Digital System Design

objectives :

1. Introduction (digital system design concepts & definition)
2. Advantages and draw backs of digital techniques compared with analog.
3. Digital Abstraction
4. Synchronous and Asynchronous systems.
5. Specification of digital systems
6. Implementation of digital systems.
7. Switching networks Types: Combinational and Sequential
8. Digital system Example.

① Introduction (Definitions & concepts)

System : A set of related components work together to a achieve a goal.

A system contains :

- Input
- behavior
- output

Behavior is a function that translates input to output.

Components are electronic components : digital, analog and mixed signals.

- Digital system is a system in which signals have a finite number of discrete values

  digital ≡ discrete (step by step)

- Analog system contains devices that manipulate continuous set of values (Analog form representation)

  analog ≡ continuous

- Mixed System (hypric) :

  mixed system can manipulate both signals (digial and analog forms).

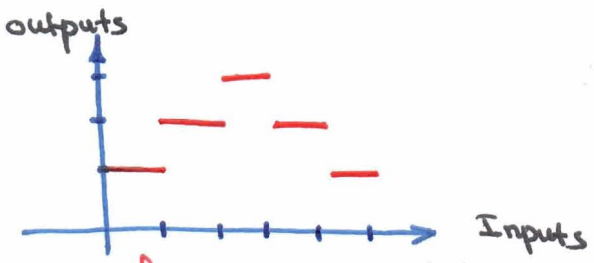


figure : Digital signal

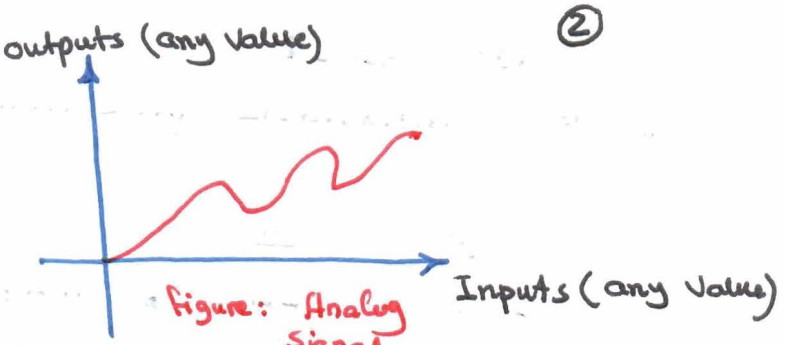


figure: Analog signal

Inputs and output (Some discrete values)

- In Analog system, for any input value → the set of Infinite output values can be obtained.
- In mixed systems, they can contain both finite and infinite values for Inputs and/or outputs.

2. Advantages and drawbacks of digital techniques Compared with analog.

Advantages

a- Digital systems are generally easier to design.
" automated design and fabrication" on IC chips"

b- Information storage is easy

c- Digital representation is very well suited for numerical and non-numerical information processing.

- numerical information :

The digital representation is simple ; 0, 100, 150.53

- non-numerical information :

The character can be represented digital in easy way.

d- Accuracy and precision are greater :

digital systems can ~~handle~~ handle as many digits of precision as you need simply by adding more switching Circuit, In analog systems, precision is usually 3-4 digits.

e- operation can be programmed.

f- Digital Circuits are less affected by noise

g- Low cost

h- Easy to duplicate similar Circuits (regular structures).

i- The main advantages :

Easily controllable by computer, The finite number of values in a digital system can be

represented by a vector of signals with just two values (Binary signals). e.g. 2 is 0010 and 10 is 1010.

So the device which process the signal is very simple say a switch - open/close.

