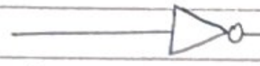
22/07/19

LOGIC GATES

* NOT -

Truth Table.

x	$\bar{x}$
1	0
0	1.

x  $f = \bar{x}$ or x'.

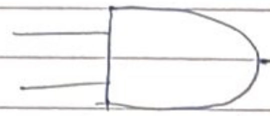
binary value.

Logic Diagram.

* AND -

Truth Table.

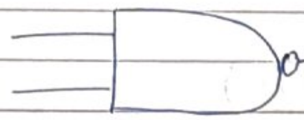
x y	$f = xy$
0 0	0
1 0	0
0 1	0
1 1	1

x, y  $f = xy$

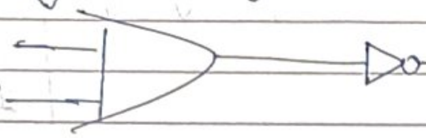
Logic Diagram

* NAND -

x	y	$f = (\overline{xy})$
0	0	1
0	1	1
1	0	1
1	1	0

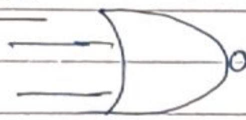
x, y  $f = (xy)'$

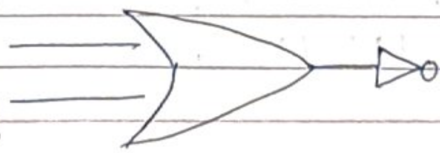
$$f = (xy)' = (\overline{xy}) = \bar{x} + \bar{y}$$

x, y  f

* NOR -

x	y	$f = (\overline{x+y})$
0	0	1
0	1	0
1	0	0
1	1	0

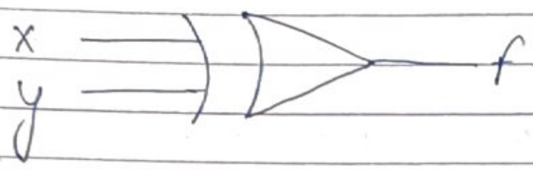
x, y  $f = (\overline{x+y}) = \bar{x}\bar{y}$

x, y  f

$x\bar{x} = 0$, $x + \bar{x} = 1$, $\bar{\bar{x}} = x$.

n- binary variables, 2^n minterms/maxterms, 2^{2^n} boolean f^n.

* XOR (ODD FUNCTION).-



x	y	$f = x \oplus y$
0	0	0
0	1	1
1	0	1
1	1	0

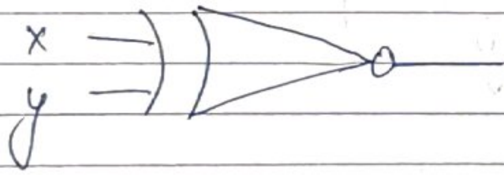
$f = x \oplus y = \bar{x}y + x\bar{y}$

e.g. $f = 1 \oplus 1 \oplus 0 \oplus 1 \oplus 1 = 0$
$f = XOR(1,1,0,1,1) = 0.$
$f = XOR(1,1,1,0,0,0) = 1.$

* PROPERTIES -

$x \oplus x = 0 \rightarrow \bar{x} \cdot x + x\bar{x} = 0 + 0 = 0$
$x \oplus \bar{x} = 1 \rightarrow \bar{x}\bar{x} + xx = \bar{x} + x = 1$
$x \oplus 0 = x \rightarrow \bar{x} \cdot 0 + x1 = x$
$x \oplus 1 = \bar{x} \rightarrow \bar{x} \cdot 1 + x \cdot 0 = \bar{x}$

* XNOR (EVEN FUNCTION)



$f = x \odot y = xy + \bar{x}\bar{y}$

x	y	$f = (x \odot y)$
0	0	1
0	1	0
1	0	0
1	1	1

CONVERSION OF OCTAL INTO BINARY NO.

binary bits $\leftarrow 2^{3} = 8^{1} \rightarrow$ octal units.

e.g. $(176)_8 \rightarrow (001\ 111\ 110)_2$.
$(776)_8 \rightarrow (111\ 111\ 110)_2$

0 + 0 = 0
1 + 0 = 1
0 + 1 = 1
1 + 1 = 0

CONVERSION OF HEXADECIMAL INTO BINARY NO.

Base = 16.

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.

binary ← $\boxed{2^{4} = 16^{1}}$ → hexadecimal.

8 4 2 1
b_3 b_2 b_1 b_0.

e.g. $(1AC)_{16} \rightarrow (000110101100)_2$.

e.g. $(1110.111)_2 \rightarrow (E.E)_{16} = E.E(H$

e.g. $(1111111.11)_2 \rightarrow (7F.C)_{16}$.

e.g. $(1111111.11)_2 \rightarrow (177.6)_8$.

COMPLEMENTS -

Two types of complements are -

r's   (r-1)'s

r = 2

1's   2's.

e.g. N = 1011100.
1's(N) = 0100011
+ 1

1st method
2's(N) = 0100100

2nd method
0100100.

e.g. N = 111110
1's = 000001
2's = 000010

e.g. N = 10101
2's = 01011

11001

Imp.

NUMBER REPRESENTATION -

			MSB	
+ve	+5	+ → 0	0101	(+5)
−ve	−5	− → 1	1101	(−5)

Positive no. has only one representation i.e., Signed Magnitude Representation.

e.g. +13 ⟶ 01101.

Negative no. are represented by three ways -

* Signed Magnitude Representation.
* 1's complement.
* 2's complement

+5 → (0101).

e.g.
* −5 → (1101) . S.M.R.
* −5 → (1010) 1's complement.
* −5 → (1011) 2's complement.

+25 → (00011001)

e.g.
* −25 → (10011001). S.M.R.
* −25 → (11100110) 1's
* −25 → (11100111) 2's

BINARY AIRTHMATIC.

* ADDITION -

$$
\begin{array}{r}
1\;1\;0\;1 \\
+\;1\;1\;1\;1 \\
\hline
1\;1\;1\;0\;0
\end{array}
$$

$\frac{2}{2}$ = rem = 0, q = 1.

```
    1111
  + 1111
  ------
   11110
```

Imp

SUBTRACTION –

Using r's complement (2's)

Using (r−1)'s complement. (1's)

e.g. (5 − 3) = ?

M = 5 = 0101
N = 3 = 0011

```
      M  =   0101
  N(2's) = + 1101
  ---------------
          (1)0010
```

Carry Discard.

If carry come it means M ≥ N.

(0010) Answer.

e.g. (3 − 5)

M = 3 = 0011
N = 5 = 0101

```
  M =   0011
  N = + 1011
  ----------
        1110   (M<N).
```

Here, carry is not found which means the result is negative. Then we convert it into 2's then we get − (0010) Answer

e.g.

M = 01011
N = 01001

```
  M =   01011
  N = + 10111
  -----------
      (1)00010
```

(00010) Answer.

M = 01011
N = 01111

```
  M =   01011
  N =   10001
  -----------
        11100
```

−(00100)

111 2
100

10

8 4 2 1

Using 1's Complement.

Q M = 0110 & N = 00111 ∨ (M − N).

$$
\begin{array}{rr}
M = & 0110 \\
N(1's) = & +1100 \\
\hline
 & (1)0010 \\
 & \to +1 \\
\hline
 & (0011) \text{ Ans}
\end{array}
$$

Q

$$
\begin{array}{r}
0011 \\
+1001 \\
\hline
1100 \\
\hline
\downarrow 1's \\
-(0011)
\end{array}
$$

* OCTAL NUMBER SYSTEM -

7's complement 8's complement.

e.g. N = $(1235)_8$ 7 (001

7's (N) = (6542)

8's (N) = (6543)

e.g. N = $(112367)_8$.

7's (N) = (665410).

8's (N) = (665411)

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$\frac{29}{16}$ 13

* DECIMAL NUMBER SYSTEM -

$N = (189954)_{10}$

$9'(s)\ (N) = (810045)$

$10'(s)\ (N) = (810046)$

* HEXADECIMAL NUMBER SYSTEM.

e.g. $N = (1EAB6)_{16}$

$15's(N) = (E1549)_{16}$

$16's(N) = (E154A)$

$N = (1543)_6$

$6'(s) = (4013)$

$5'(s) = (4012)$

15
14

e.g.
$$\begin{array}{r} (A\ 1\ B\ C\ E)_{16} \\ +(5\ F\ 1\ 3\ F)_{16} \\ \hline 1\ 0\ 0\ D\ 0\ D \end{array}$$

$\frac{29}{16} = 13$

$$\begin{array}{r} (F\ F\ F)_{16} \\ +\ (F\ F\ F)_{16} \\ \hline (1\ F\ F\ E)_{16} \end{array}$$

* DECIMAL TO BINARY -

$(13.3)_{10} \longrightarrow (1101.01001)_2$

for Decimal

$0.3 \times 2 = 0.6$
$0.6 \times 2 = 1.2$
$0.2 \times 2 = 0.4$
$0.4 \times 2 = 0.8$
$0.8 \times 2 = 1.6$

$\frac{25}{8}$ 3 r = 1   32 16 8 4 2 1

1 1 0 1 0 0

Q $(25.6)_{10}$

$(13.46)_8$

$0.6 \times 8 = 4.8$
$0.8 \times 8 = 6.4$
$0.4 \times 8 = 3.2$

Q $(152.8)_{10} \longrightarrow (98.CC)_{16}$

Other to Decimal Conversion.

