Digital circuits and Systems

Introduction:

→ signal is a basic parameter

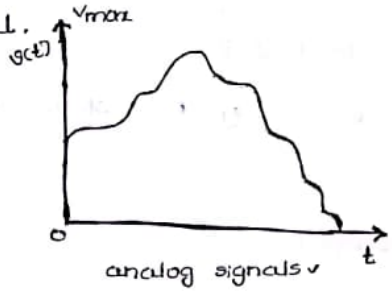
Ex: video, voice.

→ signal is a variation of Electrical Quantity usually current & voltage with time.

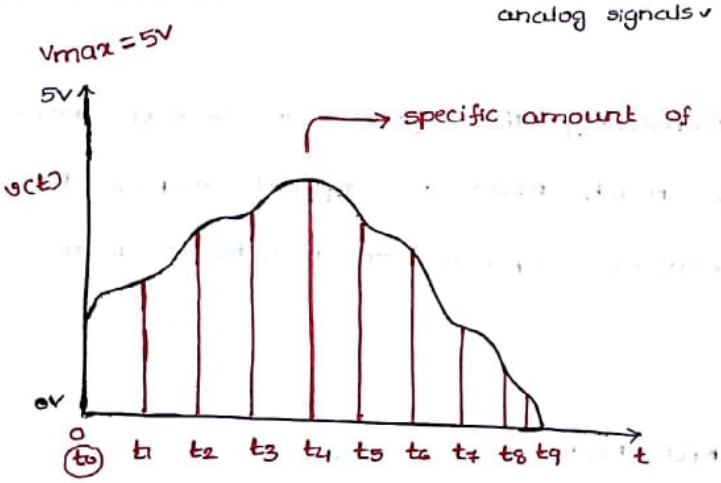
→ Transducer, a device which converts mechanical to Electrical Energy.

i) Analog signal:

A signal varies continuously with respect to time is called analog signal.



ii) Discrete signal:



→ Discrete time signal

→ Discrete signal is nothing but continuous variation in amplitude and discrete in time.

Level 1 → 0V

Level 2 → 1.25 V

Level 3 → 2.5V

Level 4 → 3.75V

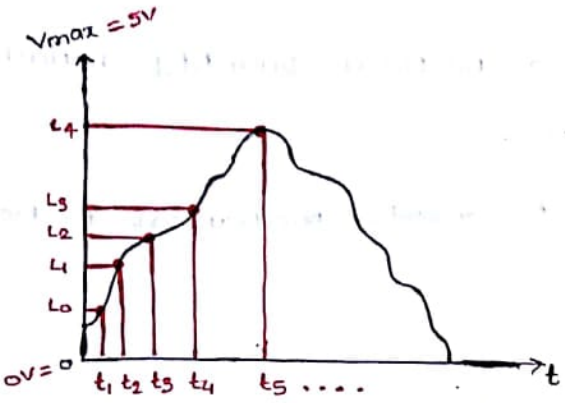
Level 5 → 5.0V

→ more and more level, accuracy also more.

iii) Digital signal:

It is defined as discrete in time and discrete in amplitude that means Quantized in Amplitude.

Ex:



Digital signal.

Q) Why we go for digital ?

Ans: Digital signals are easy to store and manipulate without error.

Q) How do store voltage ?

Ans: By using capacitor

→ uncertainity of transmitting the signals in analog domain.

→ The effect of noise is much lesser in digital compare to analog.

→ more accuracy i.e accuracy depends on number of levels

(Ex: $2^2, 2^3, 2^4, 2^8 \ldots$)

↓

levels

→ not perfect digital but better than analog.

→ more reliable

→ To improve the accuracy means to increase the levels.

