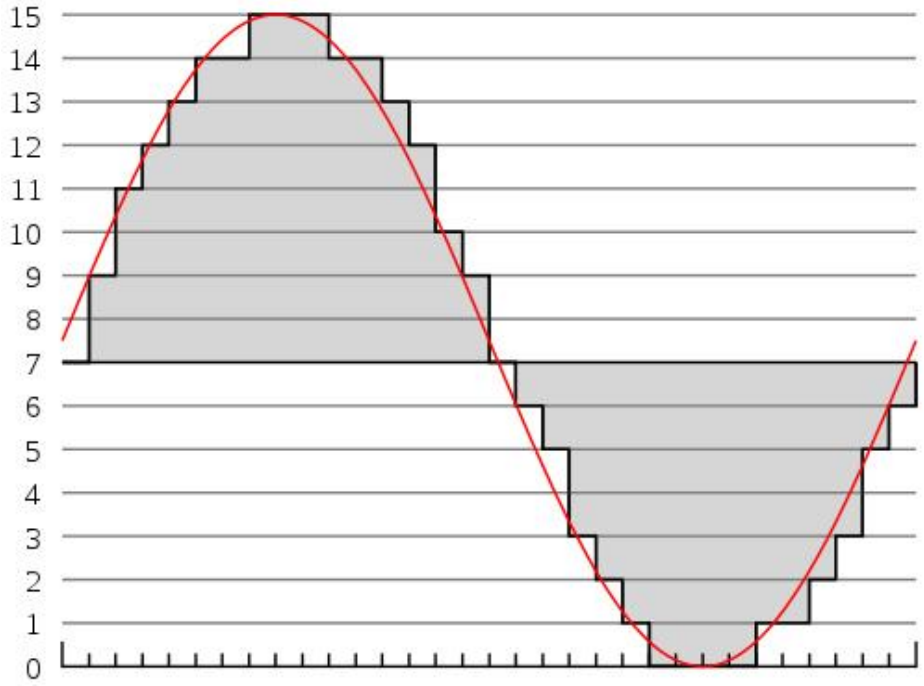
Analog vs. Digital

Analog

Digital

Source: https://learn.sparkfun.com/tutorials/analog-vs-digital

Analog vs Digital Signals



- Digital samples capture the basic structure of analog data, but it can be accurate due to limited precision.

Source: http://www.jimjesus.com/2013/06/bits-and-pvcs-my-thoughts-on-great.html

Digital Systems

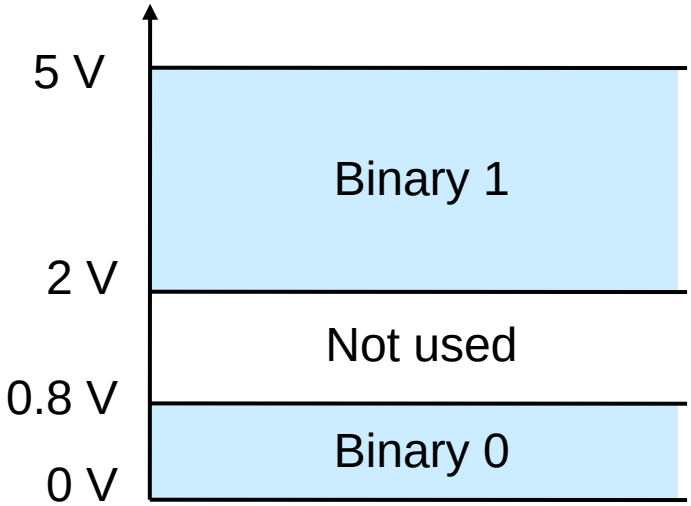
- A digital system is a device that manipulates discrete elements of information or quantities.
- Discrete elements of information are represented in a digital system by physical quantities called signals (voltages or currents).
- Electronic devices called transistors that implement these signals use just two discrete values and are said to be *binary*.
- The two discrete values by ranges of voltage values are called HIGH (1) and LOW (0).

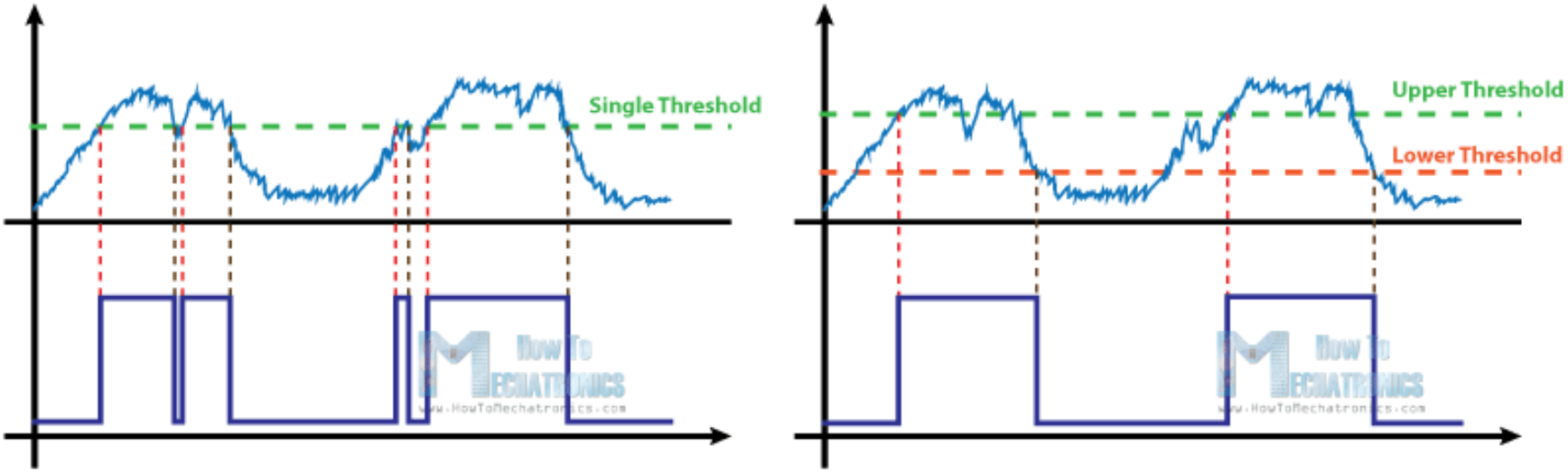
- In digital systems, a voltage of 3.6 V means the same as a voltage of 4.3 V. In analog system, the exact value of a voltage is important.

Binary 1: Any voltage between 2 V to 5 V

Binary 0: Any voltage between 0 V to 0.8 V

Not used: Voltage between 0.8 V to 2 V





- To convert noisy square waves or sine waves into clean square waves.

Source: https://howtomechatronics.com/how-it-works/electrical-engineering/schmitt-trigger/

The Digital Age

Advantages:

1. Digital systems are generally easier to design.
2. Information storage is easy.
3. Accuracy & precision are easier to maintain throughout the system.
4. Operation can be programmed.
5. Digital circuits are less affected by noise.
6. More digital circuitry can be fabricated on IC chips.

Disadvantages:

1. The real world is analog.
2. Converting data to digitized signals takes time.