Q $(1101.1101)_2 \rightarrow (?)_{10}$

$1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2} + 0 \times 2^{-3} + 1 \times 2^{-4}$

$(13.81)_{10}$

$\frac{1}{2} = 0.5, + \frac{1}{4} = 0.25, + \frac{1}{16} = 0.06$

OTHER BINARY CODES -

* BCD Code (Binary Coded Decimal)

$b_3 \quad b_2 \quad b_1 \quad b_0$

8 4 2 1

$(52)_{10} \longrightarrow (110100)_2 \rightarrow (01010010)_{BCD}$

$(10)_{10} \rightarrow (00010000)_{BCD} \rightarrow (1010)_2$

$(15.86)_{10} \rightarrow (00010101.01010110)_{BCD}$

XOR → odd f^n → modulo 2 sum → Symmetric diff.

* Excess - 3 (X3) -

$(0)_{10} \rightarrow (0011)_{Excess 3}$

$(1)_{10} \rightarrow (0100)_{Excess 3}$

$(2)_{10} \rightarrow (0101)_{Excess 3}$

$(9)_{10} \rightarrow (1100)_{Excess 3}$

$(167)_{10} \rightarrow (010010011010)_{Excess 3}$.

$\rightarrow (0001\ 0110\ 0111)_{BCD}$.

$+\ 0011\ \ 0011\ \ 0011$

$(25.3)_{10} \rightarrow (01011000 \cdot 0110)_{X3}$.

* Imp GRAY CODE (Reflected / Cyclic)

- Binary to Gray -

$N = (1\oplus0\oplus0\oplus1\oplus0\oplus0\oplus1\oplus1)_2 \rightarrow (111110)$ Gray code.

$N = (1\oplus1\oplus0\oplus0\oplus0\oplus0\oplus1)_{Binary} \rightarrow (1010010)$ Gray code)

- Gray to Binary -

$N = (10111)_{Gray\ Code} \rightarrow (11010)$

$(11010)_2$.

$N = (01111110)$ Gray code

$(01010100)_2$

Q $(211)_x = (152)_8$. (x = ? find Base x)

$(2 \times x^2 + 1 \times x + 1 \times x^0) = (1 \times 8^2 + 5 \times 8 + 5 \times 8^0)$

$(2x^2 + x + 1) = 106$

$2x^2 + x - 105 = 0$

2	210
3	105
7	35
5	5
	1

$x = \frac{-1 \pm \sqrt{1 + 864}}{4}$.

$2x^2 + 14x + 15x - 105 = 0$

$2x(x+7) - 15(x+7) = 0$.

$(2x+15)(x+7) = 0$.

$x = -15/2$ & $x = +7$

BOOLEAN EXPRESSION OR FUNCTION (LOGIC)

$f(x,y) = xy + \bar{x}y + x\bar{y}$ — $x, y, \bar{x}, \bar{y}$ (literals).

$f. = x + \bar{x}y + \bar{y}$

term

term:
- Product term (xy, $x\bar{y}$, $\bar{x}$)
- sum term ($x+y$, $xy + \bar{y}$)

Boolean Exp. (logic form)
- Standard form
  - Sum of Product (SOP)
  - Product of sum (POS)
- Canonical form
  - Sum of min. term
  - Product of max. term

$n \to 2^n \to$ min / max term $\quad (\bar{x}\bar{y})' = x+y.$

n — binary no.

x	y	min. term	max term	f1	f2	f3
		$\bar{x}\bar{y}$ (m_0)	$x+y$ (m_0)	0	0	1
		$\bar{x}y$ (m_1)	$(x+\bar{y})$ (m_1)	0	0	0
		$x\bar{y}$ (m_2)	$(\bar{x}+y)$ (m_2)	1	1	1
		xy (m_3)	$(\bar{x}+\bar{y})$ (m_3)	0	1	0.

$$\left.\begin{aligned} f_1 &= x\bar{y} \\ f_2 &= x\bar{y}+xy \\ f_3 &= \bar{x}\bar{y}+x\bar{y} \end{aligned}\right\}\text{ Sum of minterms.}$$

$$f_1 = \Sigma(m_2) = \Sigma(2)$$
$$f_2 = \Sigma(m_2, m_3) = \Sigma(2,3)$$
$$f_3 = \Sigma(m_0, m_2) = \Sigma(0,2)$$

$f(x,y) =$	m_0	0 0	$\bar{x}\,\bar{y}$
	m_1	0 1	$\bar{x}\,y$
	m_3	1 1	$x\,y.$
$f(x,y,z) =$	m_4	1 0 0	$x\bar{y}\bar{z}$
	m_6	1 1 0	$xy\bar{z}$
$f(x,y,z,w) =$	m_{11}	1 0 1 1	$x\bar{y}zw.$
	m_{13}	1 1 0 1	$xy\bar{z}w.$

$f = xy + \bar{x}y + x\bar{y}$ (Canonical form)

$f = x + xy + \bar{y}$ (Standard form) (Sum of product).

product.

ex- Q $f = x + \bar{y}$ (Sum of product).

Convert it into sum of minterms.

Solution: $x.(y+\bar{y}) = xy + x\bar{y}$ — (I)

$\bar{y}.(x+\bar{x}) = x\bar{y} + \bar{x}\bar{y}$ — (II)

$f = xy + x\bar{y} + x\bar{y} + \bar{x}\bar{y}$

$f = xy + x\bar{y} + \bar{x}\bar{y}$

$f = \Sigma(m_3, m_2, m_0)$ or $\Sigma(3,2,0)$.

Q $f = \bar{x} + x\bar{y} + y$

$\bar{x}(y+\bar{y}) = \bar{x}y + \bar{x}\bar{y}$

$y(x+\bar{x}) = xy + \bar{x}y$

$f = \bar{x}y + xy + x\bar{y} + \bar{x}\bar{y}$

$f = \Sigma(m_0, m_1, m_2, m_3) = \Sigma(0,1,2,3)$.

Q $f = xy + \bar{x} + yz$.

$\bar{x}.(y+\bar{y})(\cancel{z+\bar{z}}) = (\bar{x}y + \bar{x}\bar{y})(z+\bar{z}) = \bar{x}yz + \bar{x}y\bar{z} + \bar{x}\bar{y}z + \bar{x}\bar{y}\bar{z}$.

$xy(z+\bar{z}) = xyz + xy\bar{z}$

$yz(x+\bar{x}) = xyz + \bar{x}yz$.

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1	1
1	1

$\rightarrow$ 1 (constant).

421

K - map.

$$f = \bar{x}\bar{y}\bar{z} + xy\bar{z} + xyz + \bar{x}yz + \bar{x}y\bar{z} + \bar{x}\bar{y}z.$$

$$f = \Sigma(0, 6, 7, 3, 2, 1) = \Sigma(0, 1, 2, 3, 6, 7)$$

$$f = (x+y+z) \cdot (x+\bar{y}+\bar{z})(\bar{x}+\bar{y}+\bar{z}).$$

(product of maxterm.)
(Canonical form)

$$f = (x) \cdot (x+y)(\bar{x}+\bar{y}+\bar{z})$$

(product of sum)(Standard form).

BOOLEAN FUNCTION SIMPLIFICATION.

* USING K- MAP.

• 2- variable K- map.

x \ y	0	1
0	m_0	m_1
1	m_2	m_3

$\rightarrow \bar{x}y$

$\rightarrow xy$.

Q $f = \Sigma(m_0, m_1)$. minimize it using K-map.

Solution-

x \ y	0	1
0	1	1
1		

$\rightarrow \bar{y} + y = 1.$

$= \bar{x}$

Q $f = \Sigma(m_0, m_2, m_3)$.

x \ y	0	1
0	m_0	
1	m_2	m_3

x \ y	0	1
0	1	
1	1	1

$= \bar{y} + x$.

Q $f = \Sigma(m_0, m_3)$.

$x \backslash y$	0	1
0	1	
1		1

$f = \bar{x}\bar{y} + xy$.

- 3 - variable K-map → Gray Code

$x \backslash yz$	00	01	11	10
0	m_0	m_1	m_3	m_2
1	m_4	m_5	m_7	m_6 → $xy\bar{z}$

m_5 → $x\bar{y}z$

00 10

$x \backslash yz$	00	01	11	10
0	1			1
1	1			1

$= \bar{z}$ Answer

$f = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + AB\bar{C} + A\bar{B}\bar{C}$.

Q

$x \backslash yz$	00	01	11	10
0	1	1	1	1
1			1	

$= yz + \bar{x}$

Q

$x \backslash yz$	00	01	11	10
0	1			1
1		1		

$= \bar{x}\bar{z} + \cancel{x}\bar{y}z$

Q

$x \backslash yz$	00	01	11	10
0		1	1	
1		1	1	1

$= \cancel{\bar{x}z}$ → $z + xy$.

8 Pair = 1.
4 Pair = term (1 literals)
2 Pair = term (2 literals).
No Pair = term (3 literals).

8 4 2 1

Q $f = \Sigma(0, 1, 2, 5, 6, 7)$.

$x \backslash yz$	00	01	11	10
0	ϕ	1		1
1		1	1	1

$\bar{x}y + \bar{y}z + xz + xy + y\bar{z}$.

- 4-value K-map.

Q

$AB \backslash CD$	00	01	11	10
00	1			1
01				
11				
10	1			1

$= \bar{B}\bar{D}$

$AB \backslash CD$	00	01	11	10
00	m_0	m_1	m_3	m_2
01	m_4	m_5	m_7	m_6
11	m_{12}	m_{13}	m_{15}	m_{14}
10	m_8	m_9	m_{11}	m_{10}

Q $f = \Sigma(0, 1, 4, 5, 8, 9, 13, 15)$

⇒

$AB \backslash CD$	00	01	11	10
00	1	1		
01	1	1		1
11		1	1	
10	1	1		

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

Q

$AB \backslash CD$	00	01	11	10
00		1	1	1
01	1	1	1	1
11		1	1	1
10		1	1	1

$D + C + \cancel{\bar{C}D} + \cancel{\bar{A}B\bar{C}}\ \ \bar{A}B$.

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(15)

Q

AB \ CD	00	01	11	10
00	1	1		1
01		1	1	
11		1	1	
10	1			1

essential Prime implicant.

$\bar{B}\bar{D} + BD + \bar{A}\bar{C}D$ or $\bar{A}\bar{B}\bar{C}$

prime implicant.

- 5- variable k- map.

$\bar{A}(0)$

BC \ DE	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

$A(1)$

BC \ DE	00	01	11	10
00	16	17	19	18
01	20	21	23	22
11	28	29	31	30
10	24	25	27	26

$2^5 = 32$ minterms $(0-31)$

It uses in BCD adder & Decimal adder.

Q

$\bar{A}(0)$

BC \ DE	00	01	11	10
00				
01		1	1	
11		1	1	
10				1

$A(1)$

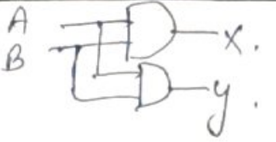
BC \ DE	00	01	11	10
00	1	1		
01	1	1	1	1
11		1	1	
10				

$f = \Sigma(5, 7, 13, 15, 21, 23, 29, 31)$ minimize it.

$= CE$ Answer $+ \bar{A}B\bar{C}D\bar{E} + AB\bar{C}\bar{D}$.

Q

2- bits binary input & provide its square as an output.



A	B	x	y	z	w
0	0	0	0	0	0
0	1	0	0	0	1
1	0	0	1	0	0
1	1	1	0	0	1

$x = xy$

$y = x\bar{y}$

$z = 0$

$w = \bar{x}y + xy$

$= y(x+\bar{x}) = y.$

DIGITAL CIRCUIT

Combinational
(Adding, Subtraction, Mux (multiplexer),
Decoding, Encoding)

Sequencial:
(Flip flops, Registers,
Counters.).

* COMBINATIONAL CIRCUIT -

Logic Circuit for digital systems may be combinational or sequential. A combinational circuit consists of logic gates whose outputs at any time are determined directly from the present combination of inputs without regard to previous inputs. A combinational circuits performs a specific information processing operation fully specified logically by a set of booleans functions.

Examples - adder, subtracter, multiplexer, encoder & decoder.

4 2 1

ex- Design a combinational circuit with three inputs & one ~~input~~ output. The output is equal to logic 1 when the binary value of the input is less than 3. The output is logic 0 otherwise.

⇒.

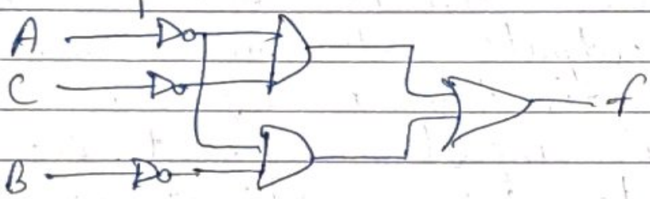
A	B	C	X
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

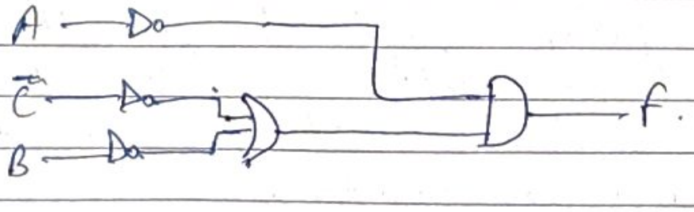
~~$\bar{A}\bar{B}\bar{C}$, $\bar{A}\bar{B}C$, $\bar{A}B\bar{C}$, $\bar{A}\bar{B}\bar{C}$~~

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

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

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





Q Design a combinational circuit with three inputs & 3 outputs. When the binary input is 0, 1, 2 or 3, the binary output is one greater than the input. When the binary input is 4, 5, 6 or 7 the binary output is less than one.

Truth Table.

A	B	C	x	y	z
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	0	1	1
0	1	1	1	0	0
1	0	0	0	1	1
1	0	1	1	0	0
1	1	0	1	0	1
1	1	1	1	1	0

x =

A \ BC				
			1	
		1	1	1

$= BC + AB + AC$.

y =

A \ BC				
		1		1
	1		1	

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

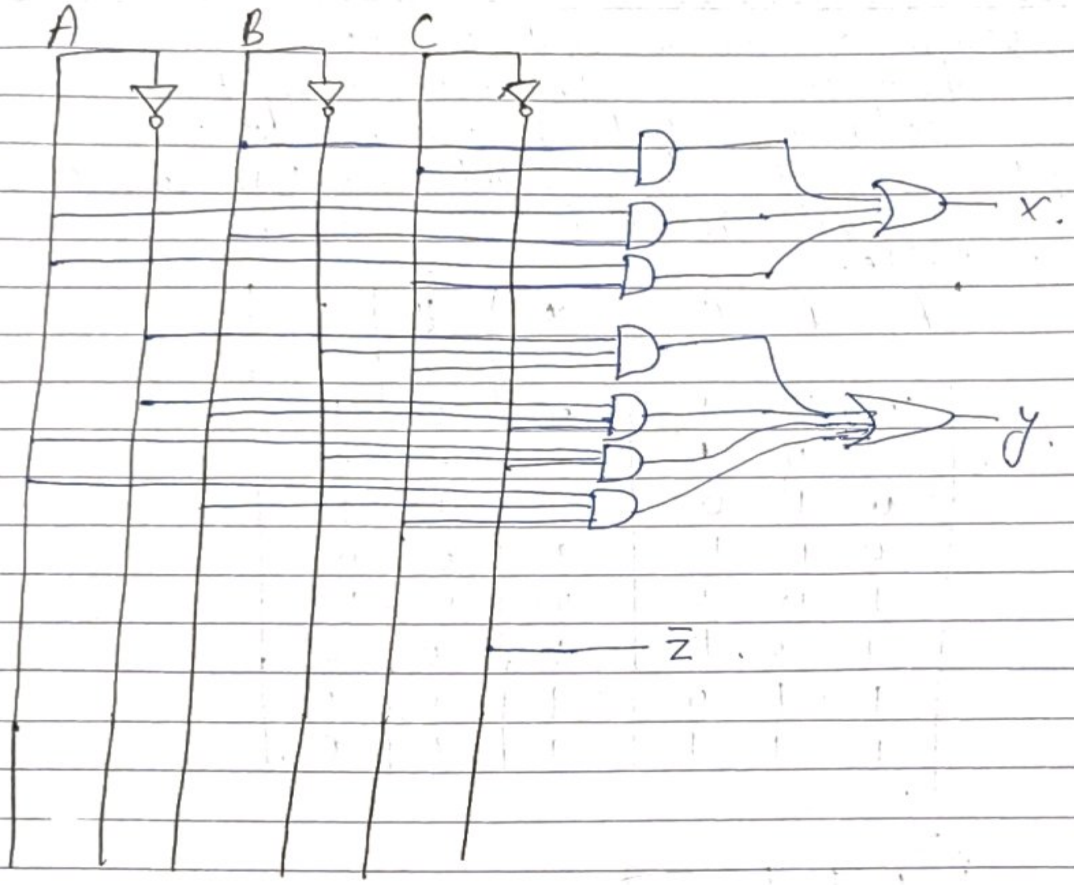
$x \oplus B \oplus C$

z =

A \ BC				
	1			1
	1			1

$= \bar{C}$.

(20)



ADDER-

* Half adder
* full adder
* Parallel adder
* BCD / Decimal adder
* Add eqⁿ with carry look ahead generator.

* HALF ADDER (2- Binary Bits). → Add 2 binary bits.

Inputs. →

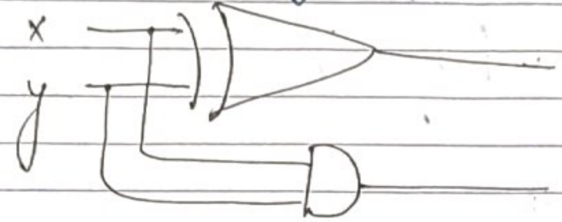
x	y	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

C → Carry
S → Sum.

Truth Table

Boolean Expression.
logic Expression.

$C = xy$ & $S = \bar{x}y + x\bar{y} = x \oplus y$.



Logic Diagram. Block Diagram.

* FULL ADDER - (Add 3-binary bits).

x	y	z	C	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

x \ yz	00	01	11	10
0			1	
1		1	1	1

x \ yz	00	01	11	10
0		1		1
1	1		1	

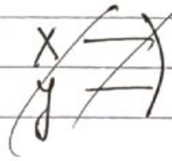
$\bar{x}z + xy + xy$.

$x\bar{y}\bar{z} + \bar{x}\bar{y}z + xyz + \bar{x}y\bar{z}$

$\bar{x}(\bar{y}z + y\bar{z}) + x(\bar{y}\bar{z} + yz)$

$x(y \oplus z)' + \bar{x}(y \oplus z)$

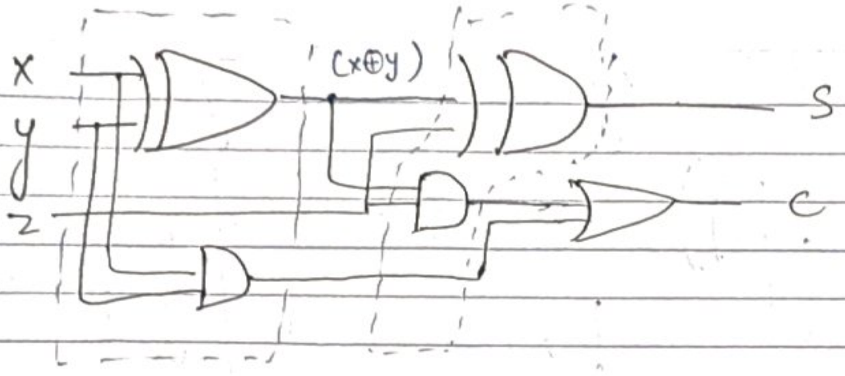
$x \oplus y \oplus z$

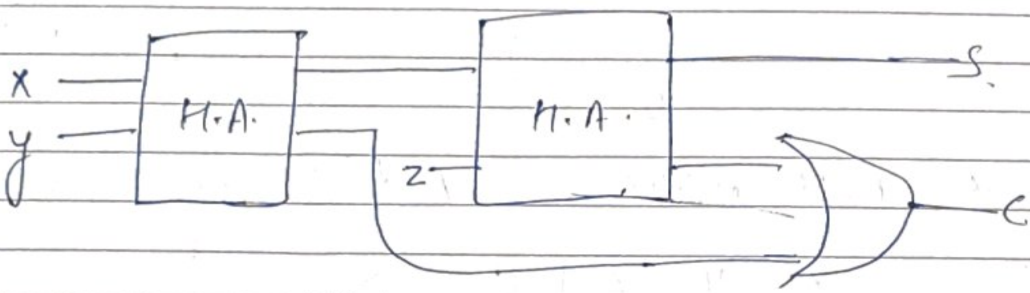


$xy + \bar{x}yz + x\bar{y}z$.

$xy + z(\bar{x}y + x\bar{y})$

$xy + z(x \oplus y)$.





* PARALLEL ADDER

Ex:-

$A = a_1 \quad a_1$ $\qquad$ $A = 1\,1$

$B = + \; b_1 \quad b_0$ $\qquad$ $B = 1\,1$

$C_2 \quad C_1 \quad C_0$ $\qquad$ 110

Q Design a combinational circuit which is used to perform addition of two binary no. of two bits.

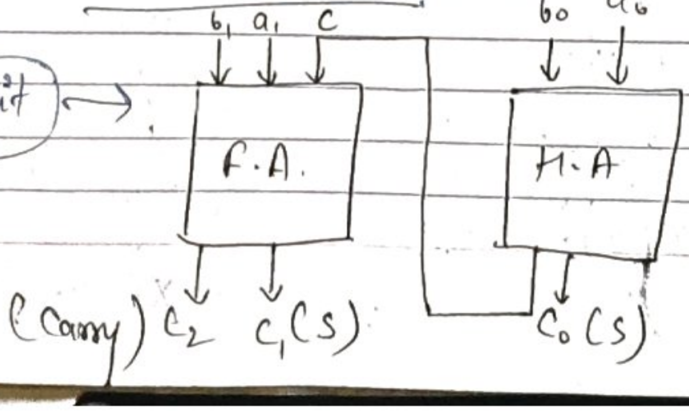
F.A. $\qquad$ H.A

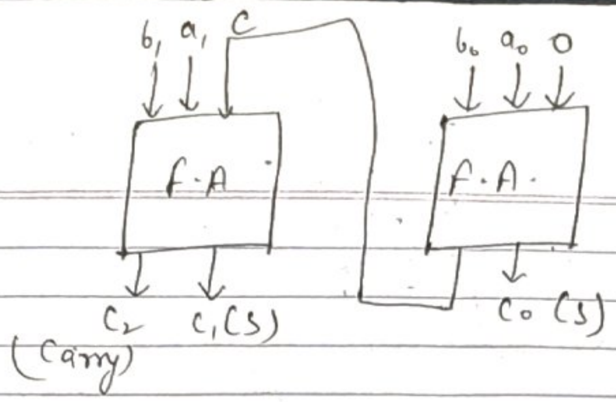
$A = a_1 \quad a_0$

$B \quad\;\; b_1 \quad b_0$

$C_2 \quad C_1 \quad C_0$

Circuit →

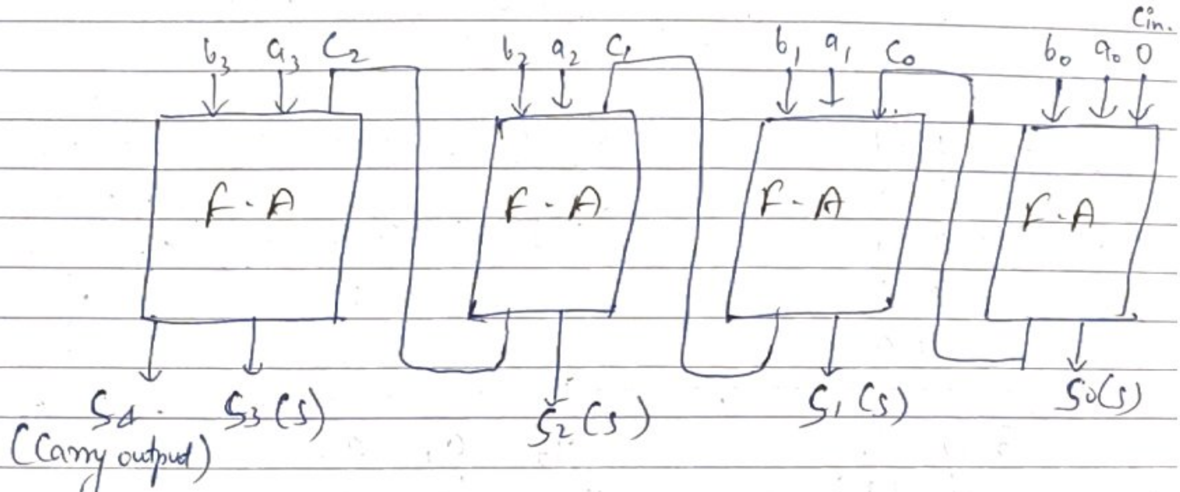




* Imp. 4-bit PARALLEL ADDER.

$$\begin{array}{rrrrrr} A = & & 1 & 1 & 1 & 1 \\ B = + & & 1 & 1 & 1 & 1 \\ \hline & 1 & \not{0} & 1 & 1 & 0 \end{array}$$

(9 inputs / 5 outputs / 4-F.A.

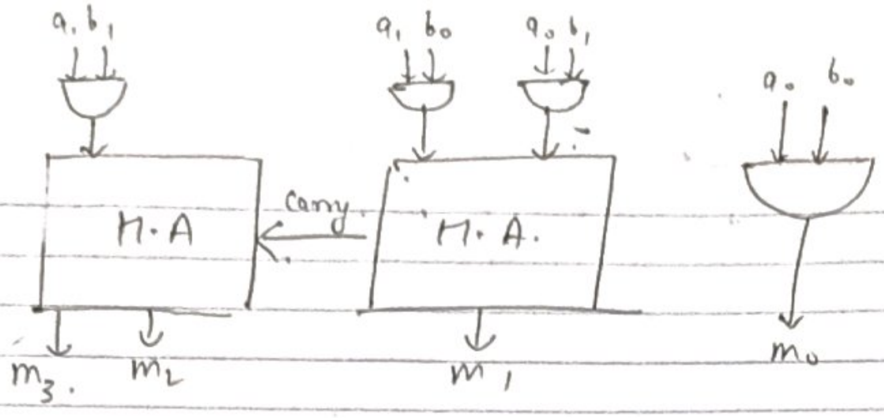


$$\begin{array}{rrrrrr} A = & & a_3 & a_2 & a_1 & a_0 \\ B = + & & b_3 & b_2 & b_1 & b_0 \\ \hline & S_4 & S_3 & S_2 & S_1 & S_0 \end{array}$$

* 2-bits binary Multiplier (2 bits by 2 bits).
(2 by 2 array multiplier / 2 by 2)

$$\begin{array}{rrrrr} A = & & & 1 & 1 \ (3) \\ B = \times & & & 1 & 1 \ (3) \\ \hline & & & 1 & 1 \\ + & & 1 & 1 & \\ \hline & 1 & 0 & 0 & 1 \ (9). \end{array}$$

$$\begin{array}{rrrr} & & a_1 & a_0 \\ & & b_1 & b_0 \\ \hline & & a_1 b_0 & a_0 b_0 \\ + & a_1 b_1 & a_0 b_1 & \\ \hline m_3 & m_2 & m_1 & m_0 \end{array}$$



Q $M = 13$ $N = 11$ $(M-N)$ using 2's complement

$M = 1101 \rightarrow 1101$

$N = 1011$ $\quad + 0101$

$\quad (1)0010 \rightarrow 0010$

Discard

$M = 1101$ $\rightarrow 1\ 0\ 1\ 1\ 1$ (Gray) (~~Binary~~)

$N = 0100$ $\rightarrow 1\ 1\ 0\ 1\ 0$ (~~Gray~~) (Binary)

1'(s) $1000\,1$

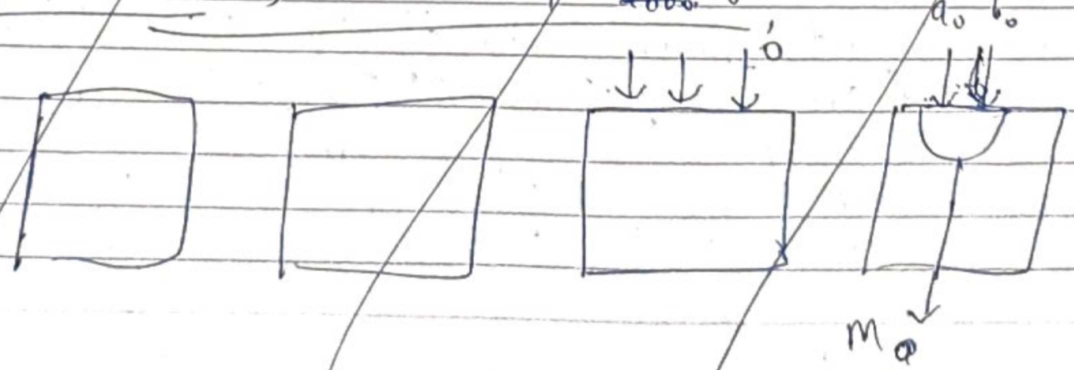
$+1$

0010

3 by 2.

			a_2	a_1	a_0
		$\times$		b_1	b_0
			a_2b_0	a_1b_0	a_0b_0
		a_2b_1	a_1b_1	a_0b_1	$\cancel{a_0b_1}$
	M_4	M_3	M_2	M_1	$\cancel{a_0b_0}\ m_0$

111
$\times$ 11
111
111
1 1 1



* 3 bits BINARY TO GRAY CONVERTOR

Binput Input			Gray Output		
A	B	C	x	y	Z
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	1
0	1	1	0	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	1	0	1
1	1	1	1	0	0

x =

A \ BC	00	01	11	10
0	[illegible]	[illegible]		
1	1	1	1	1

$= \bar{A}\bar{B} + AB = \cancel{(A \oplus B)}\ A.$

y =

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

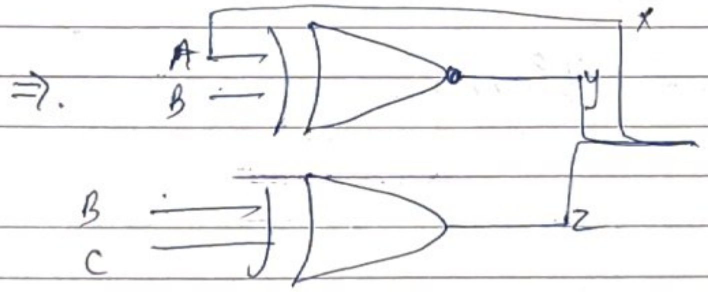
$= A\bar{B} + \bar{A}B = (A \oplus B).$

z =

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

$= \bar{B}C + B\bar{C} = B \oplus C.$

⇒.



HALF SUBTRACTOR (A combinational circuit for subtracting 2- binary bits)

Truth Table

x	y	B → Borrow	D → Difference.
0	0	0	0
0	1	1	1
1	0	0	1
1	1	0	0

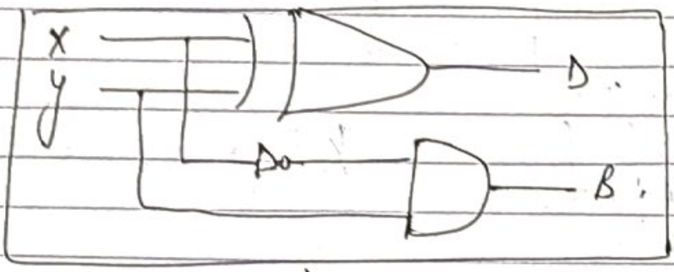
0 - 1

~~2 - 1 = 1~~

$D = \bar{x}y + x\bar{y} = x \oplus y.$

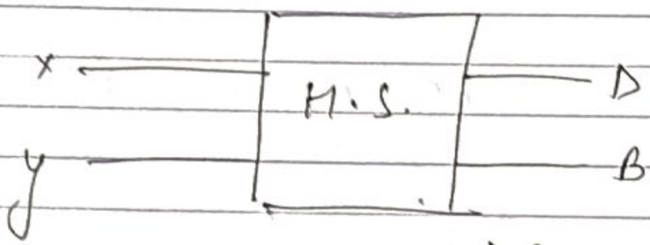
$B = \bar{x}y$

Boolean Expression.



Half Subtractor.

Logic Diagram.



Block Diagram.

← L.R.

2

(Imp).

FULL SUBTRACTOR.

x	y	z	B	D
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	1	0
1	0	0	0	1
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

B =

x \ yz	00	01	11	10
0		1	1	1
1			1	0

$= \cancel{\bar{x} + yz}\ \bar{x}y + yz + \bar{x}z$

$= \bar{x}y + \bar{x}\bar{y}z + xyz$

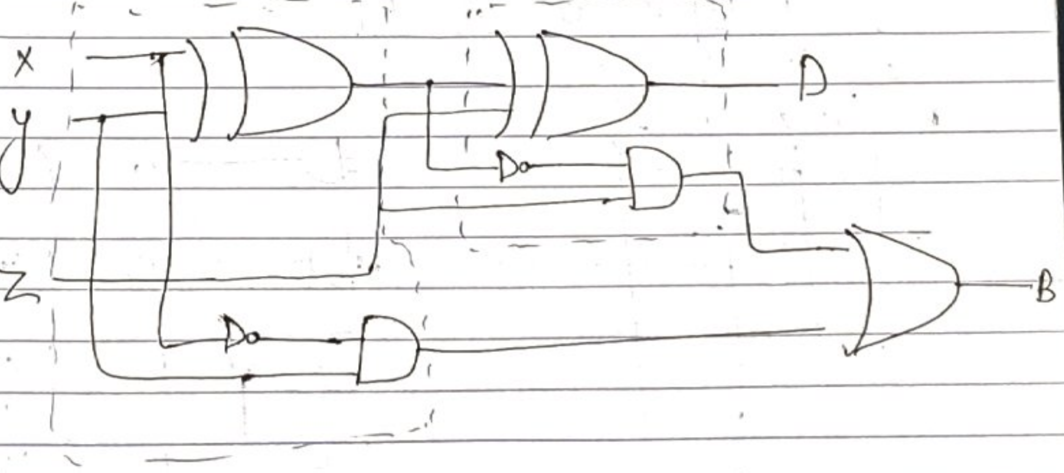
$= \bar{x}y + z(x \oplus y)'$

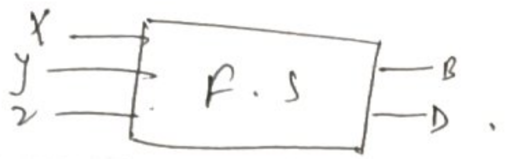
D =

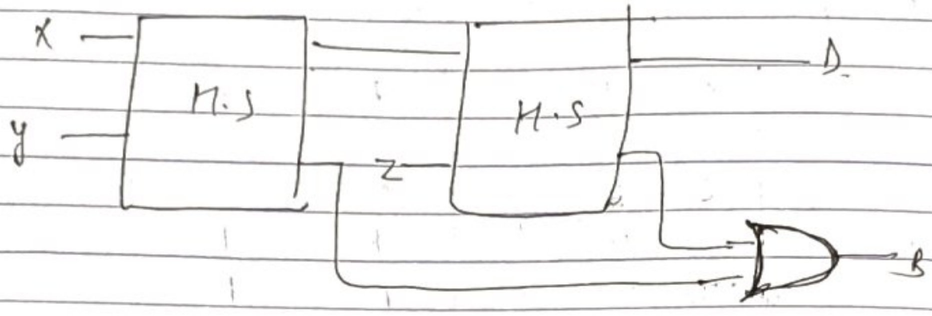
x \ yz	00	01	11	10
0		1		1
1	1		1	0

$= \cancel{\bar{x}\bar{y}z + x\bar{z} + y\bar{z}}$

$x \oplus y \oplus z.$







DECODER

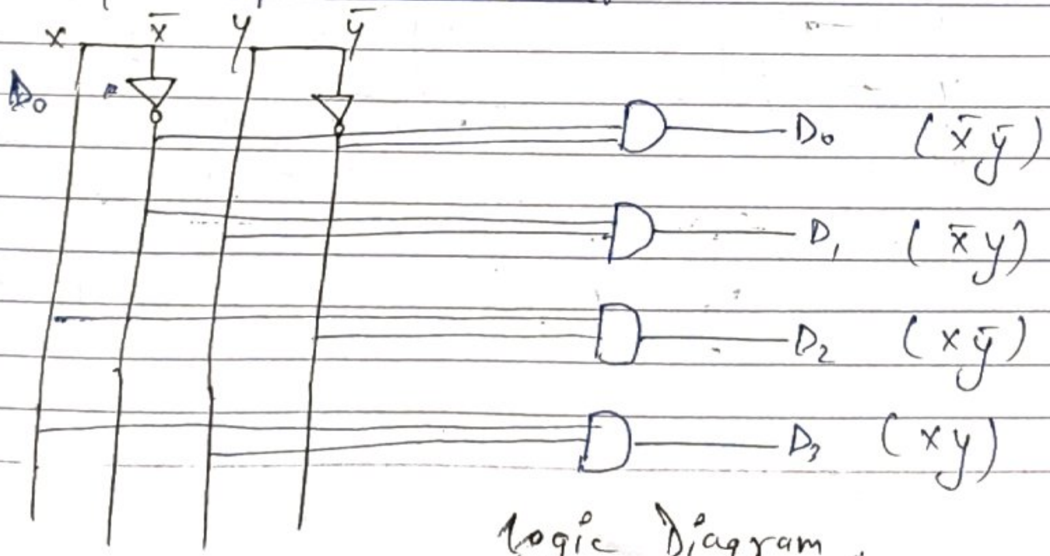
- → n inputs — 2^n (max) output.
- → binary to other code converter
- → a combinational circuit.

Ex:- (2 to 4 Line decoder).

⇒

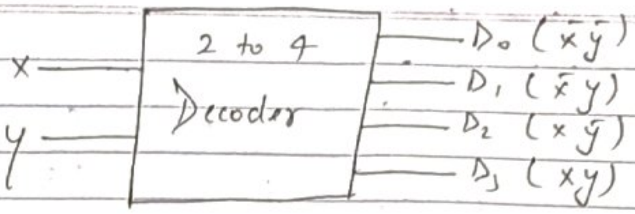
(inputs) x	y	(outputs) D_0	D_1	D_2	D_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

← TRUTH TABLE



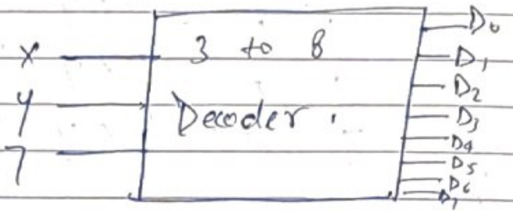
logic Diagram.

Every output of decoder represent min terms.



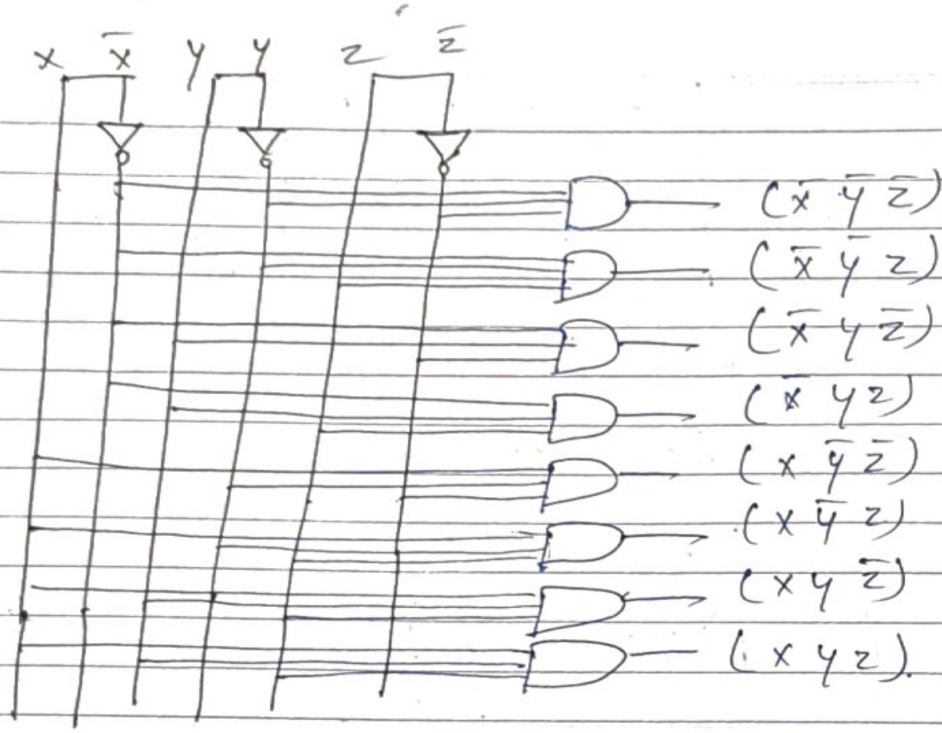
Block Diagram

Q 3 to 8 line decoder.

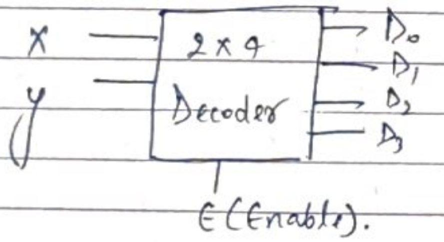


Truth Table.

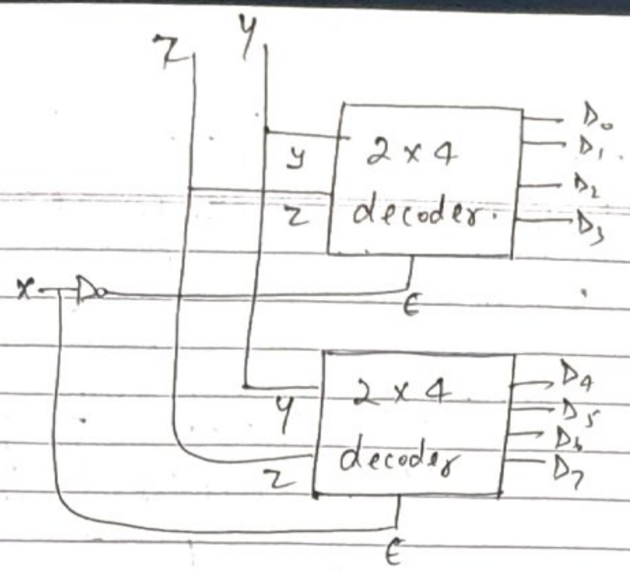
x	y	z	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1



Q Design a 3 cross decoder with a help of 2 x 4 decoder chips.



x y z	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
0 0 0	1	0	0	0	0	0	0	0
0 0 1	0	1	0	0	0	0	0	0
0 1 0	0	0	1	0	0	0	0	0
0 1 1	0	0	0	1	0	0	0	0
1 0 0	0	0	0	0	1	0	0	0
1 0 1	0	0	0	0	0	1	0	0
1 1 0	0	0	0	0	0	0	1	0
1 1 1	0	0	0	0	0	0	0	1

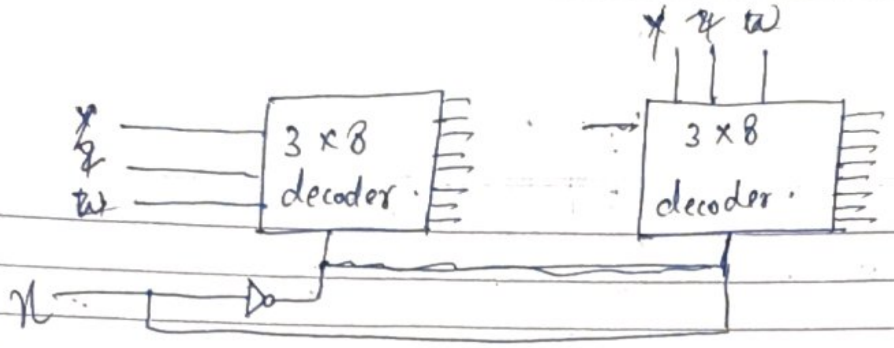


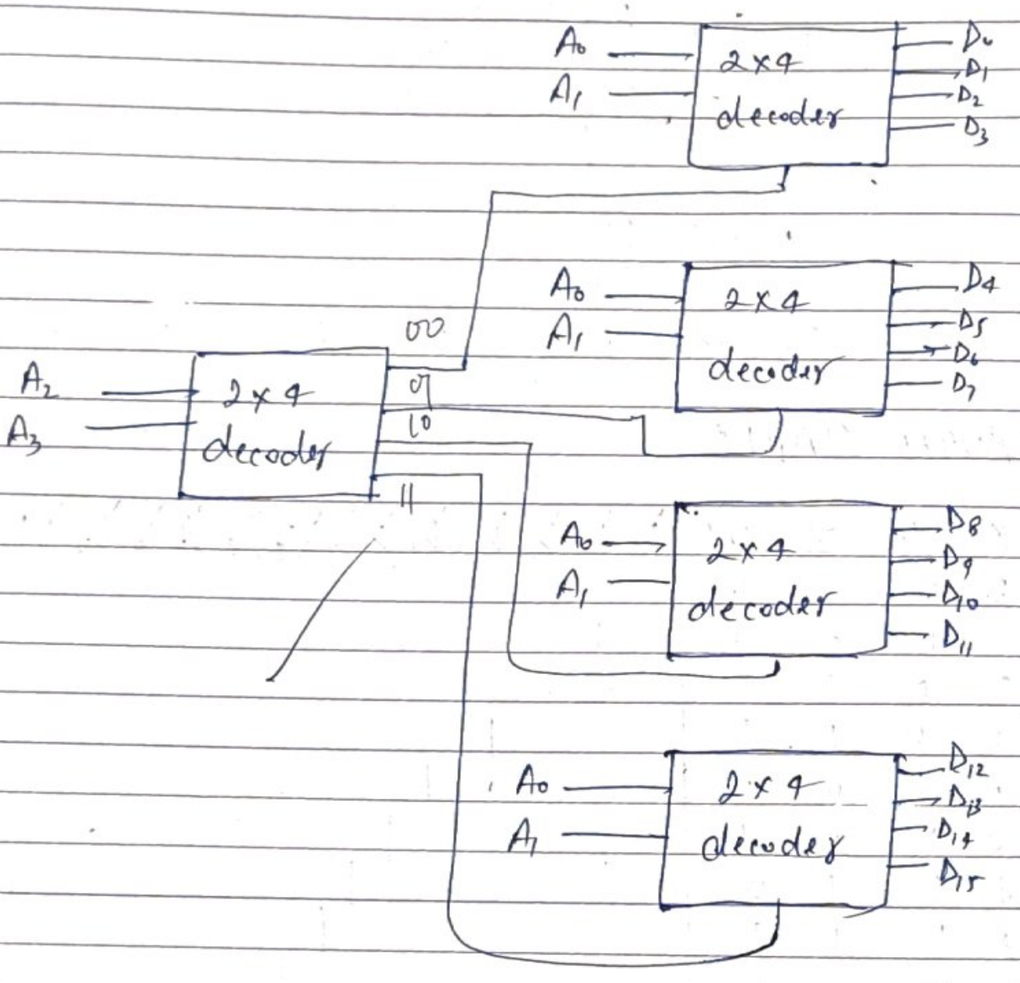
Block Diagram

Q 4x16 Decoder using 3x8 decoder, 2x4 decoder

TRUTH TABLE-

x	y	z	w	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}
0	0	0	0	1															
0	0	0	1		1														
0	0	1	0			1													
0	0	1	1				1												
0	1	0	0					1											
0	1	0	1						1										
0	1	1	0							1									
0	1	1	1								1								
1	0	0	0									1							
1	0	0	1										1						
1	0	1	0											1					
1	0	1	1												1				
1	1	0	0													1			
1	1	0	1														1		
1	1	1	0															1	
1	1	1	1																1





ENCODER.

→ n inputs → 2^n ~~inputs~~ (max.) output.

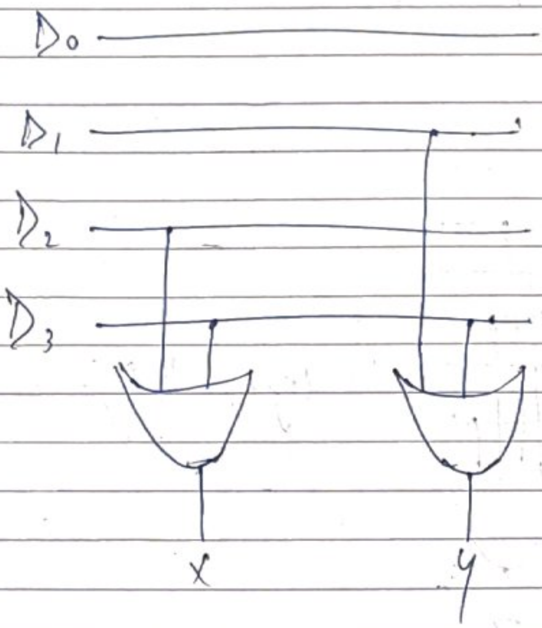
→ other code to binary code conversion.

→ a combination circuit.

⇒ 4 to 2 encoder

Truth Table.

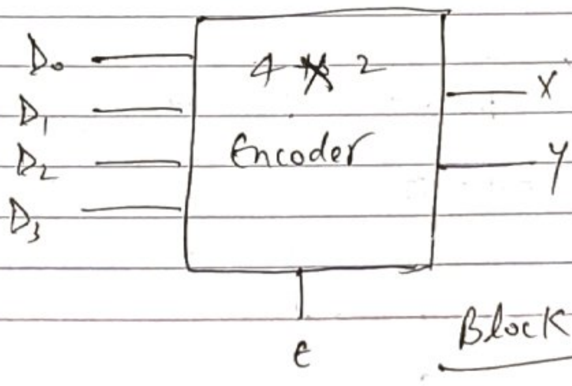
D_0	D_1	D_2	D_3	x	y
1	0	0	0	0	0
0	1	0	0	0	1
0	0	1	0	1	0
0	0	0	1	1	1



$x = D_2 + D_3$

$y = D_1 + D_3$

Logic Diagram

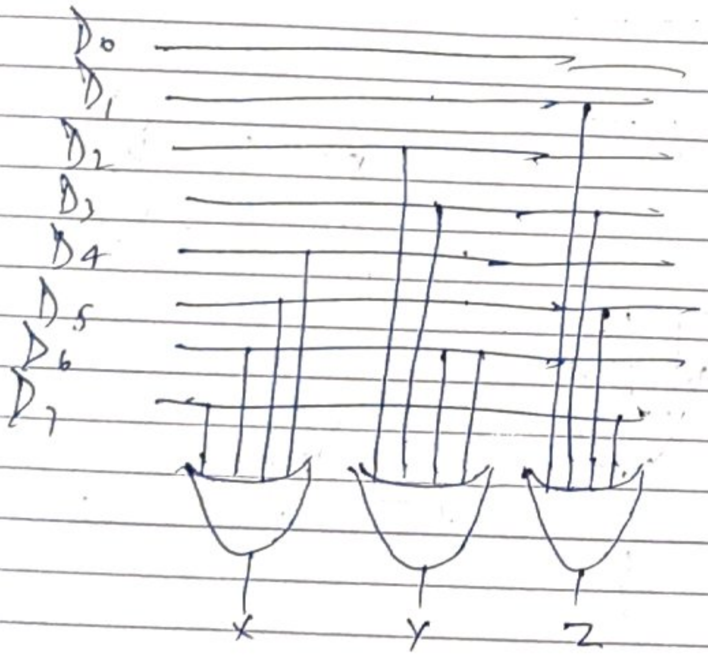


Block Diagram.

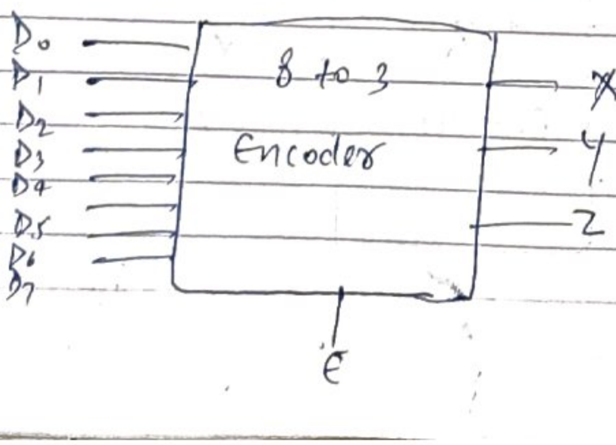
8 to 3 Encoder. (Octal to Binary).

Truth Table -

D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	X	Y	Z
1	0	0						0	0	0
	1							0	0	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



logic Diagram.



$X \rightarrow$ don't care

* PRIORITY ENCODER -

(4 to 2.)

Highest priority → D_3, D_2, D_1, D_0 ← Lowest priority

$D_3 > D_1 > D_2 > D_0$.

Truth Table.

Valid output indicator → V

D_0	D_1	D_2	D_3	x	y	V
0	0	0	0	X	X	0
X	X	X	1	1	1	1
X	1	X	0	0	1	1
X	0	1	0	1	0	1
1	0	0	0	0	0	1

$D_0 > D_3 > D_1 > D_2$

D_0	D_1	D_2	D_3	x	y	V
0	0	0	0	X	X	0
~~1~~	~~X~~	~~0~~	~~0~~	~~X~~	~~X~~	0
1	X	X	X	0	0	1
0	X	X	1	1	1	1
0	1	X	0	0	1	1
0	0	1	0	1	0	1

$x =$

$D_0D_1 \backslash D_2D_3$	00	01	11	10
00	x	1	1	1
01		1	1	
11		1	1	
10		1	1	1

$$x = D_3 + \bar{D}_1 D_2.$$

$y =$

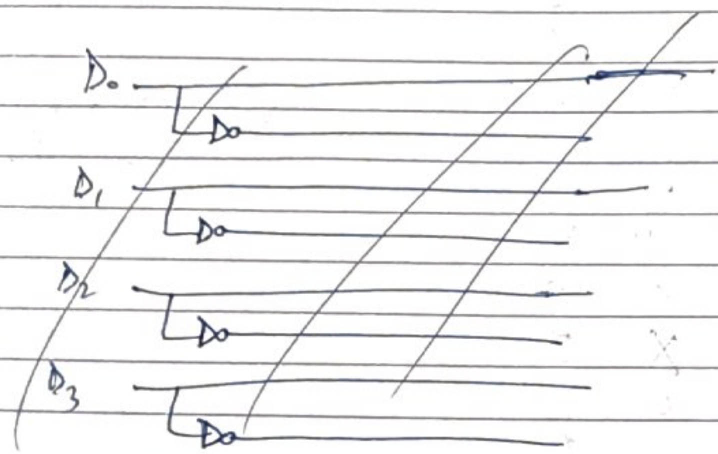
D_0D_1 \ D_3D_1	00	01	11	10
00		1	1	
01	1	1	1	1
11	1	1	1	1
10		1	1	

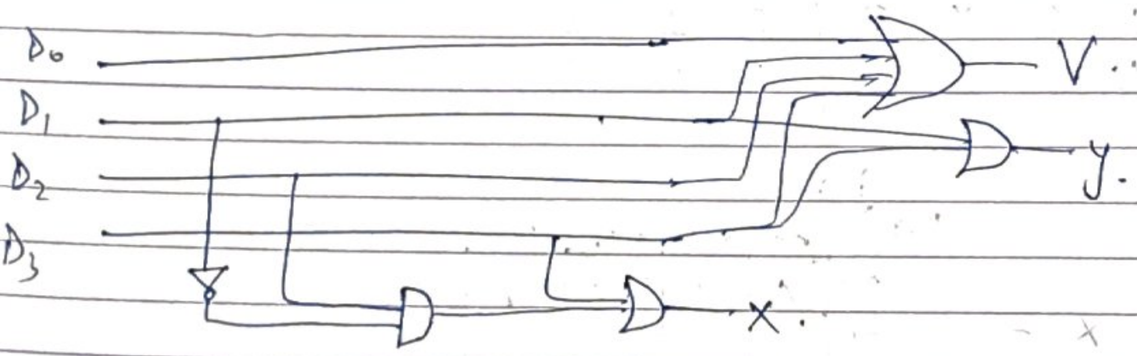
$= D_3 + D_1.$

$V =$

	00	01	11	10
00				
01				
11				
10				

$= D_0 + D_1 + D_2 + D_3.$





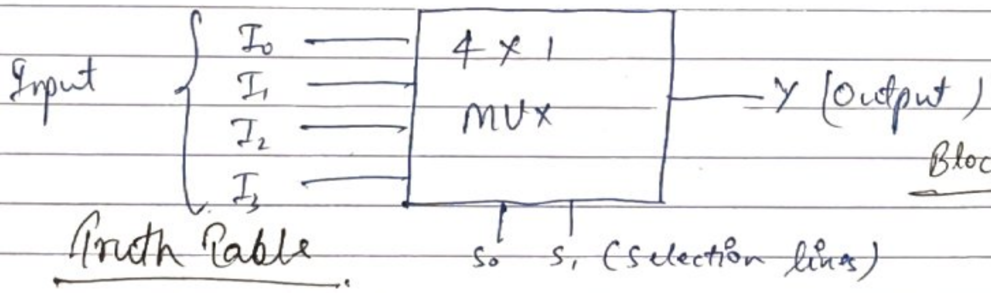
300 → nearest 2^n i.e., 512 → 2^9 = 9 → selection lines.

MULTIPLEXER (MUX). (Data Selector).

→ 2^n inputs — 1 (output).
(or less than).

Multiplexing means transmitting a large no. of information units over a smaller no. of channels or lines. A digital multiplexer is a combinational circuit that selects binary information from one of many input lines & directs it to a single output line. The selection of a particular input line is controlled by a set of selection lines. Normally, there are 2^n input lines ~~whose~~ & n selection lines, whose bit combination determine which input is selected.

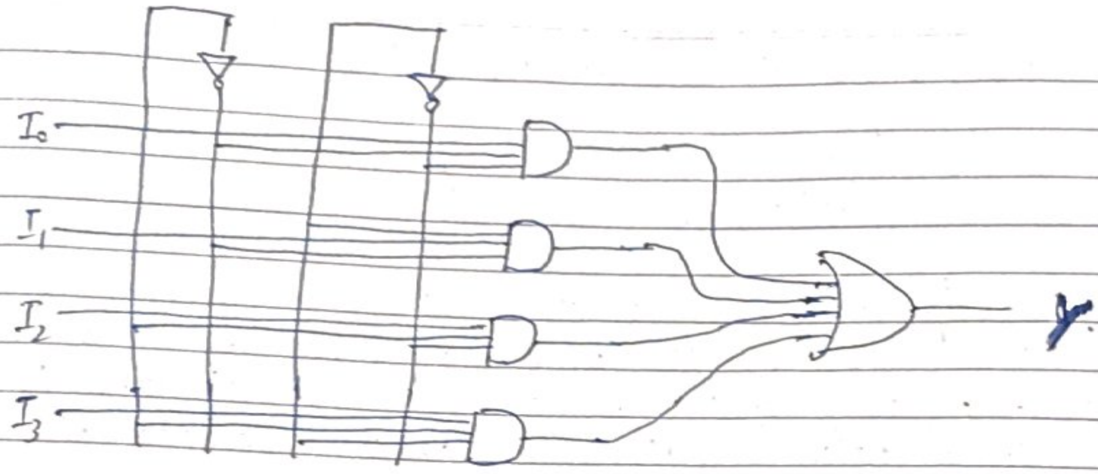
* 4 to 1 lines MUX -
2^2 means → 2 selection lines.



Block Diagram

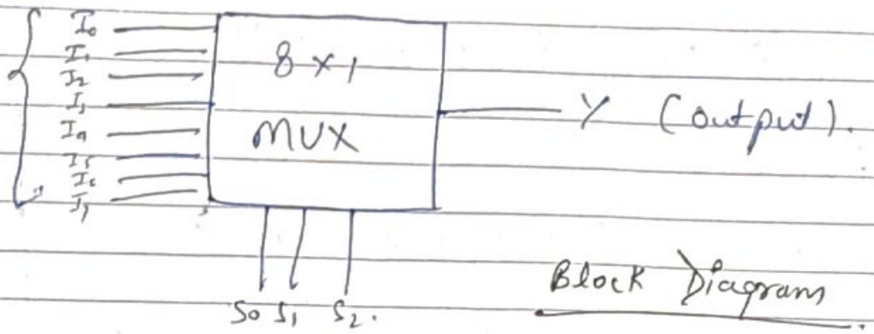
Truth Table

	Selection line S_0	S_1	Output Y
I_0	0	0	I_0
I_1	0	1	I_1
I_2	1	0	I_2
I_3	1	1	I_3



Logic Diagram

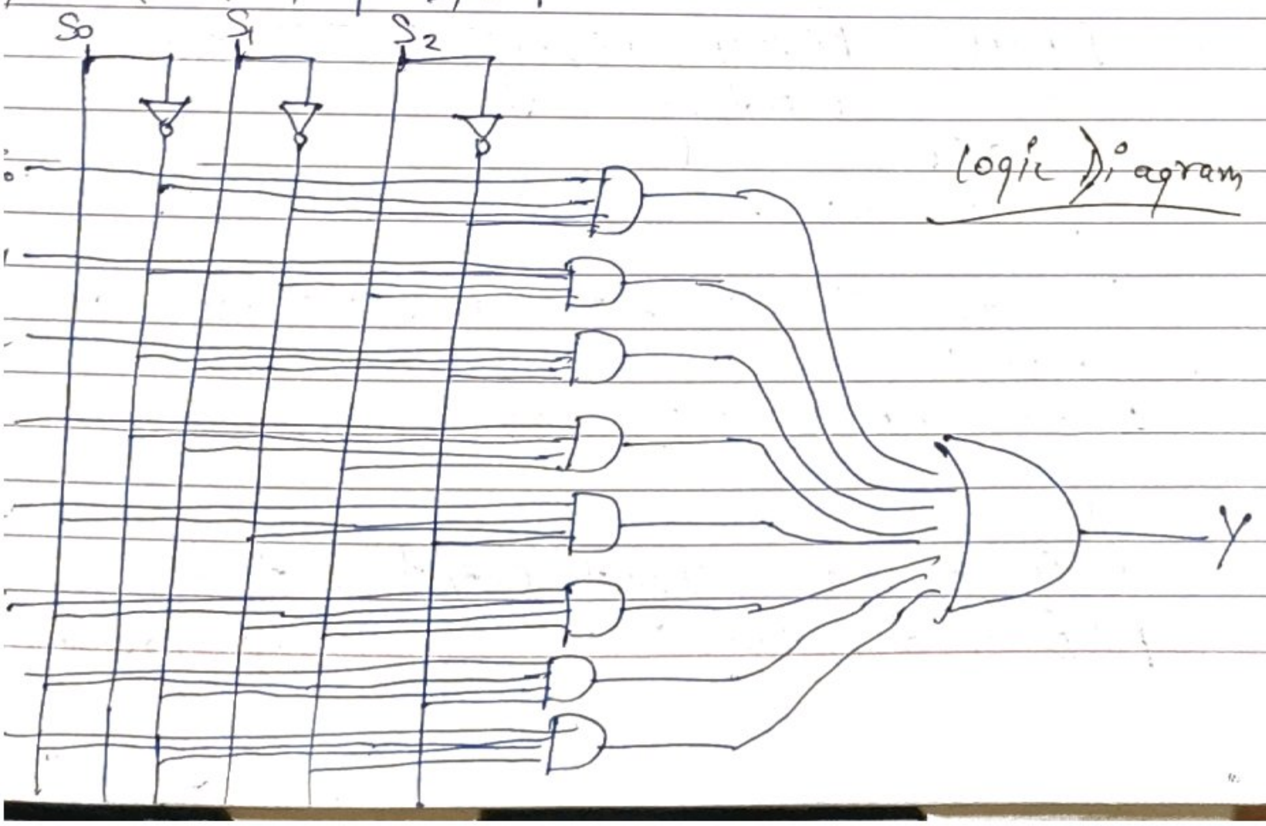
* 8 x 1 MUX.



Block Diagram.

Truth Table

	S_0	S_1	S_2	Y
I_0	0	0	0	I_0
I_1	0	0	1	I_1
I_2	0	1	0	I_2
I_3	0	1	1	I_3
I_4	1	0	0	I_4
I_5	1	0	1	I_5
I_6	1	1	0	I_6
I_7	1	1	1	I_7



Logic Diagram

Date- 19/08/19

UNIT- 4
MEMORY ORGANIZATION -

MEMORY HIERARCHY -

increasing cost per bit.

CPU Register

Cache Memory
L1, L2, L3

RAM
Physical | Virtual

Secondary Memory
Disk | Tape | Optical

increasing capacity // Access time.

//ROM → Non-volatile (Permanent)

* CPU Register is the smallest & fastest memory.

* Cahe memory have very less space.

* RAM (Primary Memory).
→ Primary Memory
→ Volatile
→ Semiconductor.

Ram are divided into two types static & Dynamic.
static RAM are made from use of flip- flop.

BIOS - Basic Input. Output System Programme
BIOS is also known as boot step lodder.