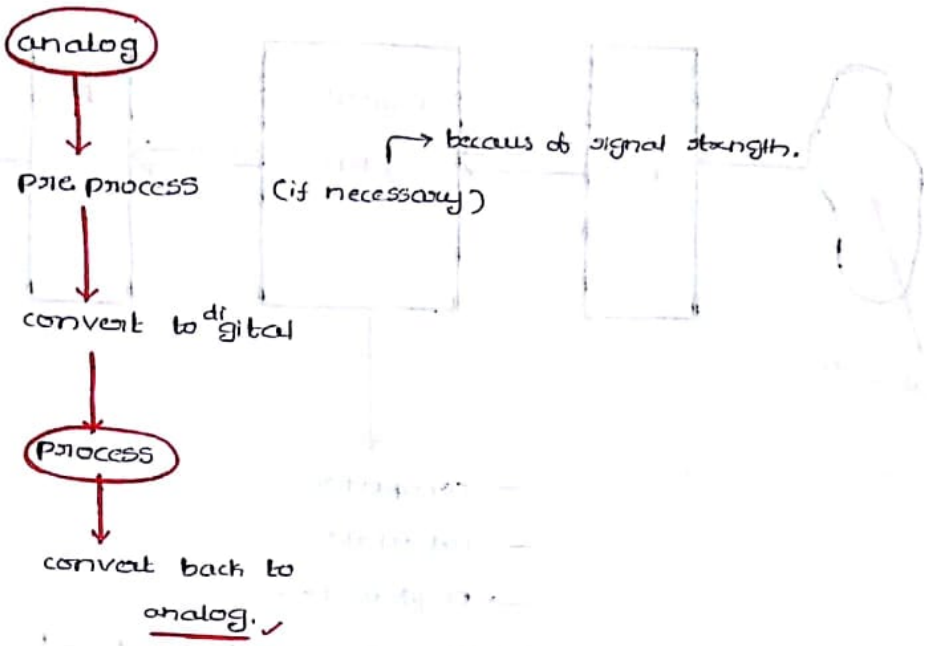
Signal handling (or) signal processing:

Signal as represented as storing, measuring and Reproducing, transmitting every thing is a part of signal is called signal handling.

Q) Why do you need analog ?

Ans: All real time signals are analog signals.

Ex: ECG wave forms, temp variations, speech.



→ improve the accuracy in analog is complexity.

⇒ Basic building blocks of digital circuits and systems:

01. analysis.

02. use.

03. Design.

→ there are two types of circuits available combinational and sequential circuits.

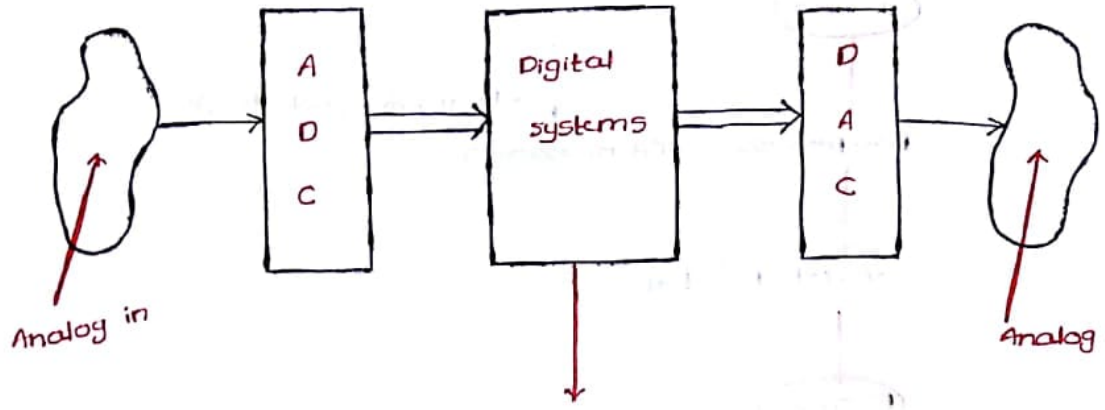
→ Digital systems 01) more reliable

02) cost effect

03) easy to design and manipulate.

→ Most of the digital systems having analog i/p's.

Block diagram:



→ computer
→ calculator
→ Digital clock
→ measuring instruments – Digital voltmeters
Digital Ammeters
→ Audio/video processing

→ improve the performance in analog system is very complex compare to digital.

→ Basically Digital system design is very easy i.e blocks inter-facing.

Ex: 1) computer
2) CPU — ALU, control logic, Registers
3) Memory
4) I/O

⇒ Heirarchial description of a digital systems:

→ Top down approach

∴ systems → subsystems → modules → functional blocks → basic units → circuits → components/devices.

→ Gate is a logic building block.

→ Every digital system is called as computer.

Ex: cell phone, washing machine, printers.

∴ Digital system being a system in which discrete levels are defined for the (V/I) Quantities. Most of the practical voltage is preferred. (i.e Vol. units)

→ with in the limit you can take any value it is continuous for analog.

→ In Digital system certain discrete levels b/w 0 to 5 analog to be taken by the parameter.

i) In analog system time varying continuously with in the limits any value allowed.

ii) In discrete system parameters can take any value but we can only locate at discrete interval's of time.

iii) In digital system we only recognize certain value of the para-meters as allowed values and any value in b/w arounded off to one of those values allow.

Q) How do make a system more accuracy?

Ans: Increase the no. of levels i.e → more accuracy

Number systems:

→ Number system is a basis for counting various items.

