Lecture 3b
Digital Logic - Timing Diagrams and Logic Gates

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Outlines [1]

Here we discuss

- timing diagrams
- the different logic gates and their working principal

Timing Diagrams

Binary Digits

- The two digits in the binary system, 1 and 0 are called **bits**

bit Contraction of *binary digit*

- In digital circuits, two different voltage levels are used to represent the two bits *(Positive Logic)*
  1. **1** is represented by the **higher voltage**, referred to as **HIGH**
  2. **0** is represented by the **low voltage**, referred to as **LOW**

  HIGH = 1 **LOW = 0**

- Groups of *bits* (combinations of 1s and 0s), called *codes* are used to represent numbers, letters, instructions, etc.

Logic Levels

- The voltages used to represent a 1 and a 0 are called *logic levels*
- Ideally, one voltage level represents a **HIGH** and another voltage represents a **LOW**
- *In a practical digital circuit, however,* a **HIGH** can be any voltage between a *specified minimum value* and a *specified maximum value*
- Likewise, a **LOW** can be any voltage between a *specified minimum* and *a specified maximum*

Note There can be no overlap between the accepted **HIGH** and the accepted **LOW** levels.

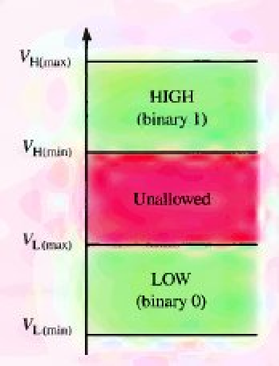


Figure: General range of **LOW**s and **HIGH**s for a digital circuit.

Digital Waveforms

- Digital waveforms consist of voltage levels that are changing back and forth between the **HIGH** and **LOW** levels or states

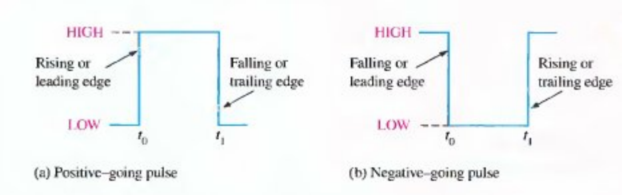
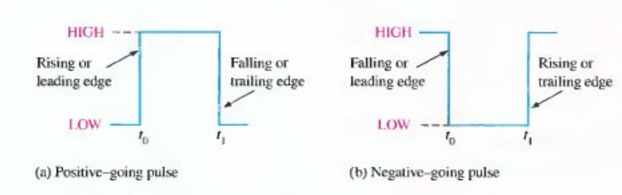


Figure (a) shows that a single positive-going **pulse** is generated when the voltage (or current) goes from its normally **LOW** level to its **HIGH** level and then back to its **LOW** level.

- A Digital waveform is made up of series of pulses

The Pulse



The pulse has two edges

1. **Leading Edge :** This occurs at time t_0
2. **Trailing Edge :** This occurs at time t_1

- The *pulses* shown are ideal because the rising and falling edges are assumed to change in zero time(instantaneously)
- *In practice, these transitions never occur instantaneously*

Non-Ideal Pulses I

Figure: Non-Ideal Pulse characteristics

Non-Ideal Pulses II

Rise time(t_r) : The time required for the pulse to go from its **LOW** level to its **HIGH** level.

Fall time(t_f) : The time required for the pulse to go from its **HIGH** level to its **LOW** level.

Practice It is common to measure rise time from 10% to 90% of the pulse **amplitude**

* The fall time is measured from 90% to 10% of the pulse **amplitude**
* The bottom 10% and top 10% of the pulse are not included in the rise and fall times because of the nonlinearities in the waveform in these areas

Pulse Width(t_w) : It is a measure of the duration of the pulse and is often defined as the time interval between the 50% points on the rising and falling edges.

Waveform Characteristics

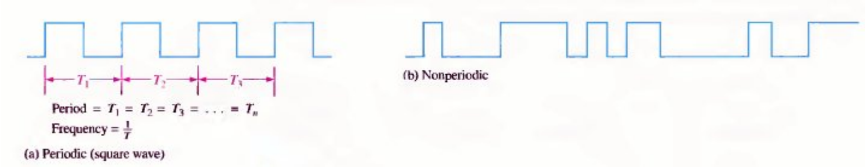


Figure: Example of digital waveforms

- Most waveforms in digital systems are composed of series of pulses, sometimes called *pulse trains*
- These *pulse trains* can be either periodic or non-periodic
- A **periodic** pulse waveform is one that repeats itself at a fixed interval, called a **period(T)**

Digital Waveform

- A digital waveform can contain binary information as a sequence of bits.
- When the waveform is HIGH, a binary 1 is present
- When the waveform is LOW, a binary 0 is present.
- Each bit in a sequence occupies a defined time interval called a **bit time**

The Clock

In digital systems, all waveforms are synchronized in which each interval between pulses (the period) equals the time for one bit.

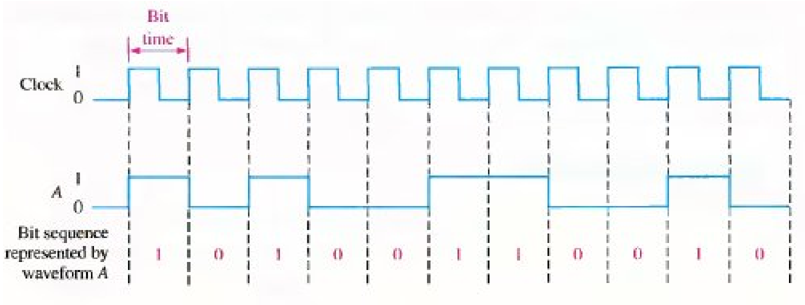
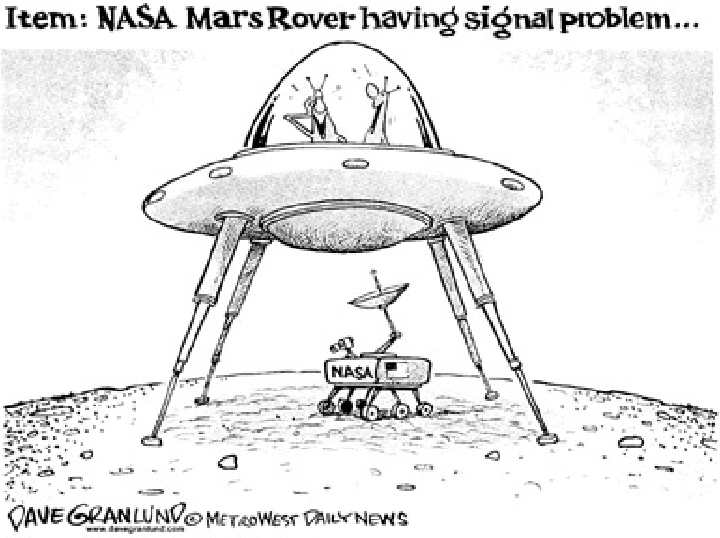


Figure: Clock waveform synchronized with a waveform representation of a sequence of bits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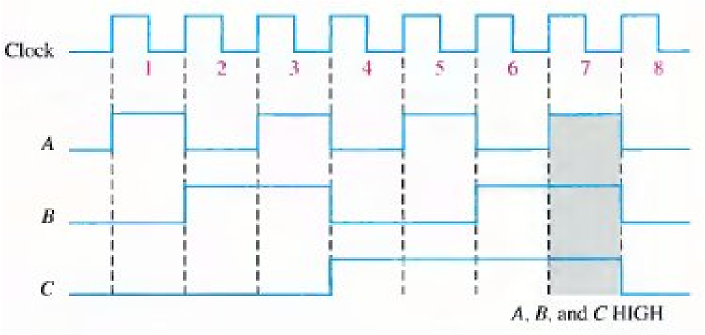
Timing Diagrams

A **timing diagram** is a graph of digital waveforms showing the actual time relationship of two or more waveforms and how each waveform changes in relation to the others,



Data Transfer

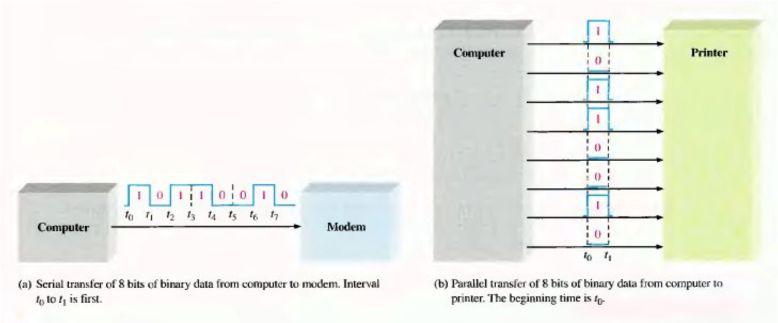


Figure: Illustration of serial and parallel transfer of binary data. Only the data lines are shown.

References

[1] Thomas L. Floyd.
Digital Fundamentals, 8th edition.
Pearson Education Inc., 2003.

QUESTIONS !!!