Finite values - 0 and 1 (Binary values)

Ex

0 - 10 decimal numbers:

0	0000	3	0011
1	0001	4	0100
2	0010	⋮	⋮
		10	1010

limitations (disadvantages) of Digital techniques:

a- Lower speed (extra time required to perform conversions)

b- The major drawback is

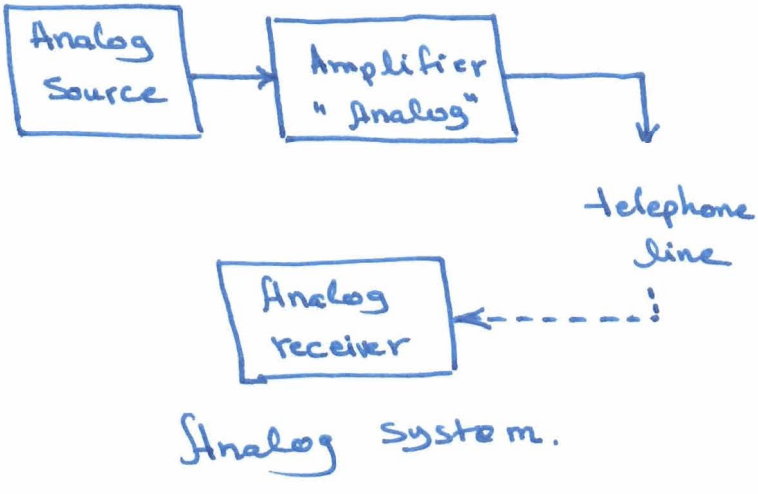
"The physical world is analog"

(temperature, pressure, talk, ...),

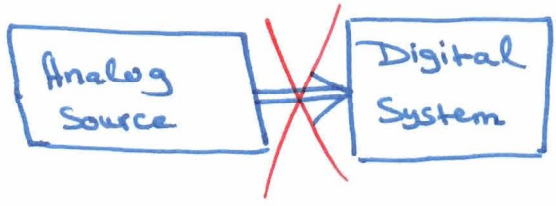
So we need to convert digital to analog and vice versa to communicate with real world.

three steps must be followed.

1. Convert the real-world analog inputs to digital form.
2. process the digital information.
3. Convert the digital outputs back to real-world analog form.

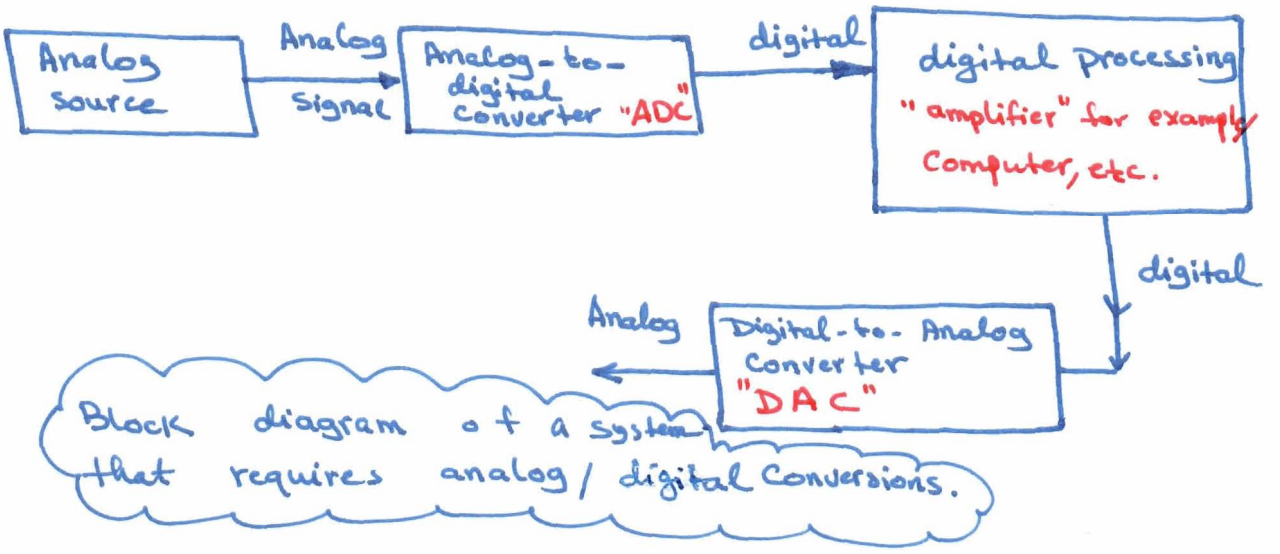


Analog system.