$(D_{n-1}, D_{n-2}, D_{n-3} \ldots\ldots\ldots D_1, D_0)_r$

MSB — LSB

Here $r = 10$ → Decimal

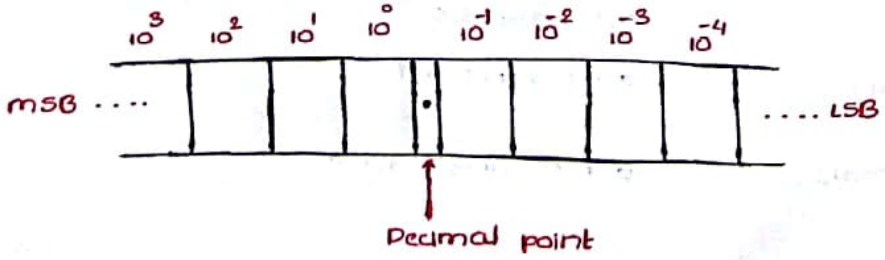
$r = 16$ → Hexa

$r = 8$ → octal

$r = 4$ → Nibble

$r = 2$ → binary

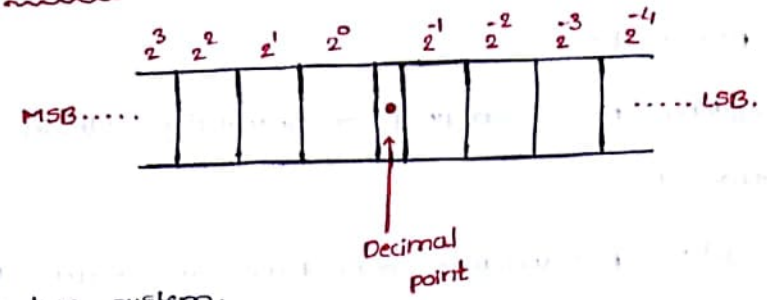
1) Decimal number:



Ex: 5678.9

$5\times10^3 + 6\times10^2 + 7\times10^1 + 8\times10^0 + 9\times10^{-1} = 5678.9$

2) Binary number:



→ Base-two system.

Ex: 1101.101

Decimal equalent is $N = 1\times2^3+1\times2^2+0\times2^1+1\times2^0+1\times2^{-1}+0\times2^{-2}+1\times2^{-3}$

$N = 8+4+0+1+0.5+0+0.125$

$N = 13.625_{10}$.

3) octal number: It uses digits 0 to 9. And the base of octal number system is (8)

Ex: $(567)_8$

equalent demal $N = 5\times8^2+6\times8^1+7\times8^0$

$N = 320+48+7$

$N = 375_{10}$ ✓

4) Hexdecimal number: base -16

digits → 0-15 [0 to 9, A, B, C, D, E, F]

Ex: $(3FD)_{16}$

equalent decimal $N = 3\times16^2+F\times16^1+D\times16^0$

$N = 768+240+13$.

$N = (1021)_{10}$.

radix (Base) (r)	characters in set
2 (Binary)	0, 1
3 (Ternary)	0 1, 2
4	0, 1, 2, 3.
:	
7	0, 1, 2, 3, 4, 5, 6
8 (octal)	0, 1, 2, 3, 4, 5, 6, 7
10 (Decimal)	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
:	
16 (Hexa decimal)	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

conversions:

i) Binary to octal conversion:

1) convert $(111101100)_2$ to octal equivalent?

Sol:

$\underbrace{111}_{7}\ \underbrace{101}_{5}\ \underbrace{100}_{4}$

Octal number = $(754)_8$

ii) octal to binary conversion

2) convert $(834)_8$ to binary?

Sol:

8 3 4

$(1000\ 011\ 100)_2$.

3) convert $(725.63)_8$ to binary?

Sol:

7 2 5 . 6 3.

$(111\ 010\ 101 . 110\ 011)_2$

iii) Binary to Hexa decimal & Hexa to Binary conversion:

4) convert $(\underbrace{1101}_{D}\ \underbrace{1000}_{8}\ \underbrace{1001}_{9}\ \underbrace{1011}_{B})_2$ to hexa decimal?

Hexa decimal number = $(D89B)_{16}$.

5) convert 3F0H to binary?

Sol:

3 F D

0011 1111 1101

Binary number = $(0011\ 1111\ 1101)_2$

6) convert (5A9.B47)H to binary

$(0101\ 1010\ 1001 . 1011\ 0100)_2$

iv) octal to Hexa decimal conversion?

i) convert octal number to its binary equivalent

ii) convert binary number to its hexadecimal equivalent

7) convert $(615)_8$ to its hexa decimal equivalent?

615 octal

$(110\ 001\ 101)_2$ binary

0001 1000 1101 hexa → 18DH

v) Hexa decimal to octal conversion:

i) convert hexadecimal number to its binary equivalent.

ii) convert binary number to its binary octal equivalent.

