EEE130 Digital Electronics I
Lecture #1_1

- Digital Waveforms -

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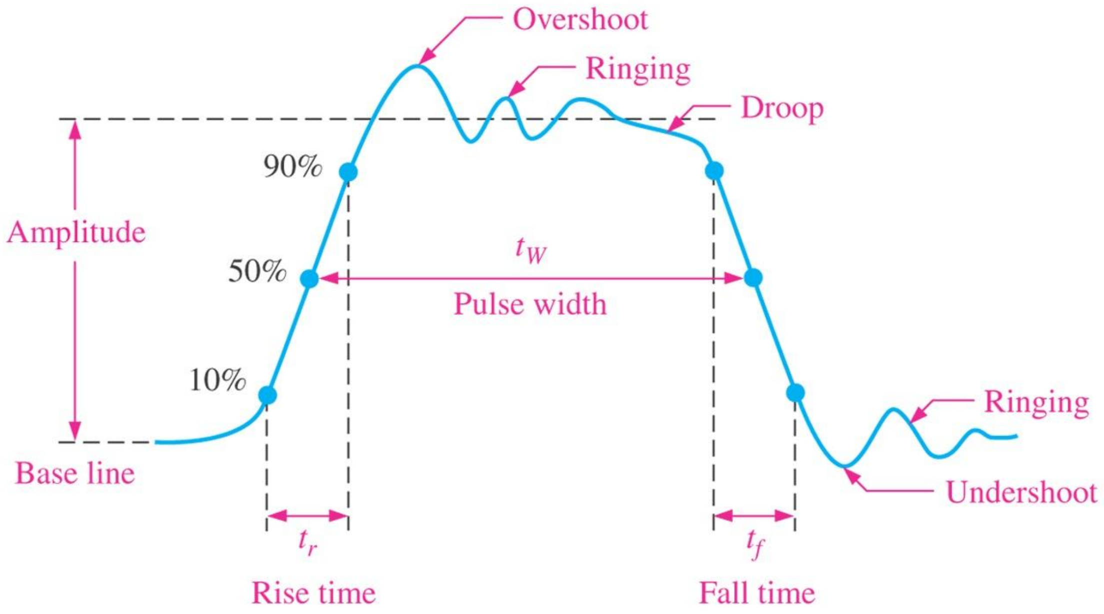
Digital Waveforms



- Important items:
  - Rise time
  - Fall time
  - Amplitude
  - Pulse width

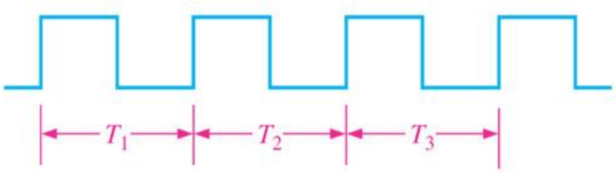
- Types of pulse: ideal and non-ideal
- Non-ideal pulse
  - Real applications exhibit this characteristic
  - Overshoot and ringing – produced by stray inductive and capacitive effects
  - Droop – caused by stray capacitive and circuit resistance (forming an RC circuit)

Information on important items

- Rise time, t_r - time required to go from LOW to HIGH
- Fall time, t_f - time required to go from HIGH to LOW
- Amplitude – height measured between HIGH and LOW (or vice versa). Measurement for rise and fall time usually made within 10% to 90% of pulse amplitude
- Pulse width, t_W -- duration of pulse, measured at 50% points on the rising and falling edges

Waveform Characteristics

- Series of pulses can be found in digital systems – called as *pulse trains*
- This can be further classified as periodic and nonperiodic
  - Periodic – repeating the same waveform at a fixed interval, called period (T)
  - Nonperiodic – opposite to periodic, where the waveform does not repeat itself at a fixed interval
- Terms to be remembered (and of course to understand) are
  - Period – total of time that a waveform repeats itself
  - Frequency – rate of how many times a waveform repeats itself
  - Duty cycle – ratio of the pulse width to the period in percentage
- Examples:



Period = $T_1 = T_2 = T_3 = \ldots = T_n$

Frequency = $\frac{1}{T}$

(a) Periodic (square wave)

(b) Nonperiodic

Relationships between period, frequency and duty cycle

- Period:

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

- Frequency:

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

- Duty cycle:

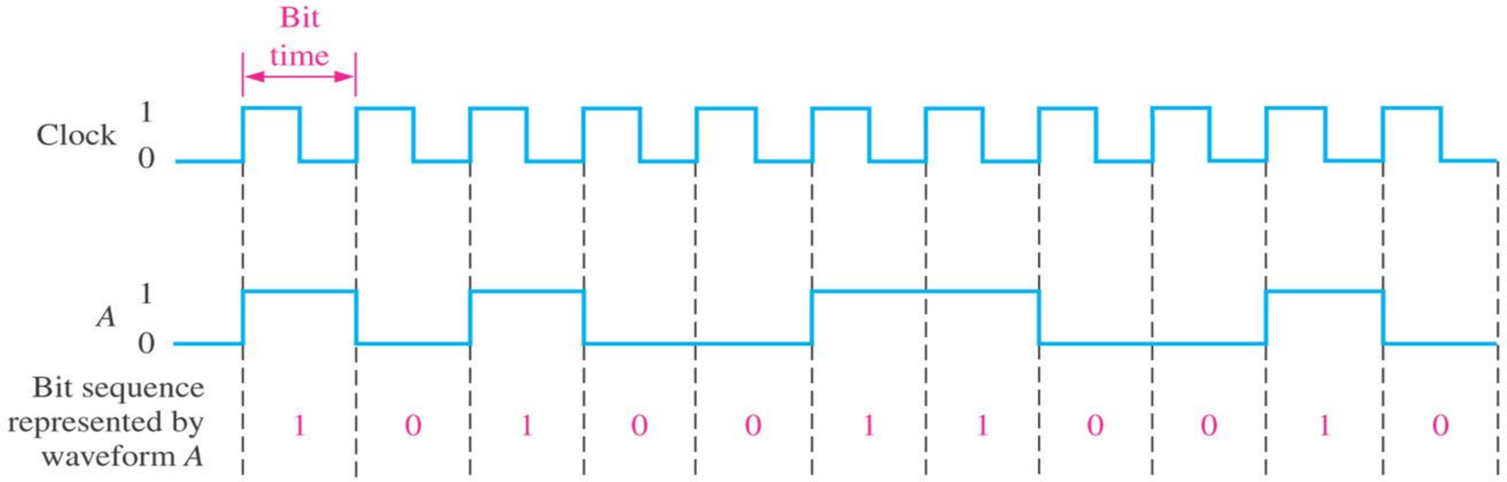
$$\mathrm{DutyCycle} = \frac{t_W}{T} 100\%$$

A Digital Waveform Carries Binary Information

- All binary information in digital systems appear as waveforms that represent sequences of bits
  - Common approach: HIGH is 1 and LOW is 0
  - Bit time – each bit in a sequence occupies a defined time interval
- What we have to know/learn to further understand this??
  - Clock – a basic timing waveform that is used to synchronize all waveforms in digital systems
  - Timing diagram – 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

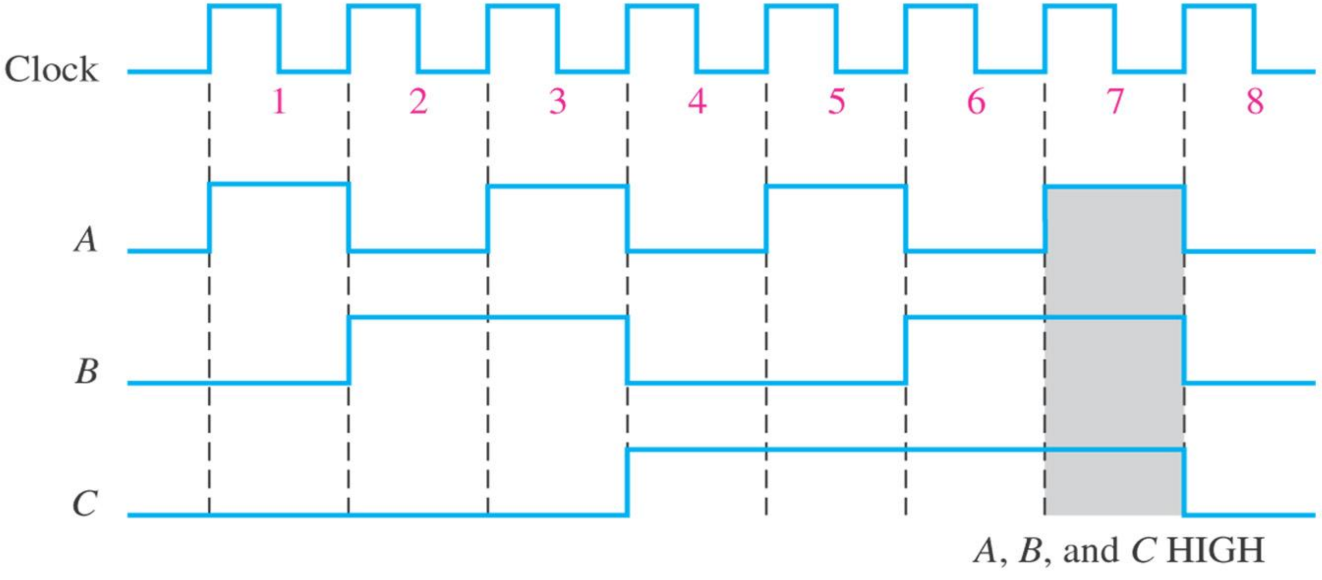
Clock

- Must be periodic!!!
- Used to synchronize all waveforms in digital systems
- Each interval between pulses in clock equals the time for one bit
- It, itself does not carry any information



Timing diagrams

- Using timing diagrams, we may know:
  - The states of all waveforms at any specified time
  - The exact time a waveform changes relative to other waveforms
- In the example below, notice that all three waveforms are HIGH only during bit time 7 and change back to LOW at the end of bit time 7



Data Transfer

- Definition of data – groups of bits that convey some type of information
- Digital systems – binary data which are represented by digital waveforms
- Why data transfer is important?
  - To make sure digital systems work accordingly
- Method of transfer
  - Serial
  - Parallel

Serial transfer

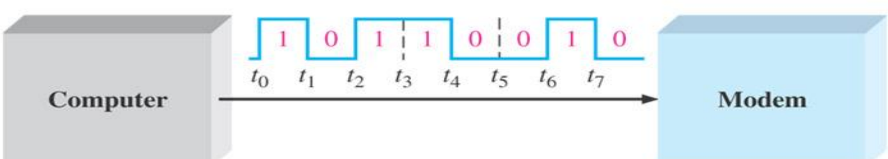
- Data are transferred in serial form from one point to another
- During the time interval from t_0 to t_1, the first bit is transferred
- Slow. Why??
  - The data have to transferred one by one
- Advantage:
  - Requires only one line

Parallel Transfer

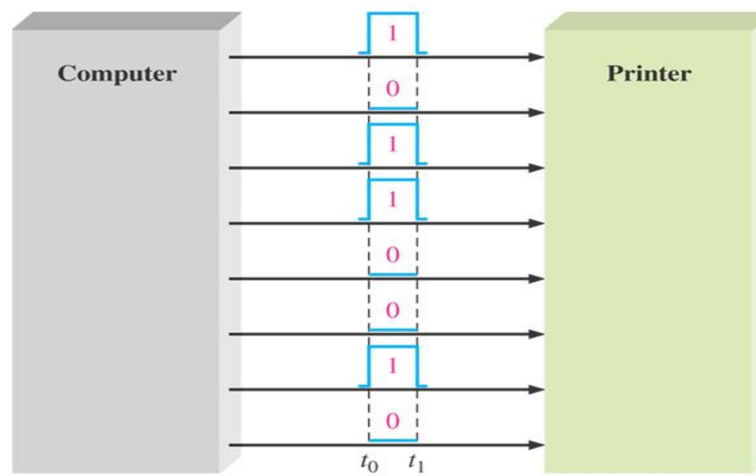
- Data are transferred in parallel form from one point to another
- During transfer, all the bits in a group are sent out on separate lines simultaneously
- Fast. Why??
  - A few bits can be sent at one time
- Disadvantage:
  - Requires a few lines

Summary of Serial and Parallel Transfer

Transfer Type	Transfer Speed	Cost
Serial	Slow	Low (Good)
Parallel	Fast	High (Not Good)



(a) Serial transfer of 8 bits of binary data from computer to modem. Interval t_0 to t_1 is first.



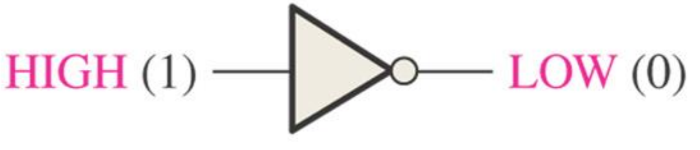
(b) Parallel transfer of 8 bits of binary data from computer to printer. The beginning time is t_0.

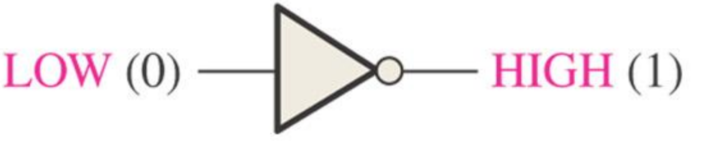
Basic Logic Operations

- Something about logics:
  - 1850s – Geoge Boolean (Irish logician and mathematician) developed a mathematical system for formulating logic statements with symbols so that problems can be written and solved in a manner similar to ordinary algebra
  - Real world basic example:
    - “The light is on” – we need to think about the bulb’s condition and the switch. What is all this about?? Let’s think!!!
- The term “logic” is applied to digital circuits to implement logic functions
- Basic logic operations are NOT, AND and OR

NOT

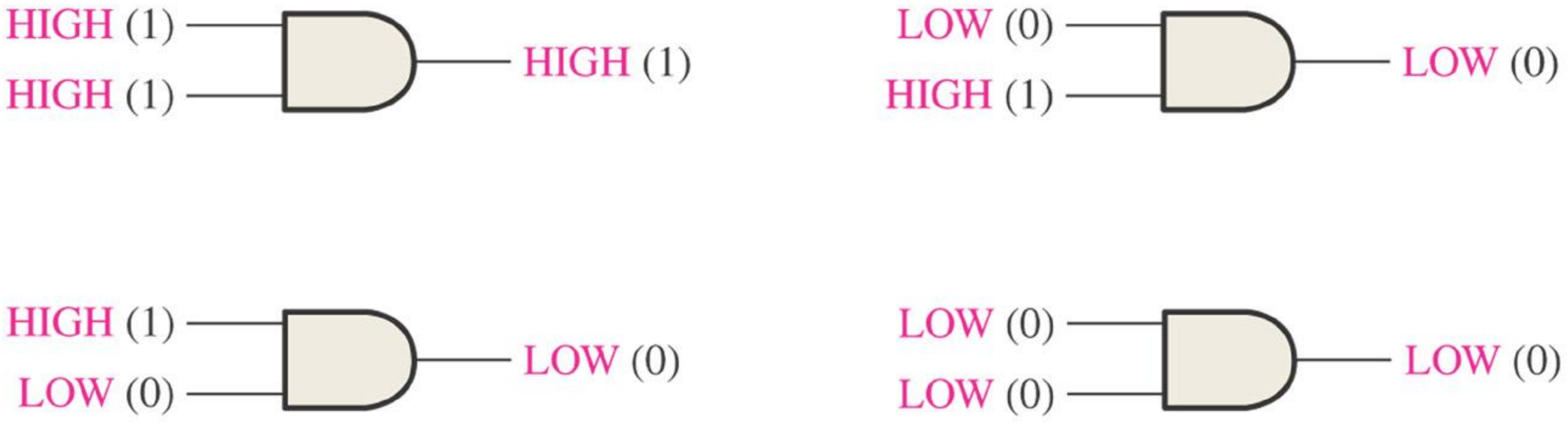
- One input and one output
- Also known as ‘inverter’. Why??
  - The output will always opposite to the input
- Definition:
  - Operation that changes one logic level to the opposite logic level





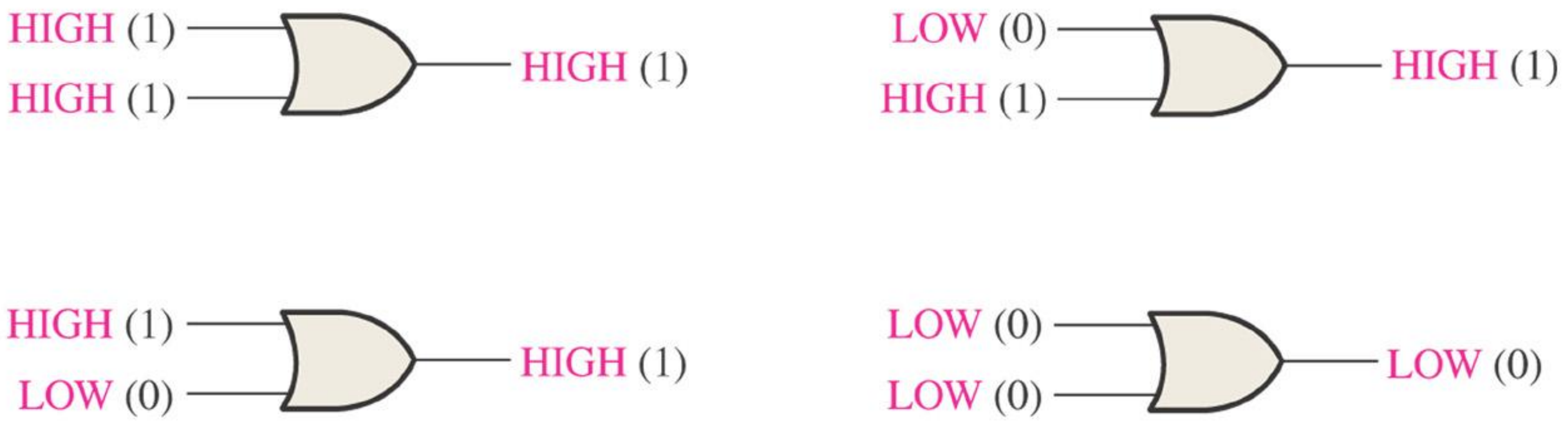
AND

- Input can be at least two and output is one
- Definition:
  - Operation produces a HIGH output only when *<u>all the inputs are HIGH</u>*



OR

- Input can be at least two and output is one
- Definition:
  - Operation produces a HIGH output when *one or more inputs are HIGH*



What we have learnt today??

- Digital waveforms and the characteristics
- Clock and time diagram
- Data transfer
- Basic logic operations