BFF1303: ELECTRICAL / ELECTRONICS ENGINEERING

Digital Electronics

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Digital Electronics-Introductory Concepts

BFF1303 ELECTRICAL/ELECTRONICS ENGINEERING

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Contents:

Outcomes

State the advantages of digital technology over analog technology.

Convert numbers between decimal, binary, and other forms.

Use the Gray code for position and angular sensors.

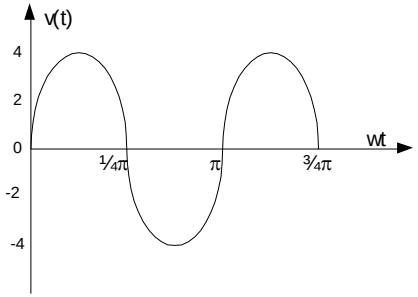
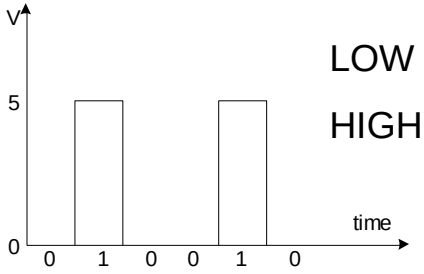
Understand the binary arithmetic operations used in computers and other digital systems.

Use Karnaugh maps to minimize the number of gates needed to implement a logic function.

Numerical Representation

- In science & technology, we are constantly dealing with quantities. There are two ways of representing the numerical value of quantities:
  - Analog
  - Digital

Numerical Representation

Analog representation	Digital representation
a quantity is represented by a voltage, current or meter movement that is proportional to the value of that quantity. it is continuous wave form that changes smoothly over time.  example1 : An automobile speedometer, in which the deflection of the needle represents the value of the automobile speed.	the quantities are represented by symbols called **digits**. it is discrete signal expressed as a burst of ON and OFF electrical pulse.  LOW (0) or FALSE : 0 Volt HIGH (1) or TRUE : 5 Volts Digital quantities vary in discrete values. Example : Digital watch, computer system.

Major difference between analog and digital quantities :

analog = Continuous

digital : Discrete (step by step)

Why Use Digital Circuit ?

- Analog electronic systems have been more popular in the past. In Real world, information dealing with time, speed, weight, pressure, light intensity, and position measurements are all analog in nature.
- Figure 8.2a shows the analog system used to interpret float level in water tank.

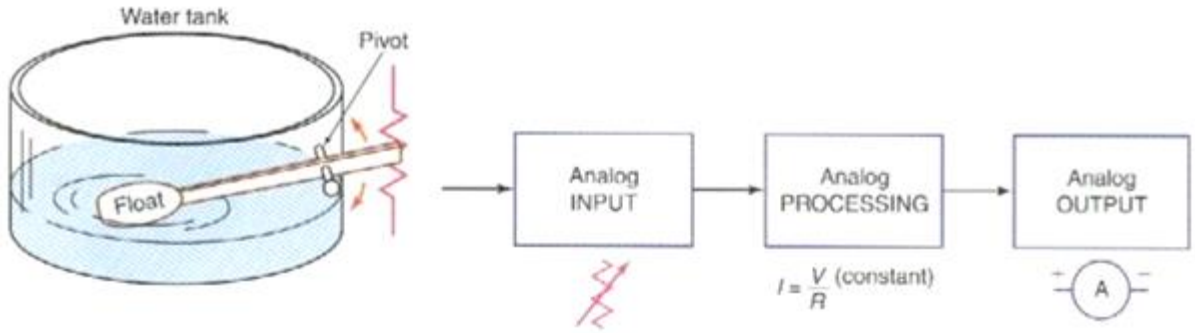


Figure 8.2a : Analog system used to interpret float level in water tank

- If more information is required about the water level, then a digital system such as the one shown in figure 8.2b might be used.
- It is required when data must be stored, used for calculations, or displayed as numbers and/or letters.

