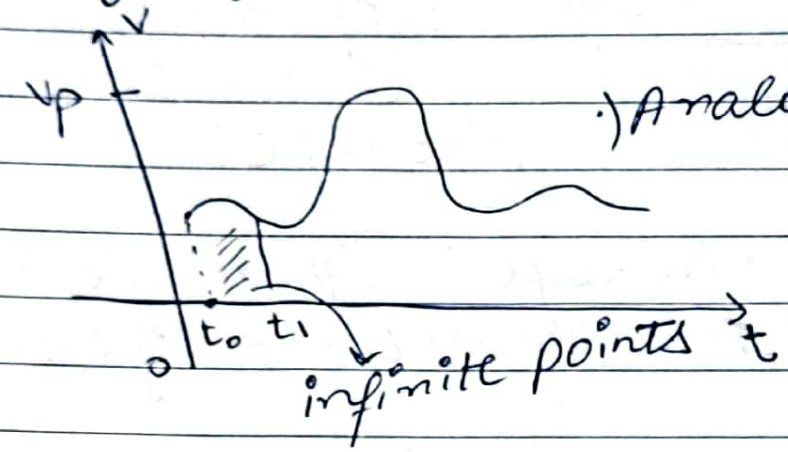
Electronics Circuits

ALA analog / continuous signals
- Current
- Voltage
- Resistence

Hardware consists of electronic components/ circuit.

Types of electronic circuit → 2
↓
Analog, Digital
↓
any signal which is continuous in time.
↓
all natural waves are analog signals



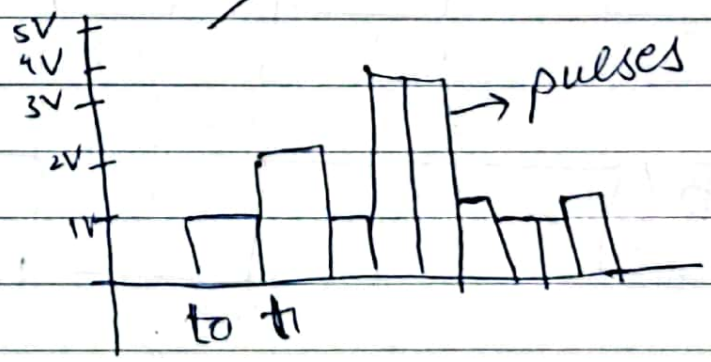
- Analog signal

Sampling → specific time pe koi specific value choose krna

- Every wave requires medium.

Quantization

Digital signals → less error



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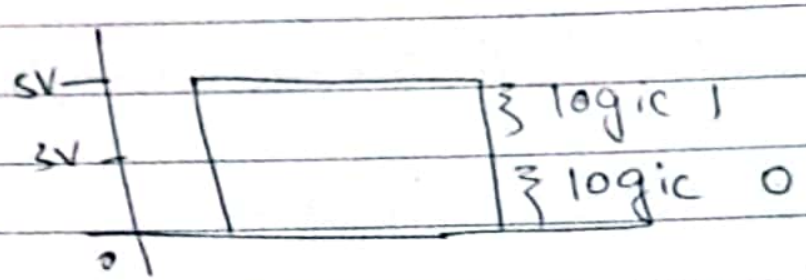
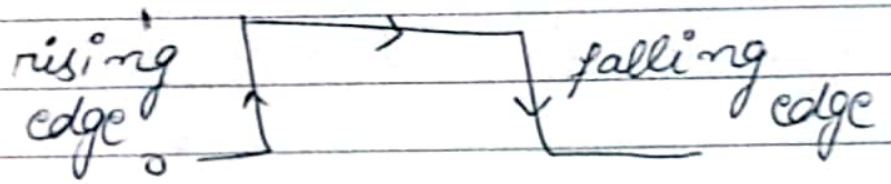


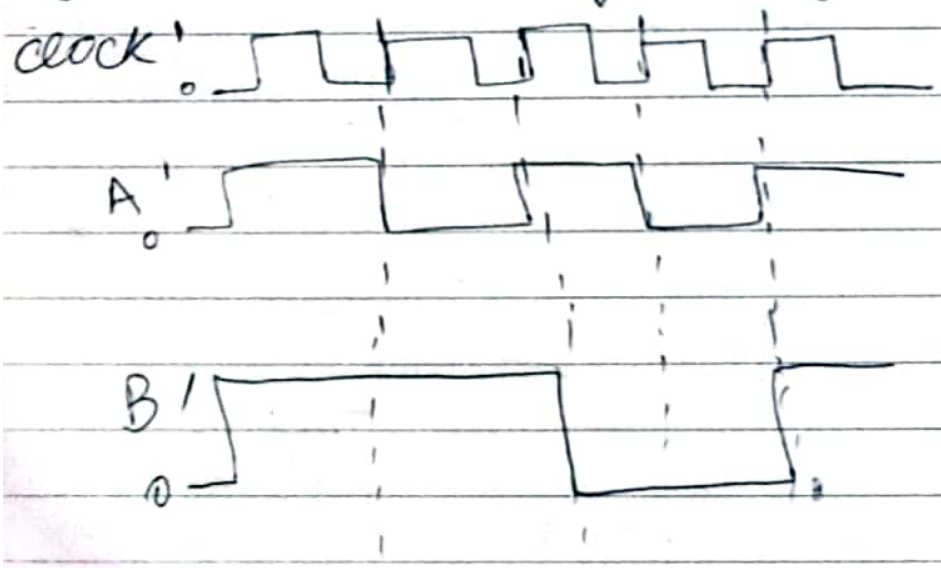
Pulse:



High → logic 1
LOW → logic 0
↓
+ive logic

-ive logic | High → logic 0
LOW → logic 1

Clock:
↓ continuous train of continuous pulses
↓
Synchronized digital signals



0101
↓
Bits = voltage levels

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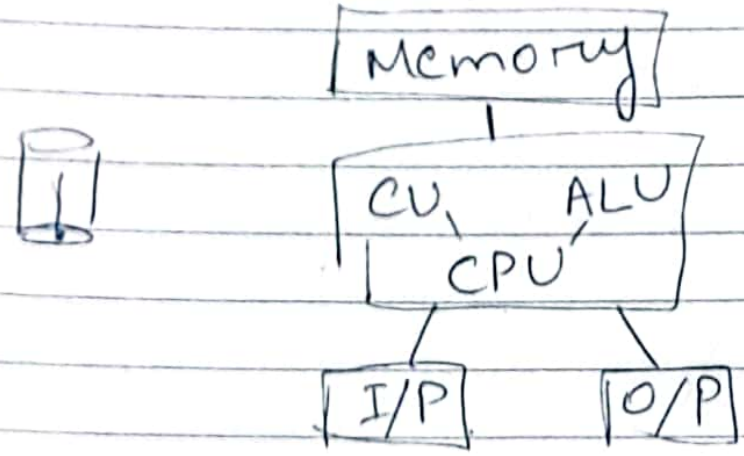
this ptr = new Point(int x, int y)
this → x = x;
this → x = x;

this → x = x;

Digital signals → Data → in form of bits

Components / Types of ~~D~~ Digital Devices:



arr[i] += 1 a++

Decimal NO : Base 10 → 0-9
Binary NO : Base 2 → 0-1

$(17.683)_{10} \rightarrow (?)_2$

17 = 10001

.683 × 2 = 1.366
.366 × 2 = 0.732
.732 × 2 = 1.464
.464 × 2 = 1.09 → ~~fro~~ decimal mein NO laana ha.

$(.683)_{10} = (1011)_2$

$(17.683)_{10} = (10001.1011)_2$

·) jo cheez converge nhin krti uss ki accuracy le leint ge. (mostly given)

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$(0110.110)_2 \rightarrow (?)_{10}$

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

$4+2 \cdot 0.5+0.125$

$6 \cdot 625 \rightarrow 6.625$

Hexadecimal Numbers:- $(2^4 = 16)$

Base $\rightarrow 16$ $(0-9, A-F)$

0 = 0000	4 = 0100	15 = F = 1111
1 = 0001	5 = 0101	12 = C = 1100
2 = 0010	9 = 1001	
3 = 0011	10 = A = 1010	

~~0001 = 16~~

~~1100~~ ~~1100 = 1×16³+1×16²+0+0~~

$(1C)_{16}$

= 0001 1100

$0001 = 0\times16^3+0\times16^2+0\times16^1+1\times16^1 = 16$

$1100 = 1\times16^3+1\times16^2+0\times16^1+0\times16^0 =$

$= .342 \times 16$

=

3
16
16
96
16×
56

0.342
16
2088
342×
5.568

16 | 650
16 | 40 - 19 (10)
2 - 8

.342
×16

16
2
32
2 16
4
64
6

$= (28A)_{16}$

$(650)_{10} = (28A)_{16}$

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Little Endian
Lower Endian
Unconventional Base

$(650.342)_{10} = (28A.57B)_{16}$

2	240
2	30 - 0
3	3 - 6

2	360
2	180 - 0
2	90 - 0
2	40 - 0
2	10 - 0
2	5 - 0
2	2 - 1
	1 - 0

(360)

Octal Numbers: (Base → 8) ⇒ 2^3 → 3 bits

Range: 0 → 7

0 = 000 3 = 011 6 = 110

1 = 001 4 = 100 7 = 111

2 = 010 5 = 101

$(240)_{10} \rightarrow (?)_8 \rightarrow (360)_8$

$(360)_8 \rightarrow (011110000)_2$

MP

- BCD → Binary Coded Decimal → used for numeric pads

↓

Represents a number in 4-bits → "8421"

13 = 0001 0011

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ASCII → 7-bit coding scheme → 128 symbols

Range: 0 → 127

0 → 7F → 0111 1111

Gray Code: (no weight attached at every bit position)

↓ changes/ one bit vary at a time

8421

0011

weight

→ for 2-bits

	Gray	Binary
0	00 0	0000
1	00 1	0001
2	0 1 1	0010
3	0 1 0	0011
4	1 1 0	
5	1 1 1	
6	1 0 1	
7	1 0 0	

flip

flip

$(28A)_{16} \rightarrow (?)_8$.

$(28A)_{16}$

$= 2\times8^2 + 8\times8^1 + 10\times8^0$

$= 2\times64 + (64) + 10$

$= 128 + 64 + 10$

$(28A)_{16}$

$= 2\times16^2 + 8\times16^1 + 10\times16^0$

$= 2\times256 + 128 + 10$

$= 512 + 138$

$= 650$

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0011 1001 1010

8 650 ×2
8 80 - 2
8 10 - 01
1 - 2

$(28A)_{16} \rightarrow (650)_{10} \rightarrow (1212)_8$

Parity Bit: No. of 1's bits in a sequence.

Even Odd used for error detection

P.B
1 0 1 1 0 1 0 1 1
→ Odd

Even PB → 1 Even ~~Odd~~ PB → 0

00011011

not flexible for more than one error.

Arithmetic operations → +, −, *, ÷
Un-signed Numbers.

→ Addition:

Binary → 00000111
+ 00000100
00001011 → 00001011

Hexa-decimal
5 9F
+ E 4b
13 E5

16 | 19
16
3

16 | 21
16
5

F=15
15+6
=21

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→ Little indian
→ Big indian

Octal:

$$\begin{array}{r} 375 \\ +\ 246 \\ \hline 643 \end{array}$$

$5+6=11$ $\quad 8\overline{)11}$ (1), 8, 3 $\quad 8\overline{)12}$ (1), 8, 4

→ Subtraction: *

Binary:

$$\begin{array}{r} 11000 \\ -\ 111 \\ \hline 10001 \end{array}$$

Hexadecimal:

$$\begin{array}{r} C\cancel{D}D88 \\ -\ 7F45 \\ \hline 5E43 \end{array}$$

$16+\Delta(13) = 29$

$16+\Delta(13)-15$ → $14 \to E$

$12 - 7 = 5$

SE43.

Octal: *

$$\begin{array}{r} 4715 \\ 1237 \\ \hline 3456 \end{array}$$

$8\overline{)12}$ (1), 8, 4

$16\overline{)69}$ (4), 64, 5

→ Multiplication:

Hexadecimal:

$$\begin{array}{r} 2\Delta E \\ 5F \\ \hline 2BB02 \\ E56X \\ \hline 11062 \end{array}$$

$E = 14$, $F = 15$ $\quad 14\times15 = 120$

$16\overline{)120}$ (13 → Δ), 16, 50, 48, 2

$16\overline{)208}$ (13), 16, 48, 48, 0

$30+13=43$

$16\overline{)43}$ (2), 32, 11

$16\overline{)70}$ (4), 64, 6

$16\overline{)64}$ (4), 5

5×4 69

13×15: 65, 13, 195, 13, 208

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Binary:

```
  11000
    101
  -----
  11000
 00000
11000
--------
11111000
```

Octal → khud karnika.

•) Big endian → most significant value → lowest memory address

•) Little endian → least sig value → stored at highest memory address.

- unsigned Number
  ↓
  only have magnitude

- Signed Number
  ↓
  Magnitude & sign.

Representation of Signed Number
- Signed Magnitude
- 1's complement
- 2's complement

•) Signed Magnitude.

left most bit → most significant bit → signed bit → remaining bits → magnitude

$\underset{+ive}{0}\ \underbrace{1101001}_{105}$ (magnitude)

MSB → no weightage
1 → -ive sign.

$\underset{-ive}{1}\ \underbrace{011010}_{26} = -26$

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$$\begin{array}{r} 128 \\ -90 \\ \hline 38 \end{array} \qquad \begin{array}{r} 64 \\ 26 \\ \hline 90 \\ -128 \end{array}$$

- 1's complement representation of signed numbers:

00100110 → 38
11011001 → -38
1's complement representation

- 2's complement:

$$\begin{array}{r} 11011001 \\ + \quad\quad 1 \\ \hline 11011010 \end{array} \rightarrow -38$$

	signed magnitude	1's complement	2's complement
+0	0000	0000	0000
+1	0001	0001	0001
+2	0010	0010	0010
+3	0011	0011	0011
+4	0100	0100	0100
+5	0101	0101	0101
+6	0110	0110	0110
+7	0111	0111	0111

unsigned numbers/positive numbers.

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1111
1
10000

1111
1
10000 carry

	signed magnitude	1's complement	2's complement
-0	1000	1111	$\boxed{1}$0000
-1	1001	1110	1111
-2	1010	1101	1110
-3	1011	1100	1101
-4	1100	1011	1100
-5	1101	1010	1011
-6	1110	1001	1010
-7	1111	1000	1001

extra bit → discarding.

1101	1100	1011	1010	1001
1	1	+1	+1	+1
1110	1101	1100	1011	1010

Range - $(2^{n-1}-1) \rightarrow 2^{n-1}-1$ (signed Magnitude / 1's complement)

2's complement → Range → $-2^{n-1} \rightarrow 2^{n-1}-1$

6 - 7 → Subtraction → 1's complement

6 = 0110 7 = 0111 → 1000 → 1000

+1

1001 → 2's complement

↓

(-7)

-7 + 6 → Addition

1001

+0110

1111

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-8×1

2	13
2	6 – 1
2	3 – 0
2	1 – 1

6 – 13

6 = 0110 13 → 01101 → 10010

0110	10011	+1
0011	00110	10011 (–13)
1001	11001	~~+001~~

↳ carry flag → when two opposite sign numbers are dealt

- Overfall in signed number when two numbers of same magnitude are added and the answer is not correct/same sign.

125	01111101	01111101
+58	00111010	00111010
183	10111	10110111

↓ –97

64
39
103
256
359

16
7
23

Wrong answer so appending a 0 in answer 010110111

↓

Overflow Flag → up

OF → up

-70 – 80 => -150

10111010	(–70)
10110000	(–80)
10110 1010	↓
↓ 100	carry + overflow → because of same sign.

10110 1010

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8 4 2 1
1 0 0 1
8 + 1

16 + 8 + 1
16 + 9

•) Overfall and carry can occur simultaneously.

-6 + 17

2	6
2	3 - 0
	1 - 1

6 = 110
= 001
+ 1
010

17 = 10001
= 01110
+ 1
01111

2	17
2	8 - 1
2	4 - 0
2	2 - 0
	1 - 0

01111
010
110001

111

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Logic Gates.

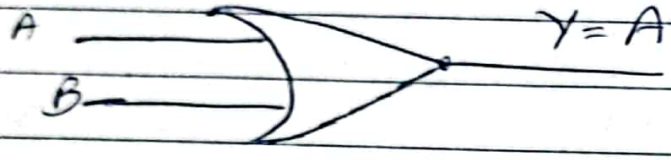
→ AND Gate:

$Y = A \cdot B / AB$

$Y = A \cdot B \cdot C / ABC$

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

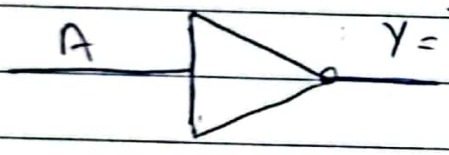
→ OR Gate:



$Y = A + B$

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

→ NOT Gate:



$Y = \bar{A}$

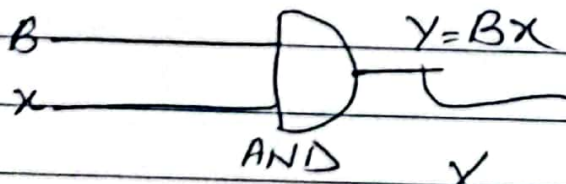
A	~~B~~	$Y = \bar{A}$
0		1
1		0

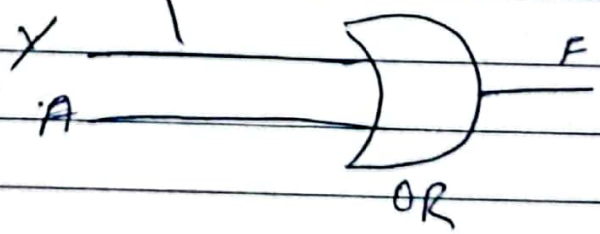
→ Boolean Expressions

$F = \underbrace{Bx}_{} + \underbrace{A}_{} \rightarrow$ B AND x OR A

Terms

Bx, A → literals /variables





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→ Combinational Circuits
Literals/Variables are combined with each other using logic gates.

→ Boolean Identities & Boolean Algebra

- $X + 1 = 1$
- $X + 0 = X$
- $X + X = X$
- $X + \overline{X} = 1$
- $\overline{\overline{X}} = X$
- $X + \overline{X}Y = X + Y$

- $X \cdot 1 = X$
- $X \cdot 0 = 0$
- $X \cdot X = X$
- $X \cdot \overline{X} = 0$
- $X + XY = X$

L.H.S: $X + XY$
$= X(1+Y)$
$= X(1) = X$ $\because X \cdot 1 =$

$\because (X + XY = X)$

$X + \overline{X}Y = X + Y$

L.H.S:
$= X + XY + \overline{X}Y$
$= X(1+Y) + \overline{X}Y$
$= X(1) + \overline{X}Y$
$= X +$

$\cancel{\because X + 1 = 1}$

$= X + XY + \overline{X}Y$ $\because (X + XY = X)$
$= X + Y(X + \overline{X})$ $\because (X + \overline{X} = 1)$
$= X + Y(1)$
$= X + Y$

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→ De-Morgan's Law:

•) $\overline{X \cdot Y} = X' + Y'$ •) $\overline{X + Y} = X' \cdot Y'$

→ Dual: → No change in literal/variable.

$$X \cdot X = X \xrightarrow{\text{Dual}} X + X = X$$

•) Literals remain same. Only change in sign

$$\overline{X \cdot X} = \overline{X} \xrightarrow{\text{Dual}} \overline{X} + \overline{X} = \overline{X}$$

•) AND → OR •) OR → AND •) 0 → 1
•) 1 → 0

$$F = \overline{X}Y\overline{Z} + \overline{X}\,\overline{Y}Z$$

Dual: $F = (\overline{X} + Y + \overline{Z}) \cdot (\overline{X} + \overline{Y} + Z)$

Complement: $\overline{F} = (\overline{X}Y\overline{Z} + \overline{X}\,\overline{Y}Z)$

$= (\overline{X}Y\overline{Z})' \cdot (\overline{X}\,\overline{Y}Z)'$

$= (X\overline{Y}Z) \cdot (XY\overline{Z})$

$= (X + Y' + Z) \cdot (X + Y + Z')$

$= (X + Y' + Z) \cdot (X + Y + Z')$

→ Consensus Theorem:

$$XY + \overline{X}Z + YZ = XY + \overline{X}Z$$

↓
Redundant Term.

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Example:

$F(x,y,z) = \bar{X}YZ + \bar{X}Y\bar{Z} + XZ$

domain — literals (eight)

$= \cancel{Y}\,\bar{X}Y(Z+\bar{Z}) + XZ$

$= \bar{X}Y(1) + XZ \qquad \because X+\bar{X}=1$

$= \bar{X}Y + XZ$

Proof of consensus theorem

$XY + \bar{X}Z + YZ = XY + \bar{X}Z$

L.H.S:

$= XY + \bar{X}Z + YZ(X+\bar{X}) \qquad \because (X+\bar{X}=1)$

$\cancel{= XY + Z(\bar{X} + Y(X+\bar{X}))}$

$= XY + \bar{X}Z + XYZ + \bar{X}YZ$

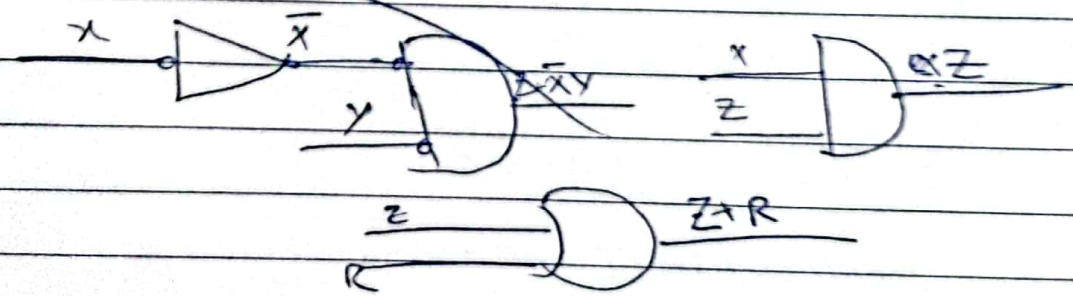
$= XY(1+Z) + \bar{X}Z(1+Y)$

$= XY + \bar{X}Z \qquad \because (1+Z=1) \because (1+Y=1)$

$XY + \bar{X}Z + YZ = XY + \bar{X}Z$

$(X+Y)\cdot(\bar{X}+Z)\cdot(Y+Z) = (X+Y)\cdot(\bar{X}+Z)$

$\bar{X}Y + XZ$



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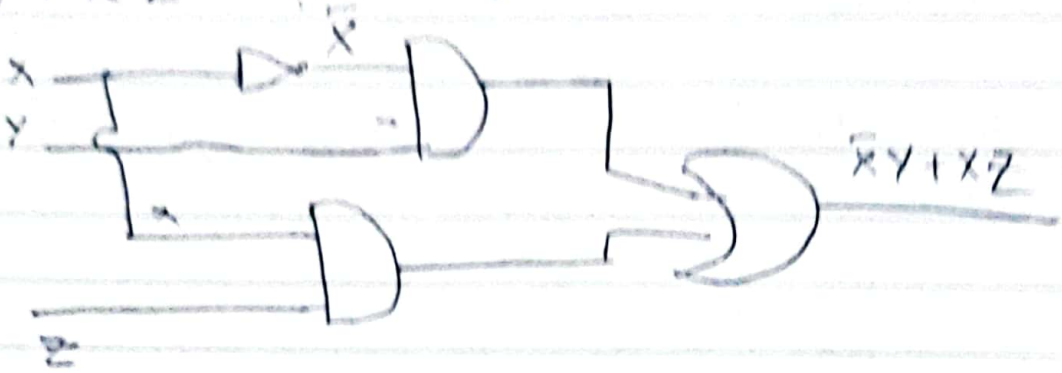
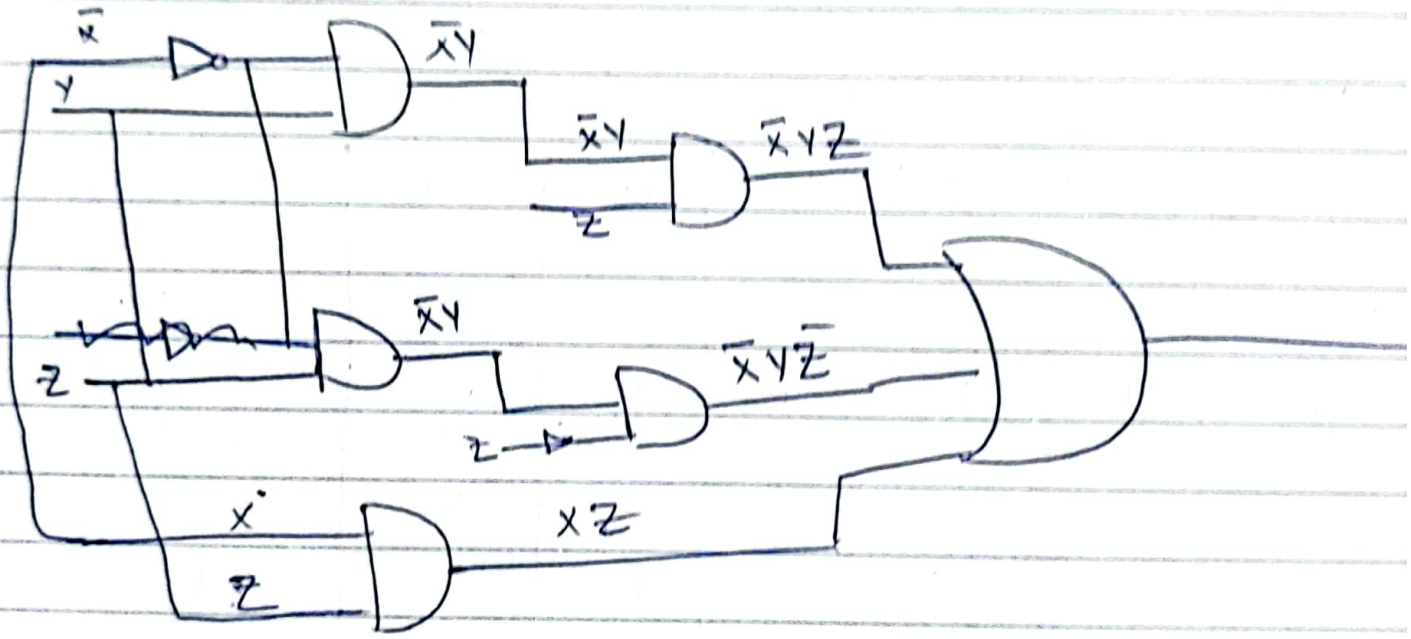
circuit

$\bar{X}Y + XZ$



$F = \bar{X}YZ + \bar{X}Y\bar{Z} + XZ$



$(A+B)(\bar{A}+C)$

$= A\bar{A} + AC + B\bar{A} + BC$ $\quad \because (A\bar{A} = 0)$

$= 0 + AC + B(\bar{A}+C)$ $\quad = AC + \bar{A}B$

$= \cancel{AC + B(\bar{A}+C)}$

$= AC + B\bar{A} + \cancel{BC} \rightarrow$ "consensus Theorem

$= \cancel{C(A+B) + B\bar{A}}$

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$\rightarrow X + XY = X$

$X(X + Y) = ?$

$X \cdot X + X \cdot Y = X + XY = X$ $\quad \because X \cdot X = Y$

$= X(1 + Y)$ $\quad \because 1 + Y = 1$

$= X(1)$

$= X$

$\rightarrow XY + \bar{X}Y$

$= Y(X + \bar{X}) = Y(1) = Y$ $\quad \because (X + \bar{X} = 1)$

$\rightarrow (X + Y)(X + \bar{Y}) = XX + X\bar{Y} + XY + Y\bar{Y}$

$= X + X\bar{Y} + XY + 0$ $\quad \because Y\bar{Y} = 0 \quad \because XX =$

$= X + XY$ $\quad \because X + X\bar{Y} = X$

$= X(1 + Y) = X(1) = X$

$\because (1 + Y = 1)$

$\rightarrow X + \bar{X}Y = (X + \bar{X})(X + Y)$ $\quad \because$ 2nd Distributive Law.

$= 1(X + Y)$

$= X + Y$

$\rightarrow F = XY + X(Y + Z) + Y(Y + Z)$

$= XY + XY + XZ + YY + YZ$

$= XY + XY + XZ + Y + YZ$ $\quad \because Y \cdot Y = Y$

$= XY + XY + XZ + Y(1 + Z)$

$= XY + XY + XZ + Y$ $\quad \because 1 + Y = 1$

$= Y(X + X) + XZ + Y$

$= XY + XZ + Y$

$= Y(X + 1) + XZ$

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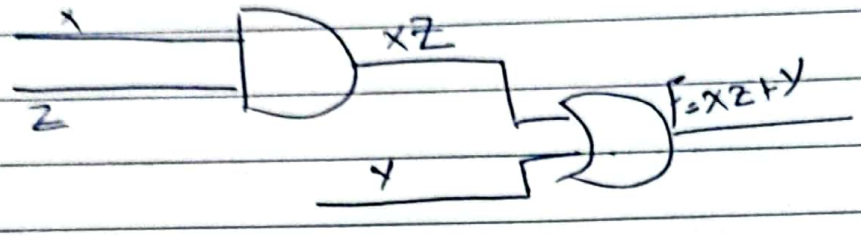
$= Y(X+1) + XZ$

$= Y + XZ$ $\quad \because X+1 = 1$

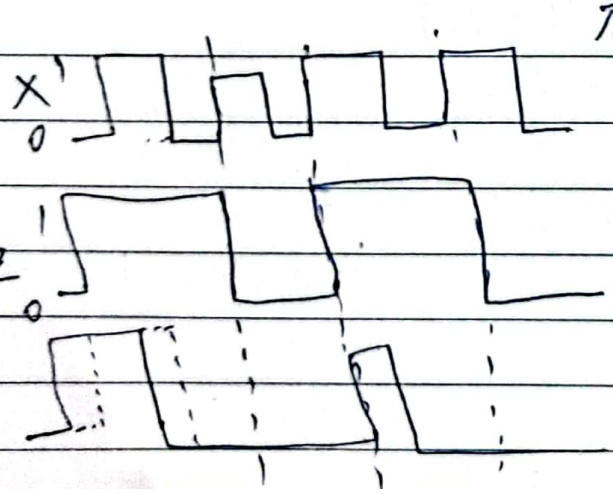
~~Truth Table:~~

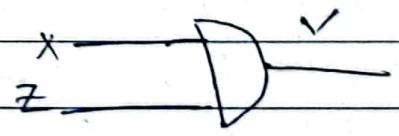


Truth Table

X	Y	Z	XZ	F=Y+XZ = XZ+Y
0	0	0	0	0
0	0	1	0	0
0	1	0	0	1
0	1	1	0	1
1	0	0	0	0
1	0	1	1	1
1	1	0	0	1
1	1	1	1	1

Timing Diagram:-





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Gate Delay: Delay in processing because of late input or any other fault.

→ $\overline{AB+AC} + \overline{A}BC$

$(AB)' \cdot (AC)' + \overline{A}BC$ ∵ De-Morgan's Law

$= (A'+B') \cdot (A'+C') + \overline{A}BC$

$= A'A' + A'C' + B'A' + B'C' + \overline{A}BC$

$= A'B'(1+C) + A' + A'C' + B'C'$

$= A'B'(1) + A' + A'C' + B'C'$ ∵ $1+C=1$

$= A'(B'+1) + A'C' + B'C'$ ∵ $1+B'=1$

$= A' + A'C' + B'C'$

$= A'(1+C') + B'C'$ ∵ $1+C'=1$

$= A' + B'C'$

→ $\overline{AB+AC} + \overline{A}BC$

$= (AB)' \cdot (AC)' + (\overline{A}BC)$

$= (A'+B') \cdot (A'+C') + \overline{A}BC$

$= A'A' + A'C' + A'B' + B'C' + \overline{A}BC$

$= A'(1+C') + A'B' + B'C' + (A'+B')C$

$= A'(1+B') + B'C' + A'C + B'C$

$= A' + A'C + B'(C'+C)$

$= A'(1+C') + B'$

$= A' + B'$

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Standard Representation of Boolean Expression

SOP → Sum of product
POS → product of Sum

→ SOP:-

$F = XY + YZ + \bar{X}YZ$ → Min Term

↓

SOP → but not standard as ≠ literals are missing from term

$F = XY(Z+Z') + YZ(X+\bar{X}) + \bar{X}YZ$

↓ All terms are MinTerm.

SOP → Standard

Redundant
↓
Repeating

$F = XYZ + XYZ' + YZX + YZ\bar{X} + \bar{X}YZ$
$F = XYZ + XY\bar{Z} + XYZ + \bar{X}YZ + \bar{X}YZ$
$F = XY\bar{Z} + XYZ + X'YZ$

→ Each term in SSOP is MinTerm
↓
Standard SOP.

→ Representation in MinTerm.

$\bar{X} \rightarrow 0$ $X \rightarrow 1$ $m_j \rightarrow j$ is decimal equivalent

→ MinTerm will always be 1.

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FAST

X	Y	Z	F → any expression (↑ supposed)	
0	0	0	1 m_0	
0	0	1	0 M_1	$F = m_0 + m_2 + m_5 + m_7$
0	1	0	1 m_2	$= \bar{X}\bar{Y}\bar{Z} + \bar{X}Y\bar{Z} + X\bar{Y}Z + XYZ$
0	1	1	0 M_3	NO. Of MinTerms = 4.
1	0	0	0 M_4	m_0, m_2, m_5, m_7
1	0	1	1 m_5	
1	1	0	0 M_6	
1	1	1	1 m_7	

$m_0 = \bar{X}\bar{Y}\bar{Z}$, $m_2 = \bar{X}Y\bar{Z}$, $m_5 = \bar{X}\bar{Y}Z$, $m_7 = XYZ$

→ POS (Product Of Sum Terms):

~~F = (X+Y~~

Sum Term.

$F = (X+Y)\cdot(Y+Z)\cdot(X+Y+Z)$

$= (X+Y) + 0\cdot(Y+Z) + 0\cdot(X+Y+Z)$ $\quad \because X\cdot\bar{X} = 0$

$= \underbrace{(X+Y)+(Z\cdot\bar{Z})}_{A \quad BC}\cdot(Y+Z)+(X\cdot\bar{X}) : (X+Y+Z)$

Distributive Law

$= (X+Y+Z)(X+Y+\bar{Z})\cdot(X+Y+Z)(\bar{X}+Y+Z)\cdot(X+Y+Z)$

$= (X+Y+Z)(X+Y+\bar{Z})(\bar{X}+Y+Z)$

↓

Standard POS → product of sum

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POS : $\bar{X} = 1$, $X = 0$

MaxTerm → Each term in a standard POS is a max term.

Represented by 0

M_j → j is a decimal equivalent

index of the term

$M_j = \overline{m_j}$ •) complement of MinTerm is MaxTerm.

→ The sum of MaxTerm is always 0.

$$F = \cancel{M_1 + M_3 + M_4 + M_6}$$
$$\cancel{= XYZ + X\bar{Y}\bar{Z} +}$$
$$\cancel{= (X+Y+\bar{Z})}$$

$$F = M_1 \cdot M_3 \cdot M_4 \cdot M_6$$
$$F = (X+Y+\bar{Z}) \cdot (X+\bar{Y}+Z) \cdot (\bar{X}+Y+Z) \cdot (\bar{X}+\bar{Y}+Z)$$
$$= 0 \cdot 0 \cdot 0 \cdot 0$$
$$= 0$$

Sum of $M_j = 0$

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$AB + B(CD + EF)$

$= AB + BCD + BEF$

only NOT AND should be used.

$F = A\bar{B}C + \bar{A}\bar{C} + AB$

$F = \bar{\bar{F}}$ $\quad \because \bar{\bar{X}} = X$

$F = \overline{\overline{(A\bar{B}C + \bar{A}\bar{C} + AB)}}$

$F = \overline{(A'+B+C')\cdot(A+C)\cdot(A'+B')}$

$F = \overline{(AB'C)'\cdot(A'C')'\cdot(AB)'}$

→ circuit will vary but not the truth table.

$F = AB + \bar{A}\bar{B} + \bar{B}C$

$F = \bar{\bar{F}}$

$= \overline{AB + \bar{A}\bar{B} + \bar{B}C}$

NIMRA

$= \overline{(\overline{AB})\cdot(\overline{\bar{A}\bar{B}})\cdot(\overline{\bar{B}C})}$

$= \overline{(\bar{A}+\bar{B})\cdot(A+B)\cdot(B+C)}$

$= (\bar{A}+\bar{B})' + (A+B)' + (B+C)'$

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A B C
0 0 1
$\cancel{A}\bar{B}C$

•) Order of literals matter in SSOP.

3-variable K-map :-

A \ BC	00	01	11	10
0		1		1
1			1	1

→ Domain (A, B, C)

① $Y = \bar{A}\bar{B}C + \bar{A}B\bar{C} + AB\bar{C} + ABC$

(A, B, C) = (0, 0, 1) (010) (110) (111)

$\sum m(1, 2, 6, 7)$

$Y = AB + B\bar{C} + \bar{A}\bar{B}C$ (*)

Grouping

→ Maximum 1's should be included

→ Adjacent cell

$2^0, 2^1, 2^2, 2^3, \ldots$

1, 2, 4, 8, ...

~~5~~ ~~5 6 7~~

A BC

A B | C

1

Reducing the cells:

ABC	ABC
111	110
110	010
AB	$B\bar{C}$

Prime impligant ↓ group of maximum one's.

② $Z = \bar{A} + A\bar{B} + \bar{A}B\bar{C}$

(A, B, C)

000 100 110

001 101

010

011

A \ BC	00	01	11	10
0	1	1	1	1
1	1	1		1

•) If a term repeats, it is written only one time.

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$Z = \bar{A} + \bar{B} + \bar{C}$ → Reduced Form of Z.

(4) $Z = \bar{A} + A\bar{B} + \bar{A}BC$

$(A, B, C) = \bar{A} + A\bar{B} + \bar{A}BC$

$F(A, B, C) = \sum m(1, 3, 4, 5, 6)$.

A \ BC	00	01	11	10
0		1	1	
1	1	1		1

(Grouping can be different)

$F(A, B, C) = (001)(011)(100)(101)(110)$

$= \bar{A}C + A\bar{B} + A\bar{C} + \bar{B}C$

$\bar{X}Y + XZ + YZ = \bar{X}Y + Z$

Redundant according to consensus Theorem.

A \ BC	00	01	11	10
0		1	1	
1	1	1		1

•) 4- Variable K-map:

AB \ CD	00	01	11	10
00				
01				
11				
10				

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XOR Gate: → odd function for 3-bits
→ even function for 4-bits

$Z = X \oplus Y = XY' + X'Y$

X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	0

XOR ↔ XNOR
↓
complement of each other

XNOR:

$Z = X \oplus Y = \bar{X}\bar{Y} + XY$

X	Y	Z
0	0	1
0	1	0
1	0	0
1	1	1

- $X \oplus 0 = X$
- $X \oplus 1 = X'$
- $X \oplus X = 0$
- $X \oplus \bar{X} = 1$

3-bit data to be transmitted in Even Parity.

Scanned with CamScanner

design Even parity generator bit for 3-bits.

X	Y	Z	P
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

X \ YZ	00	01	11	10
0		1		1
1	1		1	

$= \bar{X}\bar{Y}Z + \bar{X}Y\bar{Z} + X\bar{Y}\bar{Z} + XYZ$

$= (X \oplus Y) \oplus Z.$

$(X \oplus Y) \oplus Z$

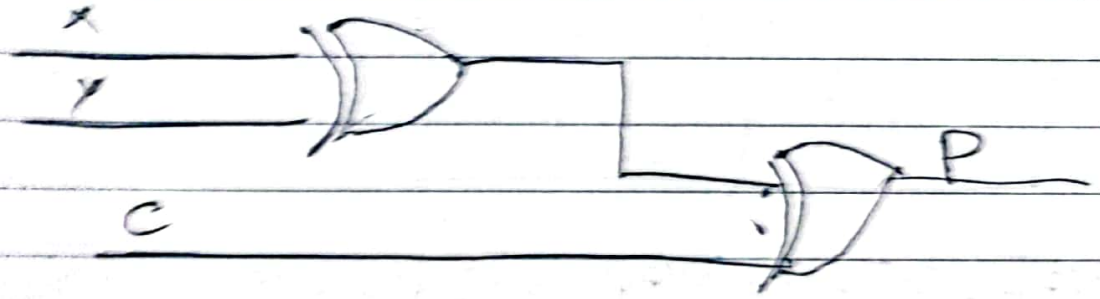
$= (XY' + X'Y) \oplus Z$

$= (XY' + X'Y)Z' + (XY' + X'Y)'Z$

$= XY'Z' + X'YZ' + [(X'+Y)\cdot(X+Y')]Z$

$= XY'Z' + X'YZ' + XYZ + X'Y'Z$

$= XYZ + X'YZ + X'Y'Z' + XYZ$



(Because of parity bits, total no. of bits = 4)

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Even:-

Parity Checker:

→ Error free

→ Erroneous/Error.

X	Y	Z	P	C	X	Y	Z	P	C
0	0	0	0	0	1	0	0	1	0
0	0	0	1	1	1	0	0	0	1
0	0	1	1	0	1	0	1	0	0
0	0	1	0	1	1	0	1	1	1
0	1	0	1	0	1	1	0	0	0
0	1	0	0	1	1	1	0	1	1
0	1	1	0	0	1	1	1	1	0
0	1	1	1	1	1	1	1	0	1

·) 4-bits including Parity bit and 5-bits including checker (5th bit → output)

XY \ ZP	00	01	11	10
00		1		1
01	1		1	
11		1		1
10	1		1	

(FOR ERRORS)

$$= \bar{X}YZ\bar{P} + \bar{X}\bar{Y}Z\bar{P} + \bar{X}YZP + \bar{X}\bar{Y}\bar{Z}P + \bar{X}YZP + X\bar{Y}ZP + \bar{X}\bar{Y}ZP + \bar{X}YZ\bar{P}$$

$$= X \oplus Y \oplus Z \oplus P.$$

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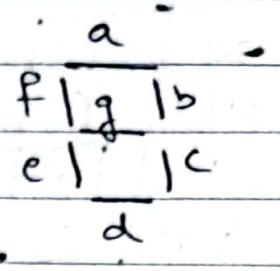
Design a circuit that displays BCD on 7-segment.
(Hexa-decimal in BCD)



→ inputs

H_3	H_2	H_1	H_0	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~ 1011111
0	1	1	1	1	1	1	1	1	1	1 1100000
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1
1	0	1	0							
1	0	1	1							
1	1	0	0							
1	1	0	1							
1	1	1	0							
1	1	1	1							

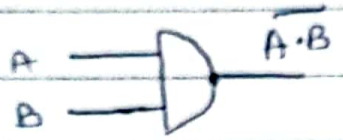
→ Don't care Terms as (0-9) digits can be represented on a 7-segment display.

Scanned with CamScanner

Universal Gates:

- NAND
- NOR

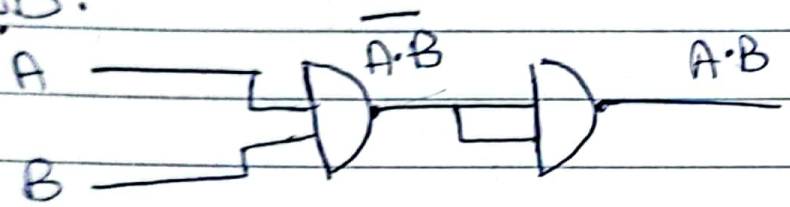
NAND:



A	B	$Z = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

NOT:

AND:

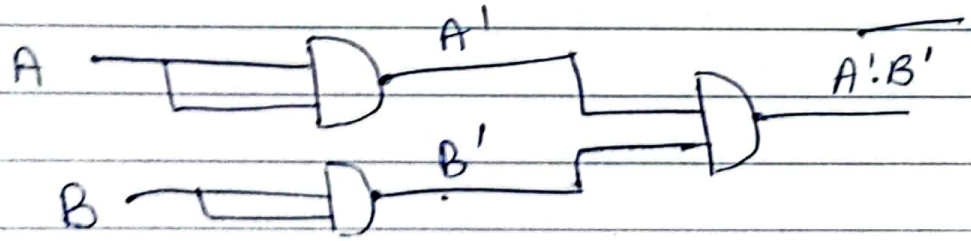


OR:

$$A+B = \overline{\overline{A+B}} = \overline{A' \cdot B'}$$

$$= (A')' + (B')' \qquad \because (A')' = A$$

$$= A+B \qquad \because (B')' = B$$



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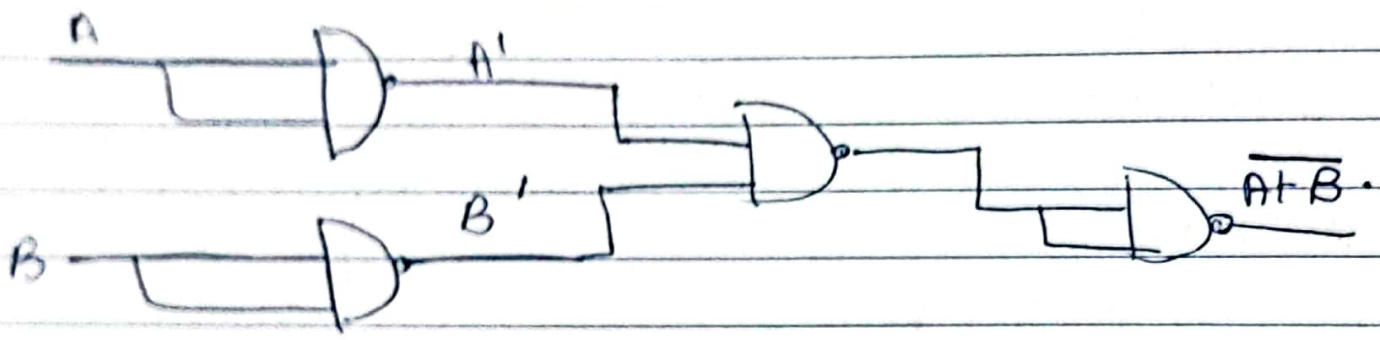
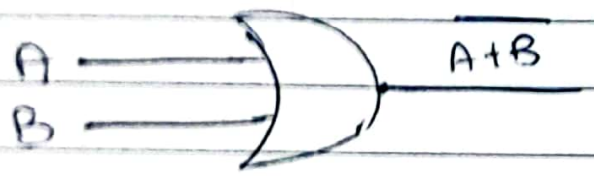
NOR:



A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

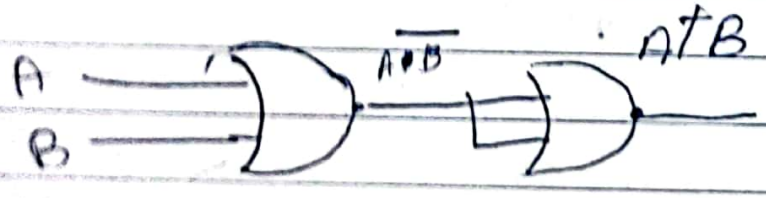
NOR:



$\overline{\overline{A \cdot B}} = \overline{A' + B'}$

NOT:

OR:



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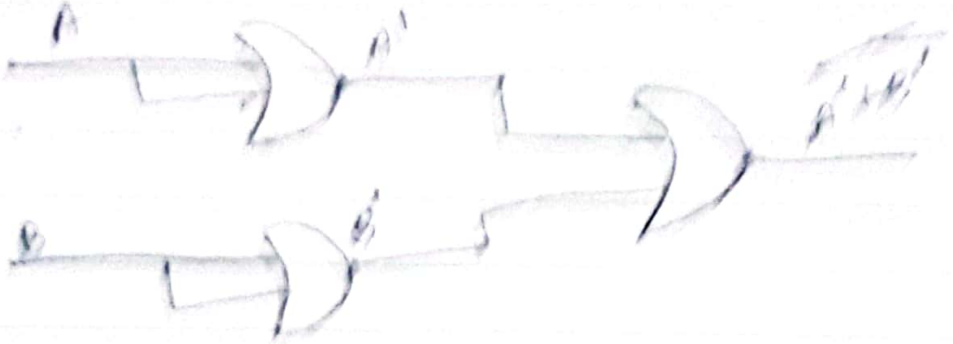
AND:



Magnitude comparator:

Comparing the magnitude of bit by bit:

- 1-Bit

A — 1Bit / B — 1Bit

A	B	A > B	A = B	A < B
0	0	0	1	0
0	1	0	0	1
1	0	1	0	0
1	1	0	1	0

A > B:

$G = AB$

A \ B	0	1
0		
1	1	

A = B:

$E = \bar{A}\bar{B} + AB$

	0	1
0	1	
1		1

A < B:

$L = \bar{A}B$

	0	1
0		
1		

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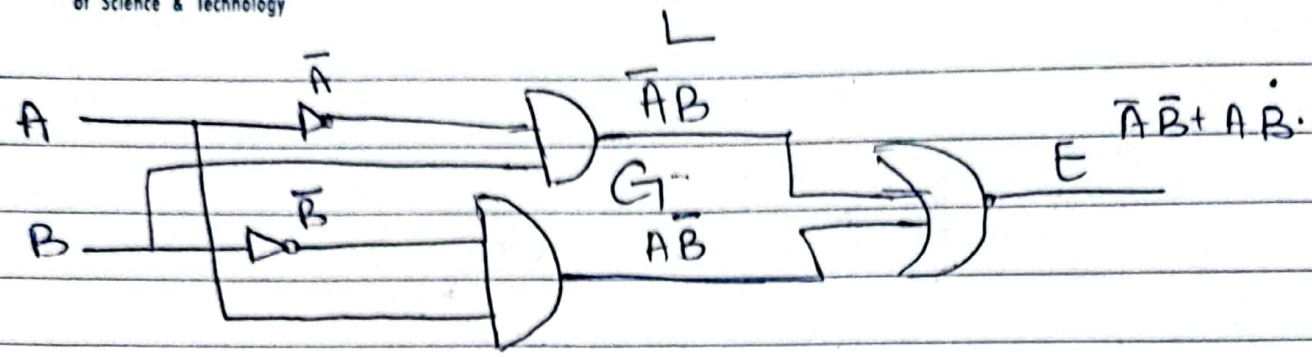


$\overline{\bar{A}B+A\bar{B}} = \bar{A}\bar{B}+AB$

$= (A'+B)'\cdot(A+B')'$

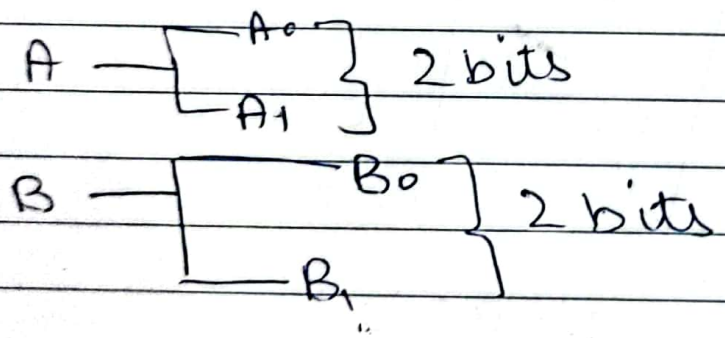
$= ((A')'+B')\cdot((A')+(B')')$

$= (A+B')\cdot(A'+B)$

$= AA'+AB+A'B'+B'B$ $\quad \because AA'=0$

$= AB+A'B'$

2-bit:



A_1	A_0	B_1	B_0
0	0	0	
0	0	1	
0	1	0	
0	1		
1	0		
1	0		

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A_1	A_0	B_1	B_0	$A<B$ L	$A=B$ E	$A>B$ G
0	0	0	0	0	1	0
0	0	0	1	1	0	0
0	0	1	0	1	0	0
0	0	1	1	1	0	0
0	1	0	0	0	0	1
0	1	0	1	0	1	0
0	1	1	0	1	0	0
0	1	1	1	1	0	0
1	0	0	0	0	0	1
1	0	0	1	0	0	1
1	0	1	0	0	1	0
1	0	1	1	1	0	0
1	1	0	0	0	0	1
1	1	0	1	0	0	1
1	1	1	0	0	0	1
1	1	1	1	0	1	0

L :

A_1A_0 \ B_1B_0	00	01	11	10
00		1	1	1
01			1	1
11				
10			1	

G :

A_1A_0 \ B_1B_0	00	01	11	10
00				
01	1			
11	1	1		1
10	1	1		

$L = \bar{A}_1 B_1 + \bar{A}_1 \bar{A}_0 B_0 + B_1 B_0 \bar{A}_0$

$G = A_0 \bar{B}_1 \bar{B}_0 + A_1 \bar{B}_1 + A_1 A_0 \bar{B}_0$

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