EEE104 – Digital Electronics (I)

Lecture 1

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This Module

Textbooks:

T. Floyd, *Digital Fundamentals*, 10^{th} Edition, Pearson Education, 2009. China Edition, Science Press, 2011, ISBN 9787030318534

Assessment:

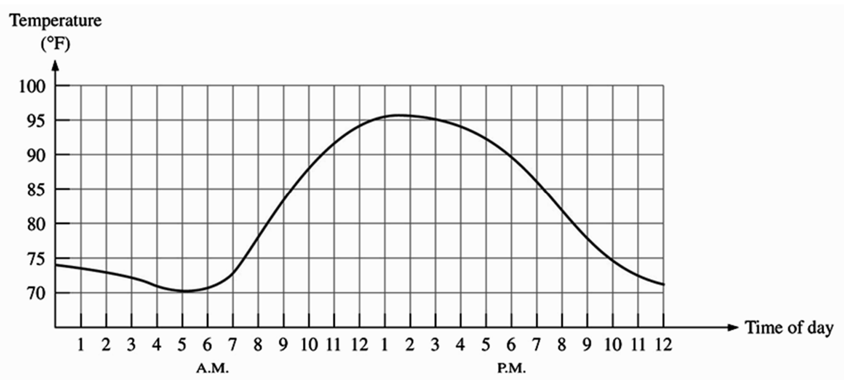
Final exam (70%), Mid-Term Class Test (10%), Lab (10%), Assignments (10%)

In This Session

- Analog and digital quantities.
- Bits, Logic Levels, and Digital Waveforms

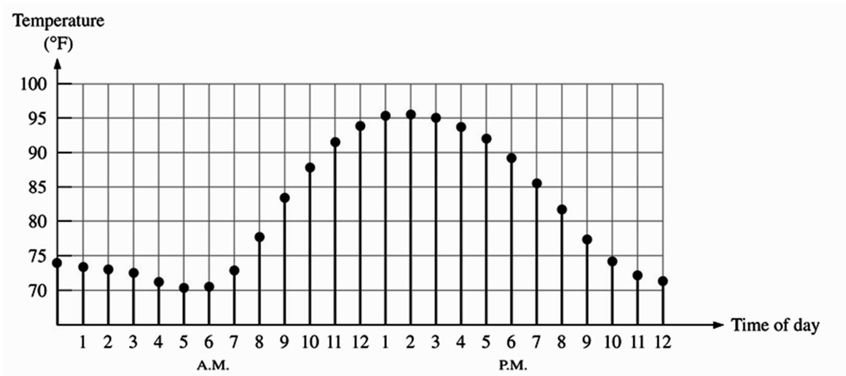
Digital and Analog Quantities

- **Analog** quantities have **continuous** values



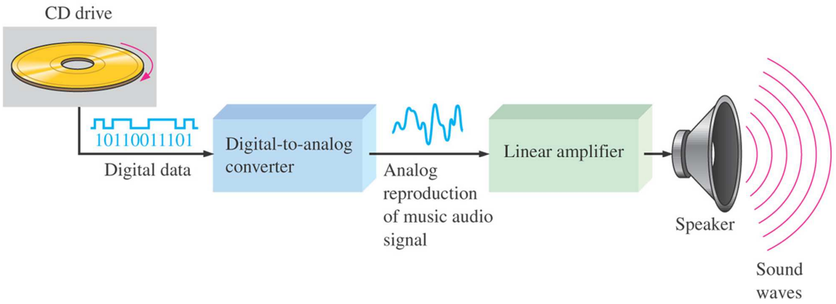
Digital and Analog Quantities

- **Digital** quantities have **discrete** sets of values, e.g. discrete time points (via sampling) and discrete values (via digitalization).

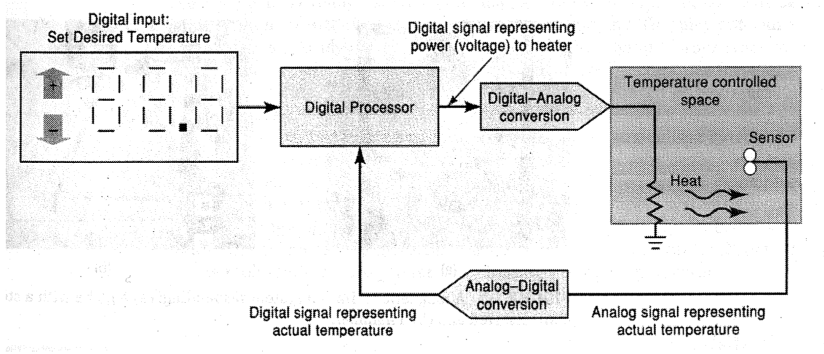


Digital and Analog Quantities

- An **analog** system contains devices that manipulate analog quantities, e.g. audio amplifiers.
- A **digital** system contains devices that manipulate digital quantities, e.g. digital audio and video equipment, computers.



Digital and Analog Quantities



Digital and Analog Quantities

Advantages of Digital Techniques

1. **Easier to design**. The range (HIGH or LOW) rather than the exact values of voltages are important.
2. **Information storage is easy**. Billions of bits of information can be stored in a small space.
3. **Accuracy and precision are easier to maintain**. They will not be degraded by the effects of temperature and humidity.

Digital and Analog Quantities

Advantages of Digital Techniques

4. **Operation can be programmed**.
5. **Less affected by noise**, as long as the noise is not large enough to convert a HIGH signal to LOW or vice versa.
6. **More digital circuitry can be fabricated on IC chips**. In analog circuitry high-value capacitors, inductors and transformers cannot be economically integrated.

Digital and Analog Quantities

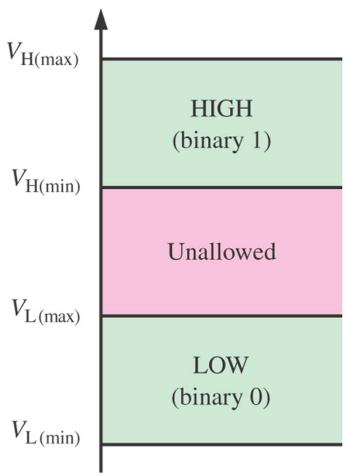
Limitations of Digital Techniques

- **The real world is analog**. We have to convert the analogy input to digital form, and after processing it convert the digital output to analog form.
- **Processing digitized signals takes time**. The more precise the numbers need to be, the longer it takes to process them.

Bits, Logic Levels, and Digital Waveforms

- The conventional numbering system uses ten digits: 0-9.
- In digital circuits, there are only two possible states: **HIGH** and **LOW**, corresponding to two different voltage levels, or open and closed switches.
- So the binary numbering system is used, which has just two digits: **0** and **1,** called **bits** (binary digits). **LOW = 0** and **HIGH = 1.**

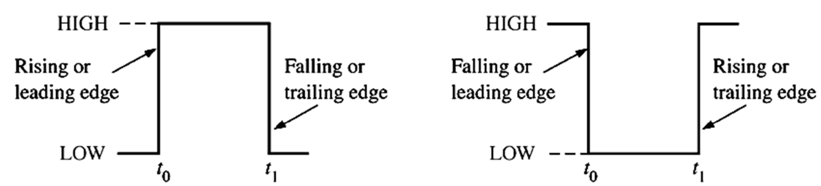
Bits, Logic Levels, and Digital Waveforms



- The voltages used to represent a 1 and a 0 are called **logic levels**.
- Each corresponds to a range of voltages.
- For TTL digital circuits , the high values range from 2 V to 5 V, and the low values range from 0 V to 0.8 V.

Bits, Logic Levels, and Digital Waveforms

- A **digital waveform** is a graph of voltage versus time.
- To represent an analog signal in digital form, multiple waveforms are required, each corresponds to one bit.
- An ideal **digital pulse**



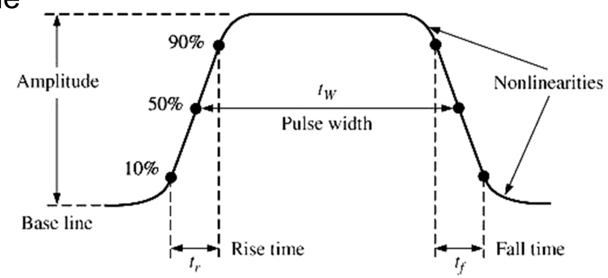
(a) Positive–going pulse

(b) Negative–going pulse

Bits, Logic Levels, and Digital Waveforms

A nonideal digital pulse

- **Rise time** (t_r) – time from 10% to 90% of the pulse magnitude
- **Pulse width** (t_w) – time between 50% points.
- **Fall time** (t_f) – time from 90% to 10% of the pulse magnitude

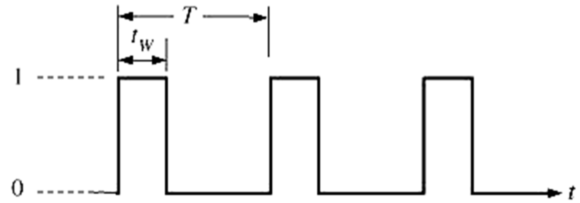


Bits, Logic Levels, and Digital Waveforms

A periodic waveform repeats itself at a fixed interval.

- T = **period** of the waveform
- f = **frequency** of the waveform

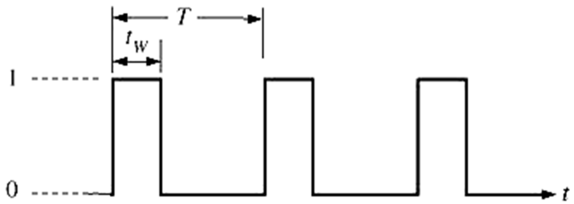
$$\mathbf{f} = \frac{\mathbf{1}}{\mathbf{T}}$$



Bits, Logic Levels, and Digital Waveforms

The **duty cycle** of a binary waveform is defined as:

$$\textbf{Duty cycle} = \left(\frac{\mathbf{t_w}}{\mathbf{T}}\right)\mathbf{100\%}$$



Bits, Logic Levels, and Digital Waveforms

- Digital waveforms are often synchronized with a periodic waveform called the **clock**.
- A **timing diagram** is used to show the relationship of multiple waveforms.