We Cannot Connect directly.

④ The right connection (using digital System) is



3. Digital Abstraction

- Digital Circuits actually deal with analog signals (Current or voltage : 0 – 10 Volts).

example :

Analog Values : 10 V power supply

0 0.5 1 1.7 1.9 2.3 , ... , 9.7 , 9.9, 10

To represent these values digitally, using just two values 0 and 1 ⇒

We first define two ranges for each 0 and 1

* a range of values ⟶ 0
  and another range ⟶ 1

for example :

one range 0 – 4.8 V ⟶ 0

4.8 – 10 V ⟶ 1

So the digital representation for the above sequence is :

0	0.5	1	1.7	1.9	....	9.7	9.9	10
↓	↓	↓	↓	↓		↓	↓	↓
0	0	0	0	0		1	1	1

Digital Abstraction

- Digital abstraction allows analog signals to be ignored and allows some discrete values to be used.

Example : Binary System

Only two values are allowed - 1 and 0

1 means high value or Logic "TRUE"

0 means low value or Logic "FALSE"

4. Synchronous and Asynchronous systems

- Synchronous system :

elements change their values at certain specified times (clocked)

- Asynchronous system :

output can change at any instant of time.

Example :

- Digital clock :

* if a digital clock is set to alaram at every minute

10:10 , 10:11, 10:12, 10:13, etc

then the system is synchronous.

* if a digital clock is set to alaram at any time:

10:10 , 10:50, 11:33, 13:15, etc

then the system is Asynchronous.

5. Specification of digital systems

Specification of system is the description of the system functions and another characteristics required for designing it.

- speed, cost and power (requirements)

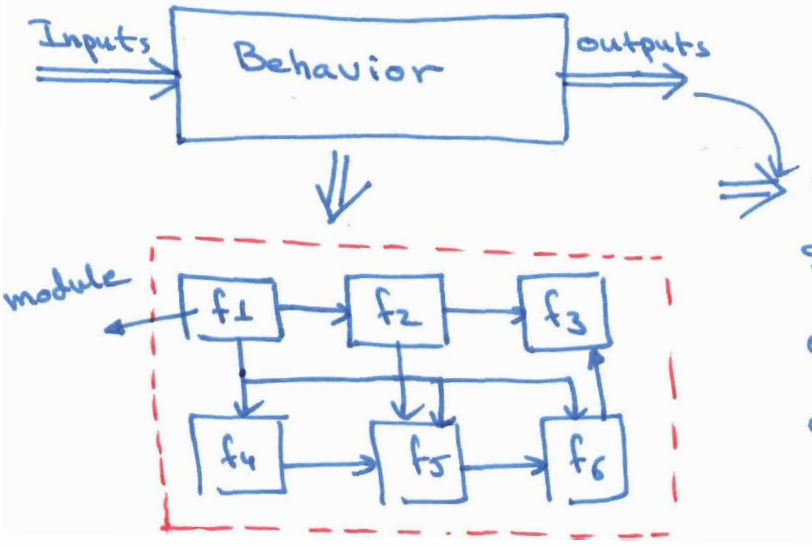
they are related, when construct a system.

6. Implementation of digital system.

- Implementation means how the system is constructed from smaller and simpler components called modules.
- The modules can vary from simple Gates to complex processors.
- Digital system follows some hierarchical Implementation.

Hierarchical Implementation:

- **Modular design:**
  - Divide and Conquer
  - modules are designed and built separately and then assembled to form the system.
  - Simplifies implementation and testing

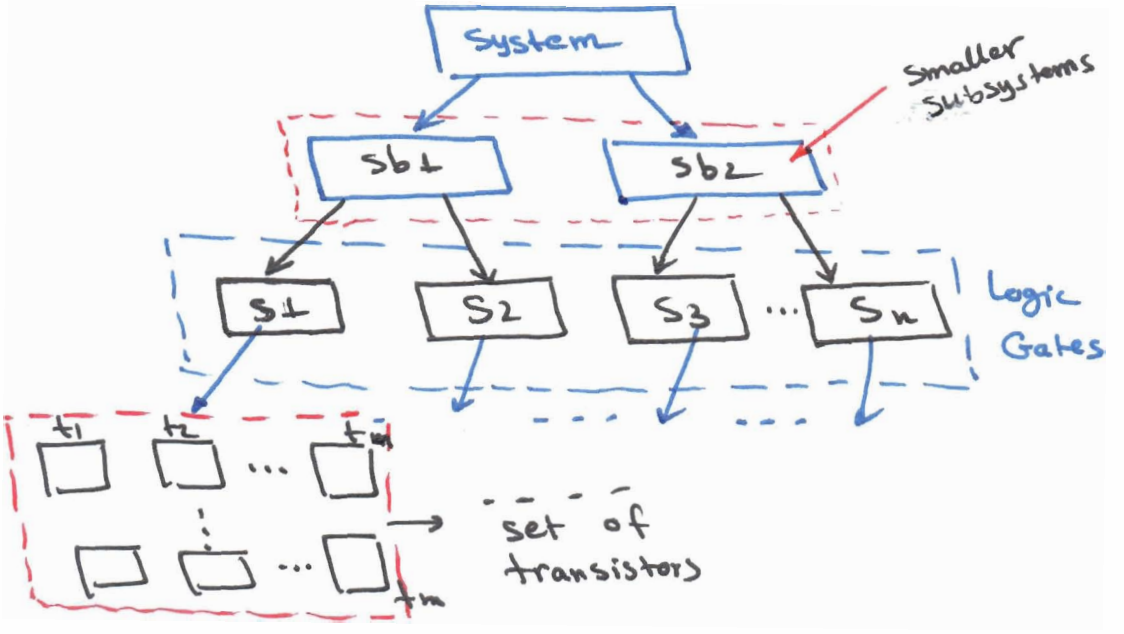


We can break to smaller blocks, each block has its own function.

Design approaches:

1. Top- down Design:

- Starts at the top and works down
- decomposes the system into subsystem and then subsystem into simpler and smaller subsystems and so on.
- Stop when subsystem can be realized by directly available module.



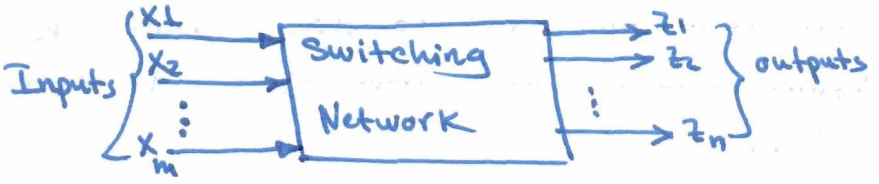
2- Bottom-up Design

- Starts at the leaves and put pieces together to build up the design.
- subsystems are assembled to form a bigger subsystem.
- Stop when required functional specification is achieved.

7. Switching networks Types: Combinational and Sequential

- Switching network :

many of the subsystems of a digital system take the form of switching network.



- Switching networks Types:
  - Combinational
  - Sequential

In Combinational network: the output values depend only on the present value of the inputs and not on past values.

In Sequential network the output depend on both the present and the past input values (we need a memory).

In general, a sequential network is composed of a combinational network with added memory elements.

⇒ The basic building blocks used to construct combinational network are Logic gates

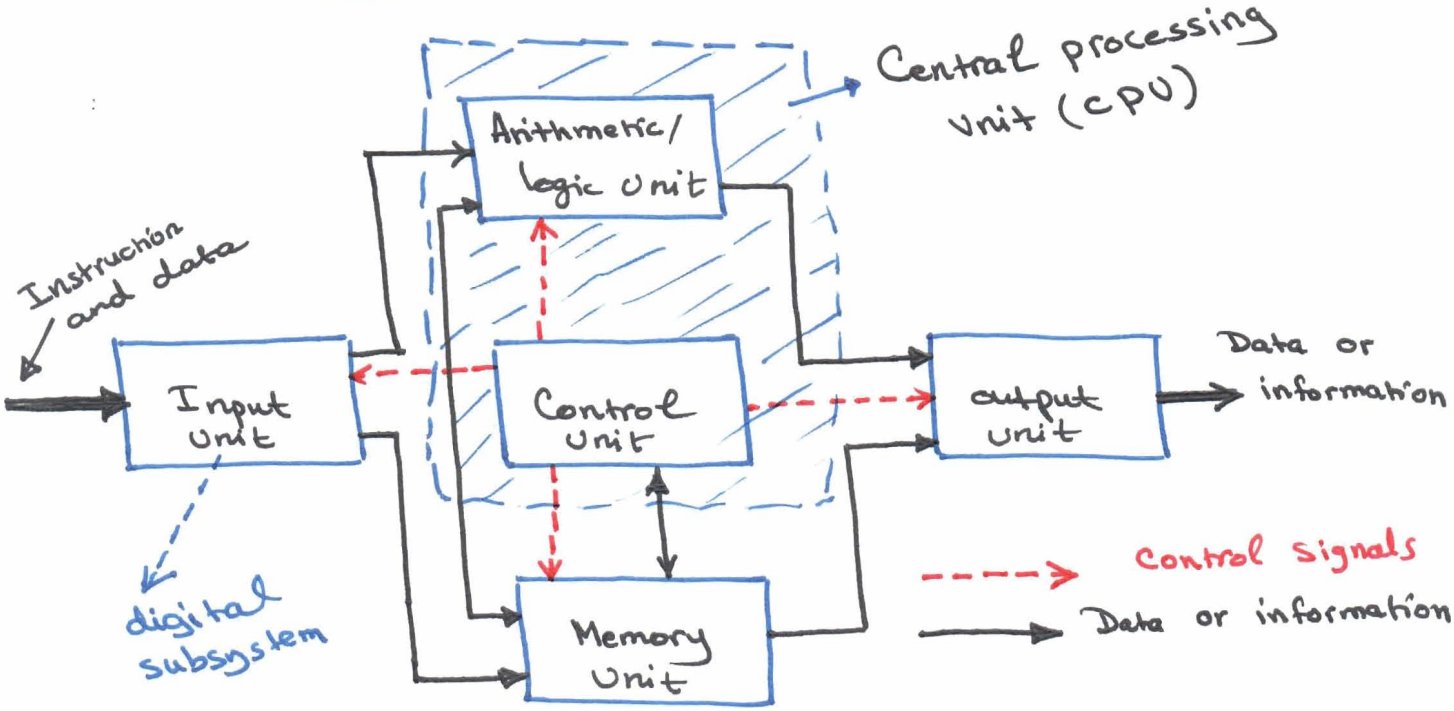
⇒ The relationship between the input and output signal of the logic gates can be described mathematically using Boolean Algebra

8. Digital system examples :

- Digital Calculator
- Digital Watch
- Digital Computer

functional parts of a digital computer :

1. Input Unit ⇒
   enter a set of instructions and data.
2. Memory Unit
   Stores the instructions and data received from the input unit.
3. Control Unit .
   Send appropriate signals to all the other units to cause the specific instruction to be executed.
4. Arithmetic / Logic Unit .
5. output unit .



Genral diagram of a digial computer

* Each Component (Input/ output/ memory / cpu) is a digital sub system .