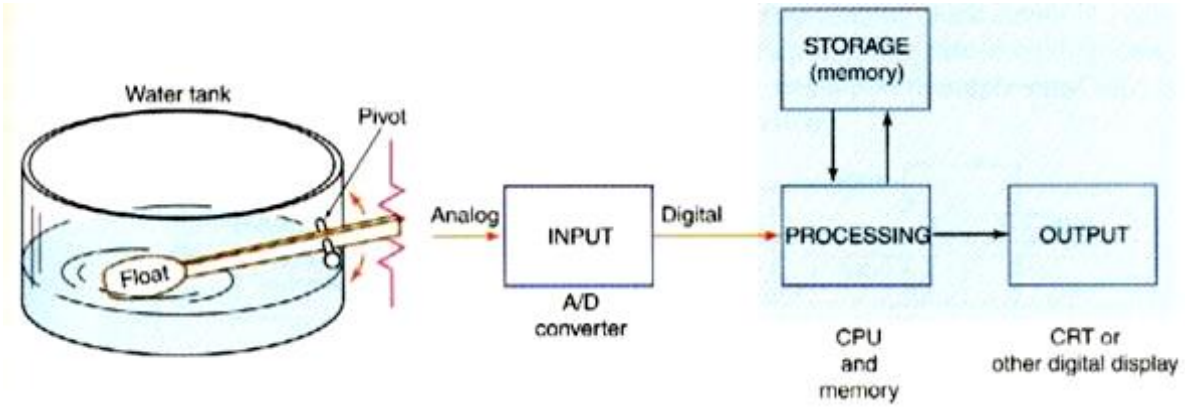
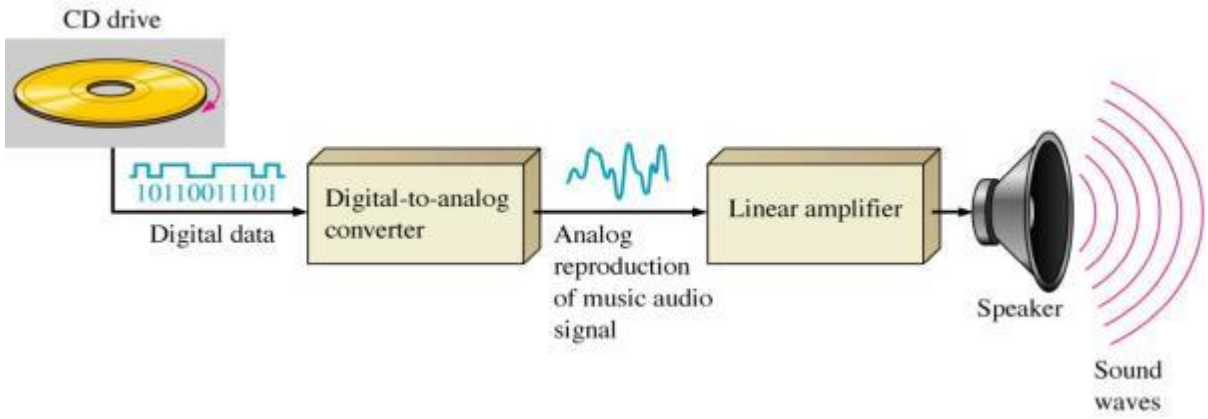


Figure 8.2b : Digital System used to interpret float level in water tank

- Figure 8.3 shows another example that is both analog and digital circuit are used in a basic principle of a CD player. This system can't be operating without digital circuit because all data/music are stored in digital form on the compact disk.



Analog and Digital Systems

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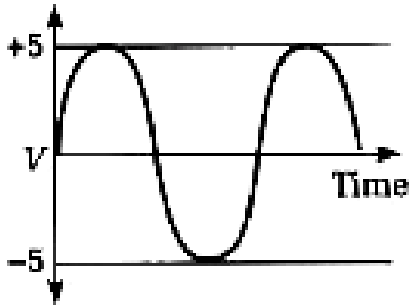
Analog system :

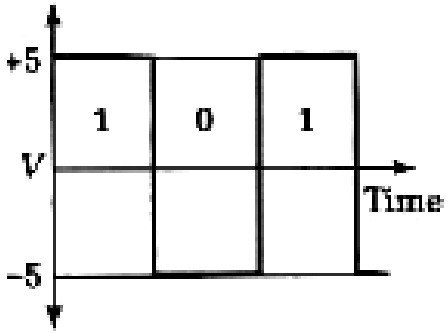
- Inputs and outputs are represented by **continuous** values.
- More close to real-world signals.
- Often used as interface circuits.



analog waveform

Digital system :

- Inputs and outputs are represented by **discrete** values.
- Easier to handle and design.
- More tolerable to signal degradation and noise.
- **Binary digital systems** form the basis of all hardware design today



digital waveform

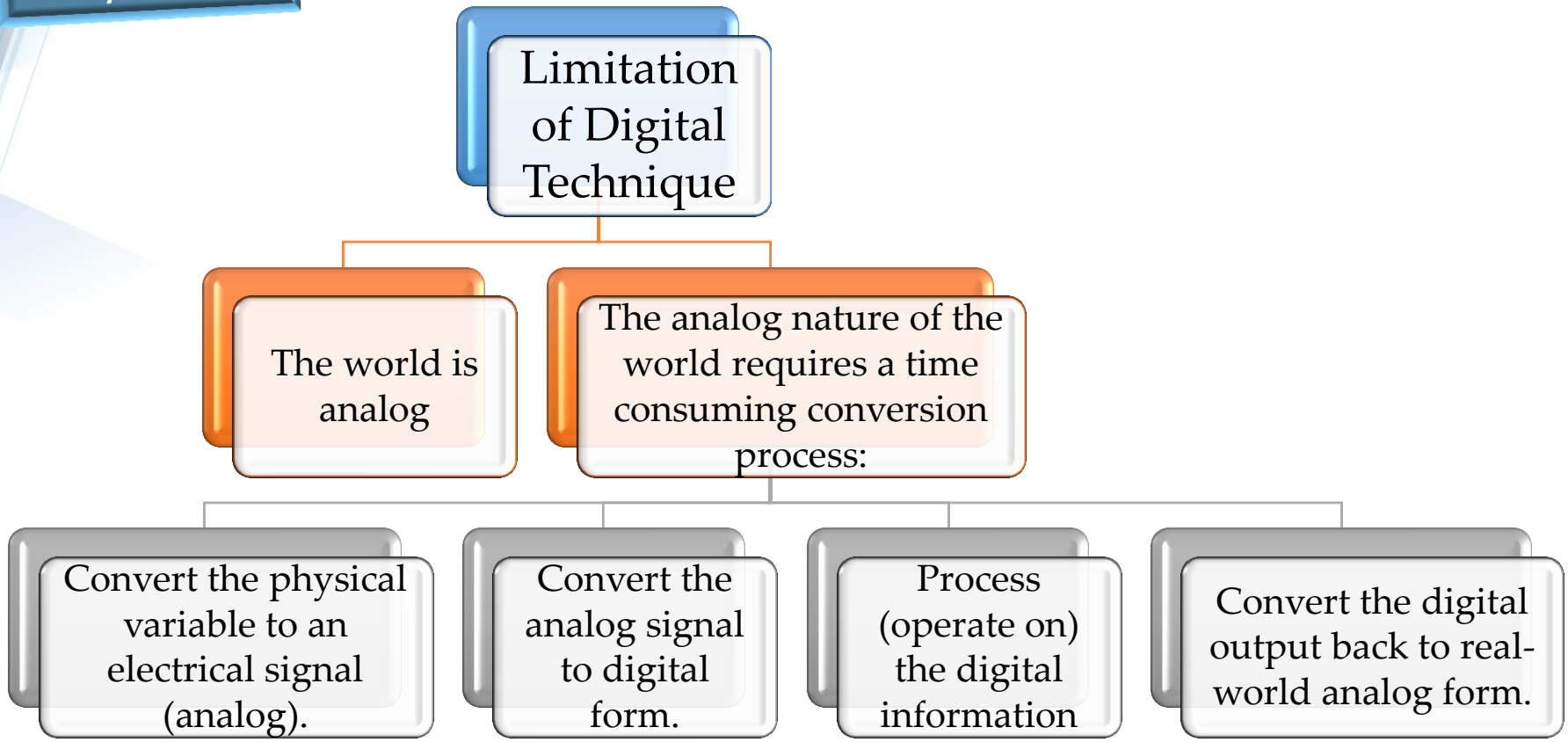
Analog has Ambiguity
Digital has only one interpretation

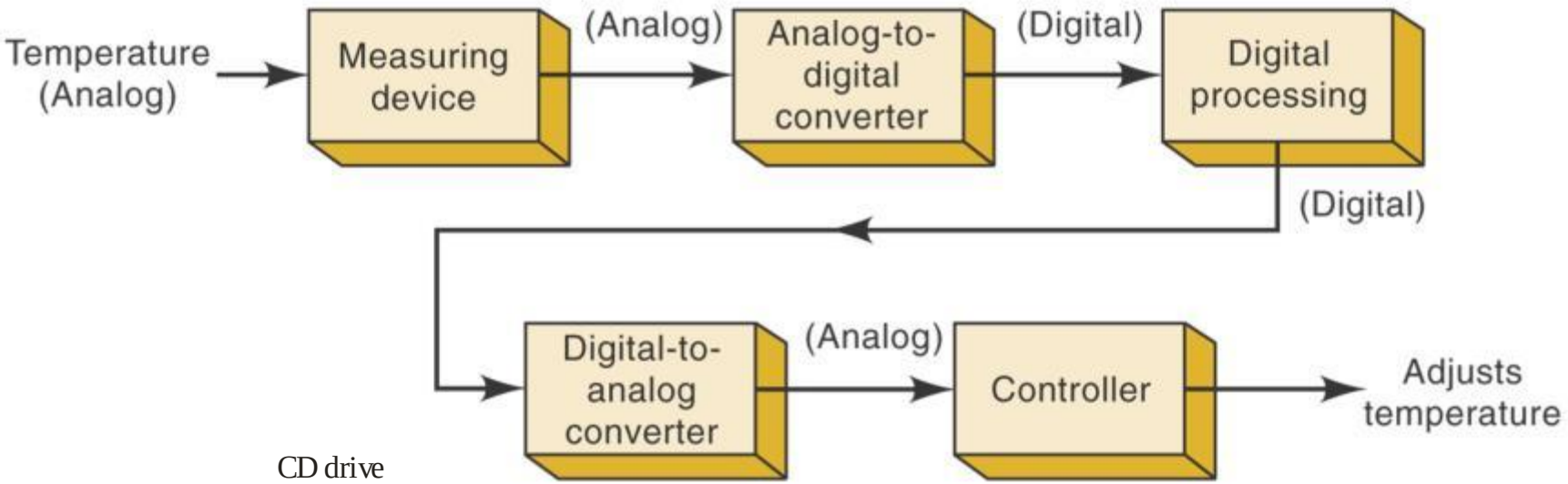
Analog Clock

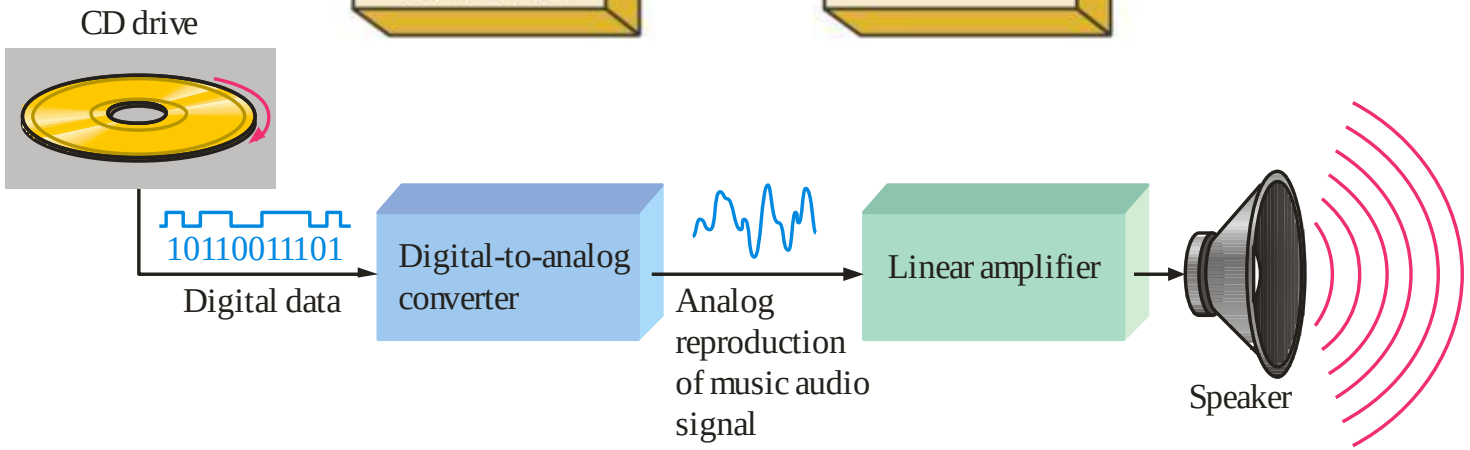
Digital Clock

1:56 pm

Analog and Digital Systems


Limitation of Digital Technique
The world is analog
The analog nature of the world requires a time consuming conversion process:
Convert the physical variable to an electrical signal (analog).
Convert the analog signal to digital form.
Process (operate on) the digital information
Convert the digital output back to real-world analog form.


Temperature (Analog)
Measuring device
(Analog)
Analog-to-digital converter
(Digital)
Digital processing
(Digital)
Digital-to-analog converter
(Analog)
Controller
Adjusts temperature


CD drive
10110011101
Digital data
Digital-to-analog converter
Analog reproduction of music audio signal
Linear amplifier
Speaker
Sound waves

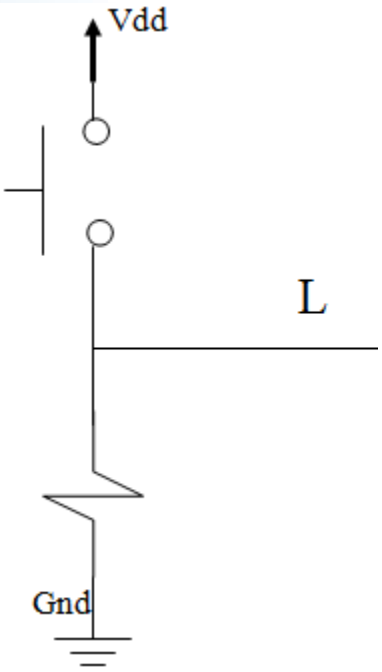
Binary Representation

- The basis of all digital data is binary representation.
- Binary - means 'two'
  - 1, 0
  - True, False
  - Hot, Cold
  - On, Off
- Two ways to think about logic signals

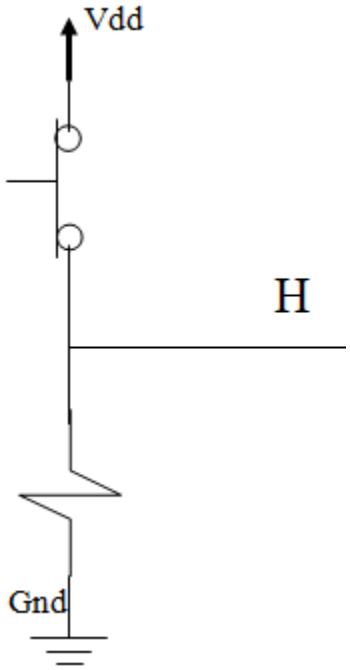
- Fixed logic convention
  - High voltage always means 1, TRUE, Asserted
  - Low voltage always means 0, FALSE, Negated
- Mixed Logic convention
  - Can have High and Low true signals
  - High true signals means that high voltage means 1, True, asserted
  - Low true signals means that low voltage means 1, True, asserted
  - In **real world**, have both high and low true signals.

High True button (switch)

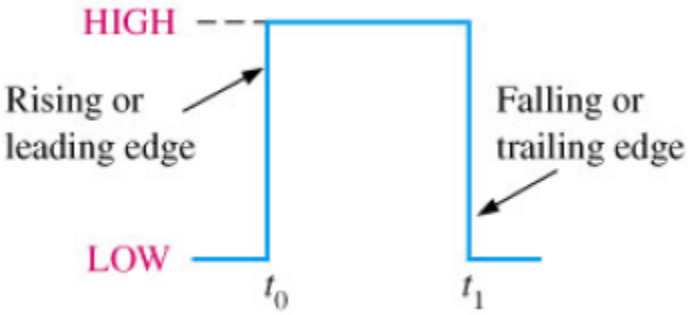
- Different ways to say that a signal is **high** true
  - Is high if signal is TRUE, is low if signal is FALSE
  - Is high if signal is 1, is low if signal is 0



Switch open (negated), output is L



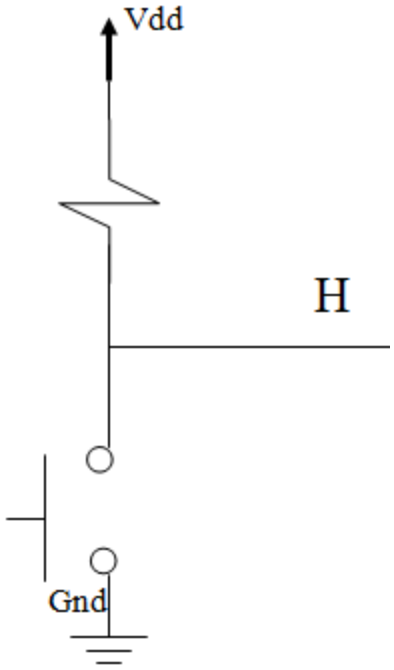
Switch closed (asserted), output is H



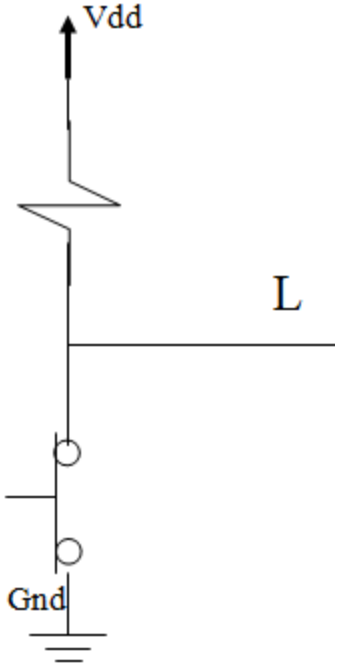
Ideally positive-going pulse

Low True switch

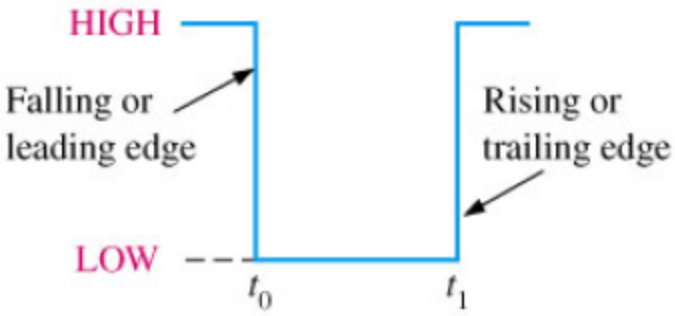
- Different ways to say that a signal is **low** true
  - Is low if signal is TRUE, is high if signal is FALSE
  - Is low if signal is 1, is high if signal is 0



Switch open (negated), output is H

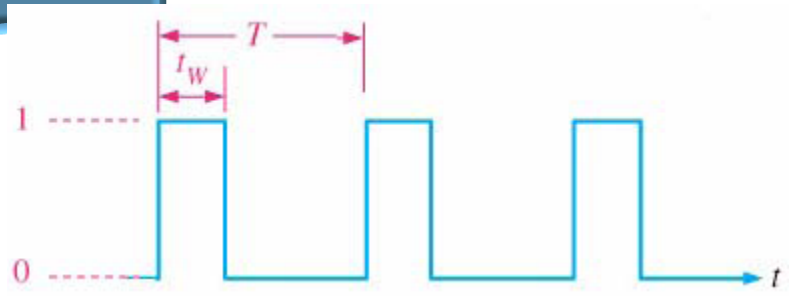


Switch closed (asserted), output is L



Ideally negative-going pulse

Ideal form for binary pulse:

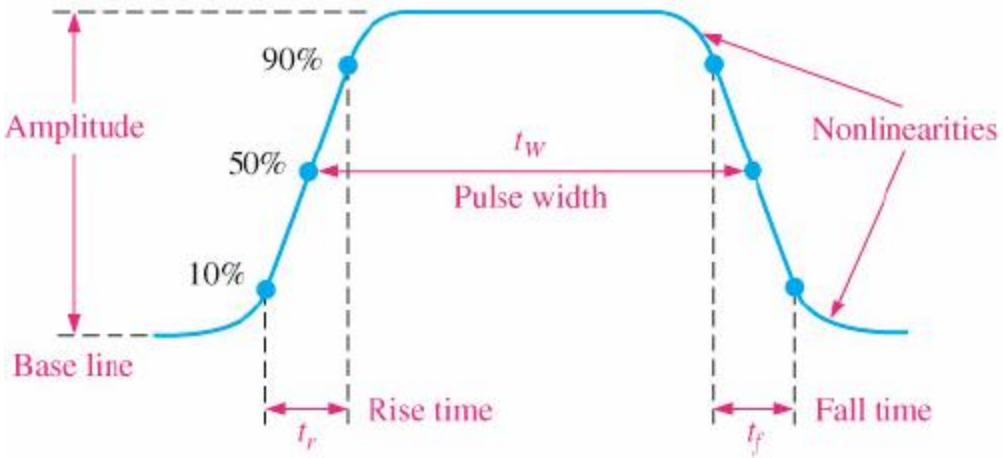


t_w = pulse width
T = period of the waveform
f = frequency of the waveform = 1/T

The duty cycle of a binary waveform is defined as:

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

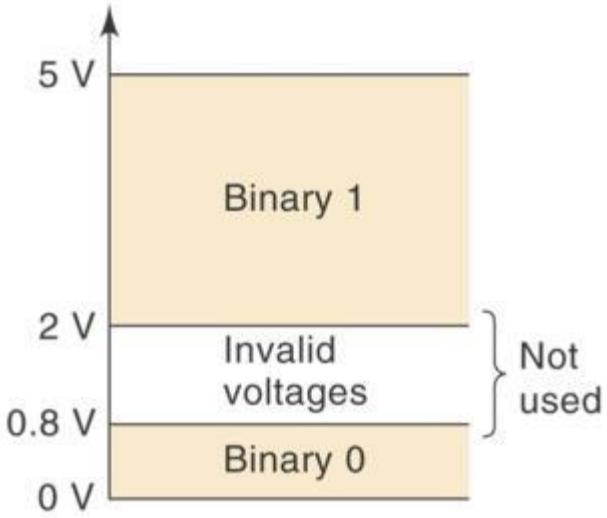
Practically form for binary pulse:



Major parts of a digital pulse:

- Base line
- Amplitude
- Rise time (t_r)
- Pulse width (t_w)
- Fall time (t_f)

- Exact voltage level is not important in digital systems.
- A voltage of 3.6 V will mean the same (binary 1) as a voltage of 4.3 V.

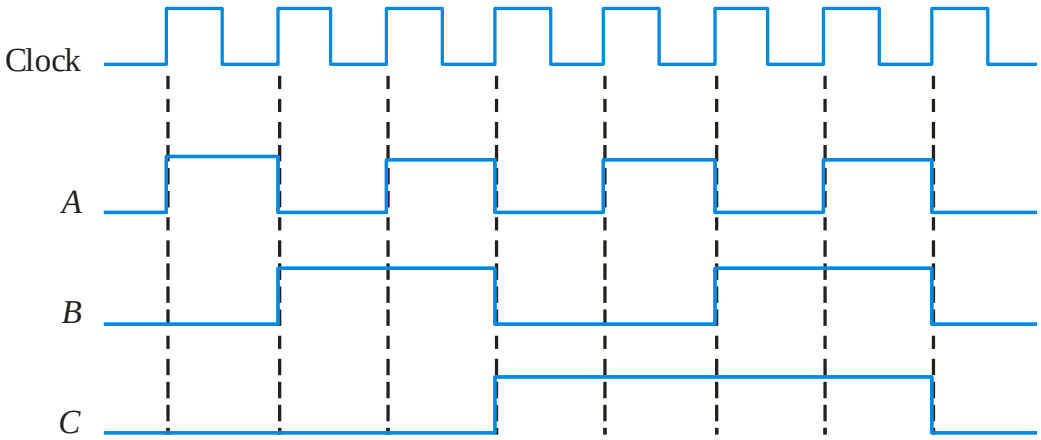


(a)

Digital Signals and Timing Diagrams

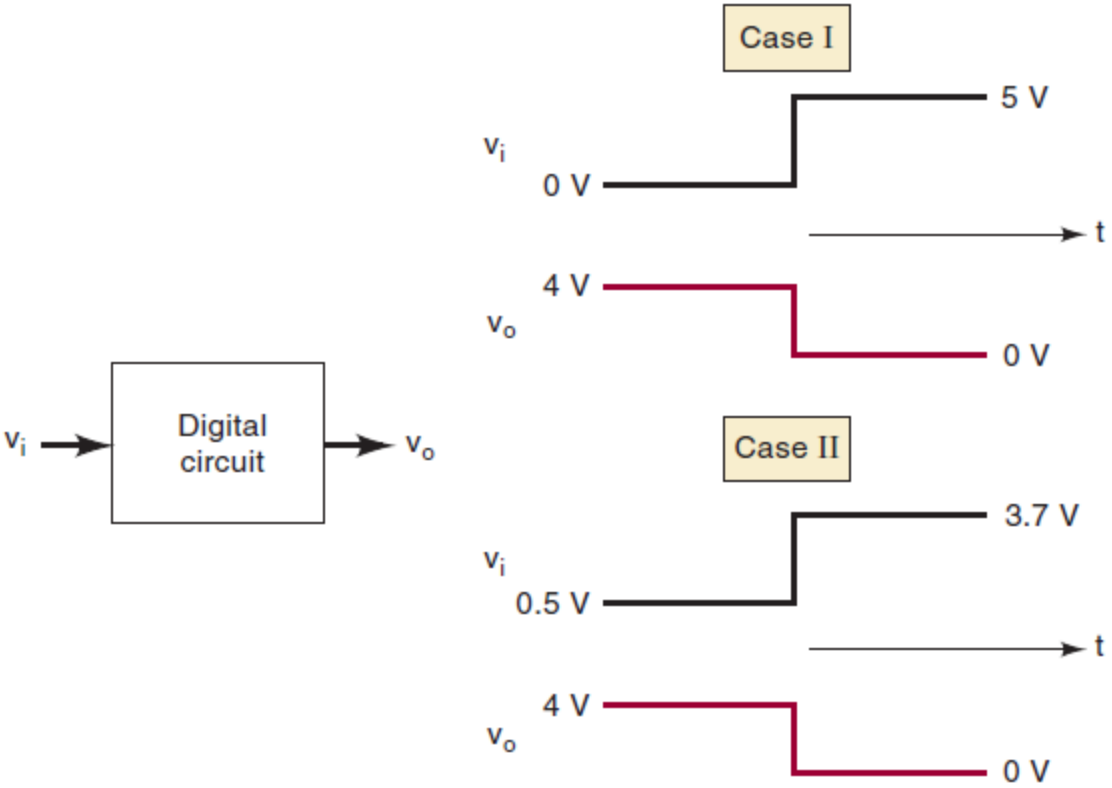
- Timing diagrams show voltage versus time.
- Horizontal scale represents regular intervals of time beginning at time zero.
- Timing diagrams are used to show how digital signals change with time.
- Timing diagrams are used to compare two or more digital signals.
- The oscilloscope and logic analyzer are used to produce timing diagrams.

Representing Binary Quantities



Digital Circuits

- Digital circuits - produce and respond to predefined voltage ranges.
- Logic circuits – used interchangeably with the term, digital circuits.
- Digital integrated circuits (ICs) – provide logic operations in a small reliable package.


Case I
5 V
v_i
0 V
t
4 V
v_o
0 V
v_i
Digital circuit
v_o
Case II
3.7 V
v_i
0.5 V
t
4 V
v_o
0 V

Parallel and Serial Transmission

- Data can be transmitted by either serial transfer or parallel transfer.
- Parallel transmission – all bits in a binary number are transmitted simultaneously. A separate line is required for each bit.
- Serial transmission – each bit in a binary number is transmitted per some time interval.