8) convert 25BH to its octal equivalent ?

↓
Binary

0010 0101 1011

001 001 011 011

1 1 3 3

→ octal number = $(1133)_8$

In general number can be represented as

$$N = A_{n-1} \cdot r^{n-1} + A_{n-2} r^{n-2} + \dots + A_1 r^1 + A_0 r^0 + A_{-1} r^{-1} + A_{-2} r^{-2} + A_m r^{-m}$$

N = Number in decimal

A = Digit

r = Radix @ base of a number system

n = number of digits in the integer portion of no.

m = the number of digits in the fractional portion of number.

problems:

I.

a) 1101.1 to Decimal

$N = 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 1\times2^{-1}$

$N = 8 + 4 + 0 + 1 + 0.5$

$N = 13.5_{10}$

b) $(475.25)_8$ to Decimal

$N = 4\times8^2 + 7\times8^1 + 5\times8^0 + 2\times8^{-1} + 5\times8^{-2}$

$N = (317.32813)_{10}$

c) $(9B2.1A)_H$ to Decimal

$N = 9\times16^2 + B\times16^1 + 2\times16^0 + 1\times16^{-1} + A(10)\times16^{-2}$

$N = 2304 + 176 + 2 + 0.0625 + 0.039$

$N = (2482.1)_{10}$.

d) $(3102.12)_4$

$N = 3\times4^3 + 1\times4^2 + 0\times4^1 + 2\times4^0 + 1\times4^{-1} + 2\times4^{-2}$

$N = 210.375_{10}$.

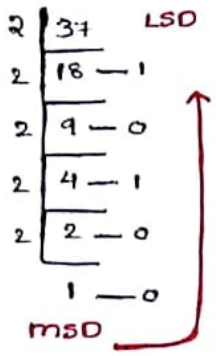
e) $(614.15)_7$

$N = 6\times7^2 + 1\times7^1 + 4\times7^0 + 1\times7^{-1} + 5\times7^{-2}$

$N = (305.244186)_{10}$.

II.

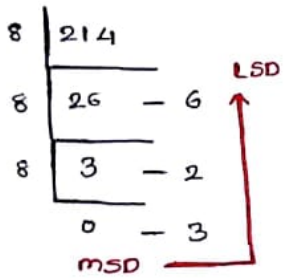
a). $(37)_{10}$ to binary equivalent?



binary equivalent = $(100101)_2$

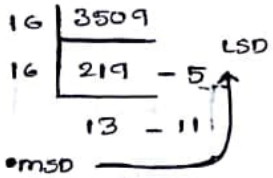
b) $(214)_8$ — $(010\ 001\ 100)_2$

c) $(214)_{10}$ to octal equilent?



$(214)_{10} = (326)_8$

d) $(3509)_{10}$ to Hexa decimal?



$(3509)_{10} = DB5H$ ✓

III

a) $(0.8125)_{10}$ to it's binary equivalent

MSD

$0.8125 \times 2 = 1.625 \Rightarrow 0.625$ with a carry of 1

$0.625 \times 2 = 1.25 \Rightarrow 0.25$ with a carry of 1

$0.25 \times 2 = 0.5 \Rightarrow 0.5$ with a carry of 0

$0.5 \times 2 = 1.0 \Rightarrow 0.0$ with a carry of 1

LSD

$(0.8125)_{10} = (.1101)_2$

Incase octal equivalent

then 0.8125×8 ✓

$\rightarrow 0.8125 \times 16$ ✓

0.8125×4 ✓

b) $(0.640625)_{10}$ to its octal equivalent ?

$0.640625 \times 8 = 5.125$ — 5 (MSD)

$0.125 \times 8 = 1.0$ — 1 (LSD)

$(0.640625)_{10} = (.51)_8$

c) $(0.1289062)_{10}$ to its hexa equivalent ?

$0.1289062 \times 16 = 2.0625$ — 2 (MSD)

$0.0625 \times 16 = 1.0$ — 1 (LSD)

$(0.1289062)_{10} = (.21)_{16}$

d) $(24.6)_{10}$ to binary equivalent ?

2 | 24		
2 | 12 – 0		
2 | 6 – 0		
2 | 3 – 0		
1 – 1		
MSD	$0.6 \times 2 = 1.2$	1 (MSD)
LSD	$0.2 \times 2 = 0.4$	0
	$0.4 \times 2 = 0.8$	0
	$0.8 \times 2 = 1.6$	1
	$0.6 \times 2 = 1.2$	1 (LSD)

$(11000.10011)_2$

Binary addition:

A	B	sum	carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Binary subtraction:

A	B	Diff	borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Signed binary numbers: