03.07.18

Chapter-1

Number System.

1. Binary Number System
2. Decimal " "
3. Octal " "
4. Hexadecimal " "
   (Hex)

2. Decimal → 0, 1, 2, ... 9

$356 = 3\times100 + 5\times10 + 6\times1$

$= \underbrace{3\times10^2 + 5\times10^1 + 6\times10^0}_{\text{weights}}$

Base or radix of decimal no. system = 10

1. Binary ⇒ 0 and 1

   Base of no is 2.

3. Octal ⇒ 0, 1, 2, 3, 4, 5, 6, 7

   Base of system is 8

4. Hexadecimal ⇒ 0, 1, 2, .. 10, 11, 12, 13, 14, 15.
   A B C D E F

   Base of system is 16.

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conversion

1. of decimal base 10

Binary (repeated division by 2)

octal (repeated div by 8)

Hex. (repeated ÷ by 16)

2	356	
2	178	0
2	89	0
2	44	1
2	22	0
2	11	0
2	5	1
2	2	1
	1	0

8	356	
8	44	4
	5	4

$(544)_8$

16	356	
16	22	4
	1	6

$(164)_{16}$

Resultant

Binary value $\Rightarrow (101100100)_2$

Octal value $\Rightarrow (544)_8$

Hex value $\Rightarrow (164)_{16}$

2. 356.87

.87

To binary :-

$0.87 \times 2 = 1.74$

$0.74 \times 2 = 1.48$

$0.48 \times 2 = 0.96$

$0.96 \times 2 = 1.92$

$0.92 \times 2 = 1.84$

$0.84 \times 2 = 1.68$

1. Take only decimal value repeatedly
2. Take the integer value from top to bottom

$356.87 \Rightarrow$ binary $\Rightarrow (101100100.110111)_2 \ldots$

To octal

.8

0.87

0.96

0.68

To hex

.87

0.87

0.92

0.72

0.52

CONVERSI

(11011

To octal

.87.

$0.87 \times 8 = 6.96$ upto 5 values.

$0.96 \times 8 = 7.68$

$0.68 \times 8 = 5.44$

$\Rightarrow (544.675)_8$

To hex

.87

$0.87 \times 16 = 13.92 \Rightarrow D.92$

$0.92 \times 16 = 14.72 \Rightarrow E.72$

$0.72 \times 16 = 11.52 \Rightarrow B.52$

$0.52 \times 16 = 8.32 \Rightarrow 8.32$

$\Rightarrow (164.DEB8)_{16}$

CONVERSION OF BINARY TO DECIMAL.

$(110110)_2 \Rightarrow (\;54\;)_{10}$ [decimal]

$0 \times 2^0 = 0$

$+$

$1 \times 2^1 = 2$

$+$

$1 \times 2^2 = 4$

$+$

$0 \times 2^3 = 0$

$+$

$1 \times 2^4 = 16$

$+$

$1 \times 2^5 = 32$

54

CONVERSION OF BINARY TO OCTAL.

1.Q) $(110110)_2 = (66)_8$

MSB ↓ ... ↓ LSB

① start from least significant bit [last value] (or) LSB

MSB ⇒ Most significant bit

② Group it in terms of 3 from right (LSB)

OCTAL IN BINARY :-

0 — 000
1 — 001
2 — 010
3 — 011
4 — 100
5 — 101
6 — 110
7 — 111

2.Q) $(001101111101)_2 = (1575)_8$

CONVERSION OF BINARY TO HEXA DECIMAL.

8 4 2 1 → weight of binary

Group into 4

0 — 0000
1 — 0001
2 — 0010
3 — 0011
4 — 0100
5 — 0101
6 — 0110
7 — 0111
8 — 1000
9 — 1001
A — 1010
B — 1011
C — 1100
D — 1101
E — 1110
F — 1111

19) $(0110110)_2 = (36)_{16}$

20) $0\,(0011\,0111\,1101)_2 = (37D)_{16}$

I. convert the following numbers to DECIMAL

1. 10110.0101
2. $(16.5)_{16}$
3. $(26.24)_8$
4. $(DADA.B)_{16}$

1. 10110.0101

$0 \times 2^0 \longrightarrow 0$

$1 \times 2^1 \longrightarrow 2$

$1 \times 2^2 \longrightarrow 4$

$0 \times 2^3 \longrightarrow 0$

$1 \times 2^4 \longrightarrow 16$

$\overline{22}$

.0101

$0/2^0 \quad 0/2^1 \quad 0/2^2 \quad 1/2^3$

$\frac{1}{2} + \frac{1}{?}$

22.3125

0.0101

0×2^{-1}

$1 \times 2^{-2} \longrightarrow \frac{1}{4}$

0×2^{-3}

$1 \times 2^{-4} = \frac{1}{16}$

$22 + 1/16 + 1/4 = (22.3125)_{10}$

2. $(16.5)_{16}$ to decimal

$6 \times 16^0 = 6$

$1 \times 16^1 = 16$

$0.5 \times 16^{-1} = 5/16$

$\Rightarrow 6 + 16 + 5/16 = (22.3125)_{10}$

3. $(26.24)_8$

$\rightarrow 6 \times 8^0 \rightarrow 6$

$\rightarrow 2 \times 8^1 \rightarrow 16$

0.24

$\rightarrow 2 \times 8^{-1} = 2/8$

$\rightarrow 4 \times 8^{-2} = 4/64$

$\Rightarrow 6 + 16 + 2/8 + 4/64$

$= 22 + 20/64 = 22 + 5/16 = (22.3125)_{10}$

4. $(DADA.B)_{16}$

DADA . B

$13 \times 16^1 \quad 10 \times 16^0 \quad 11 \times 16^{-1}$

10×16^2

13×16^3

$\Rightarrow 53248 + 2560 + 208 + 10 + 0.6875$

$= (56026.6875)_{10}$

6.7.18

1. 011011110110

to decimal.

1 1 0 1 1 1 1 0 1 1 0

$0 \times 2^0 = 0$

$1 \times 2^1 = 2$

$1 \times 2^2 = 4$

$0 \times 2^3 = 0$

$1 \times 2^4 = 16$

$1 \times 2^5 = 32$

$1 \times 2^6 = 64$

$1 \times 2^7 = 128$

$0 \times 2^8 = 0$

$1 \times 2^9 = 512$

$1 \times 2^{10} = 1024$

1782

$(1782)_{10}$.

TO hexa decimal $\rightarrow (6F6)_{16}$, To octal $(3366)_8$

⇓

0110 1111 0110

$(6F6)_{16}$

⇓

$(3366)_8$

011 011 110 110

BINARY CODES

ASCII → American Standard code for Information Interchange.

$\boxed{8421}$ → Binary code ⇒ 0 to 15 → hexadecimal

84-2-1

2421

BCD

Gray

Biquinary

Excess-3

Binary coded Decimal WEIGHTED CODES ~~Binary coded decimal~~

	BCD (~~8421~~, 8 4 2 1)	84-2-1	2421 (~~84-2-1~~ → 8)	Excess 3 (Non Weighted) +3 to BCD		Biquinary Bi 50
0	0000	0000	0000	0011	0	01
1	0001	0111	0001	0100	1	01
2	0010	0110	0010	0101	2	01
3	0011	0101	0011	0110	3	01
4	0100	0100	0100	0111	4	01
5	0101	1011	1011	1000	5	10
6	0110	1010	1100	1001	6	10
7	0111	1001	1101	1010	7	10
8	1000	1000	1110	1011	8	10
9	1001	1111	1111	1100	9	10

- Gray code [Non weighted codes]

Reflected code (or) Unit distance code (or) cyclic

(0 to 15)

	Gray code
0	0000
1	0001
2	0011
3	0010
4	0110
5	0111
6	0101
7	0100
8	1100
9	1101
10	1111
11	1110
12	1010
13	1011
14	1001
15	1000

reflected o/p

Excess-3

0011

~~0010~~ 0100

1011

1100

1101

1110

1111

$\boxed{0}$10

1 10

Sign magn...

+13 } sign (0)

-13 } (1)

no...

13 00...

+13 00...

-13 1 0...

MSB a...

(Non Weighted)

• Excess 3

+3 to BCD

0011
0100
0101
0110
0111
1000
1001
1010
1011
1100

Biquinary (Weighted)

	Bi 50	quinary 43210
0	01	00001
1	01	00010
2	01	00100
3	01	01000
4	01	10000
5	10	00001
6	10	00010
7	10	00100
8	10	01000
9	10	10000

Finding of ones parity.

$\boxed{0}$1011000 → no of 1s is 3
odd parity

1 1011000 → no of 1s is 4
even parity.

Signed Numbers / Integers.

Decimal
- 9's (Diminished radix)
- 10's (Radix)

Sign magnitude form

+13 → (0)
signed nos
−13 → (1)

13 00001101

+13 00001101

−13 10001101

MSB add(1)

[can be of 8 (or) 5 bit]

One's complement (Diminished Radix comp)

+ → same

− → take complement
1→0, 0→1

00001101

00001101

11110010

Two's complement (Radix)

− → take complement
1→0, 0→1
add +1.

```
  11110010
+        1
----------
  11110011
```

00001101

00001101

11110010

[In computers subtraction is done in 2's complement]

BINARY ADDITION

A	B	CY (→carry)
0	0	00
0	1	00
1	0	00
1	1	10

TRUTH TABLE

10+1 => 11

1Q)

```
  1 1 1
  1 0 1 1
  1 1 1 1
 ---------
 1 1 0 1 0
```

summation is more than the required bit it is called as **CARRY**

2Q)

```
  1
  1 1 0 1
  1 1 0 1
  1 1 0 1
 ---------
 1 0 0 1 1 1
```

```
2 | 25
2 | 12 - 1
2 |  6 - 0
2 |  3 - 0
     1 - 1
```

8 4 2 1
1 1 1 1

1-Q)

	sign Mag.	1's comp	2's comp
25	00011001		
+25	00011001	00011001	00011001
-25	10011001	~~00011010~~ 11100110 +1	11100111

BINARY SUBTRACTION

```
   0 10
   1 0  1 1
(-) 1 1 0 1
-----------
    1 1 0 1
-----------
```

By 2's comp method.

```
13 →    1101   ⟶   1101
11 → −  1011       0101
                 --------
                  10010
                 --------
```

Steps

1. first no. take as it is
2. 2nd no take 2's comp
3. add both

1's comp

```
     0100
   +    1
   ------
2's comp  0101
   ------
```

```
  11     1011      1011
− 13     1101      0011
                  ------
                  11010 → 2's
                  ------
```

```
~~0010~~
  0001
 +   1
 -----
  0010
 -----
```

LOGIC GATES

AND $y = A \cdot B$

OR $y = A + B$ [diff from binary addition]

NOT $y = \bar{A}$

Basic gates

NAND $y = \overline{A \cdot B}$ NOT + AND

NOR $y = \overline{A + B}$ NOT + OR

Universal gates

XOR $y = A \oplus B \Rightarrow \bar{A}B + B\bar{A}$

X NOR $y = A \odot B \Rightarrow AB + \bar{A}\bar{B}$

Both are complementary to each other.

$$\overline{A \oplus B} = A \odot B$$

$$\overline{A \odot B} = A \oplus B$$

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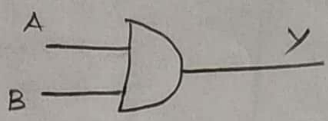
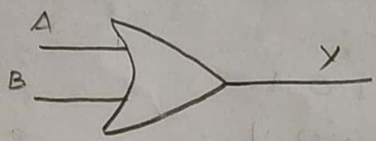
Symbols

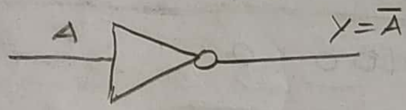
AND



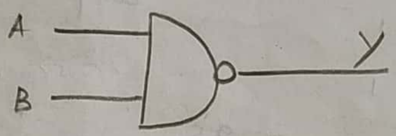
OR



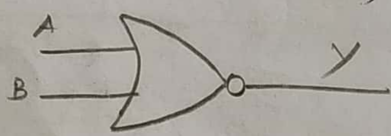
NOT



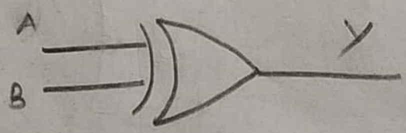
NAND



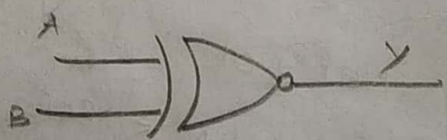
NOR



XOR



XNOR



10.7.18

Logic gates.

AND = $Y = A \cdot B$

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

XOR

A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

OR

A	B	$Y = A + B$
0	0	0
0	1	1
1	0	1
1	1	1

XNOR

A	B	$Y = A \odot B$
0	0	1
0	1	0
1	0	0
1	1	1

Inverter (NOT)

A	Y = $\overline{A}$
0	1
1	0

NAND

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

NOR

A	B	$Y = \overline{A + B}$
0	0	1
0	1	0
1	0	0
1	1	0

AND laws:-

$A \cdot 0 = 0$

$A \cdot 1 = A$

$A \cdot A = A$

$A \cdot \bar{A} = 0$

OR laws:-

$A + 0 = A$

$A + 1 = 1$

$A + A = A$

$A + \bar{A} = 1$

Double Inversion law:-

$(A')'$ $\bar{\bar{A}} = A$

Commutative laws:-

$AB = BA$

$A+B = B+A$

Associative laws:-

$A(BC) = (AB)C$

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

Distributive laws:-

$A(B+C) = AB + AC$

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

Absorption law :

$A(A+B) = A$

$A + AB = A$

$A \cdot A + A \cdot B$
$= A + A \cdot B$
$= A(1+B)$
$= A$

De Morgan's law :

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

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

Boolean expression.

$Y = A'B + BCD$

individuals are called as literals

Reduction of Boolean Expression.

1. Boolean laws (simple)
2. Karnaugh Map. (complicated)
3. Tabulation method . (V. complicated)

I. Use Boolean laws & reduce the expression.

1. $xy + xy'$
2. $xyz + x'y + xyz'$
3. $(a+b+c')(a'b'+c)$

Answers.

1. $xy + xy'$
$x(y+y') = x \cdot 1$
$= x$

2. $xyz + x'y + xyz'$
$= xy(z+z') + x'y$
$= xy + x'y$
$= y(x+x')$
$= y \cdot 1 = y$

3. $(a+b+c')(a'b'+c)$

$= aa'b' + a'b'b + a'b'c + ac + bc + \underbrace{c'c}_{0}$

$= 0 + 0 + a'b'c' + ac + bc$

$= a'b'c' + ac + bc$ //

4. $(BC' + A'D)(AB' + C'D')$

$= \underbrace{AB'\cancel{B}C'}_{0} + \underbrace{BC'\cancel{C}D'}_{0} + \underbrace{AA'\cancel{D}B'}_{0} + \underbrace{A'D\cancel{C}D'}_{0}$

$= 0$

5. $A'B(D' + C'D) + B(A + A'CD)$

$= A'BD' + \underline{A}'BC'\underline{D} + BA + B\underline{A}'C\underline{D}$

$= \cancel{A'D(BC' +}$

$= A'BD(C' + C) + A'BD' + BA$

$= A'BD + A'BD' + BA$

$= A'B(D + D') + BA$

$= A'B + BA$

$= B(A + A')$

$= B$

6. $(A'+C)(A'+C')(A+B+C'D)$ $\quad A'(B+C'D)$

4 lit

$= (A'A' + A'C' + CA' + \cancel{C}C')(A + B + C'D)$

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

$= A'(\cancel{A'A} + A'B + A'C'D + C'A + C'B + C'C'D + AC + CB + C\cancel{C}'D)$

$= A'(A'B + \underline{A'C'D} + C'A + C'B + C'C'D + AC + CB)$

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

$= A'[B + A + C'C'D + A'C'D + A'B]$

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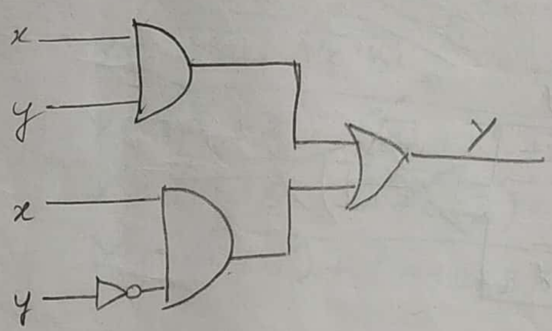
$(A' + CC')(A + B + C'D)$

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

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

Implementation using Logic gates.

$Y = xy + xy'$

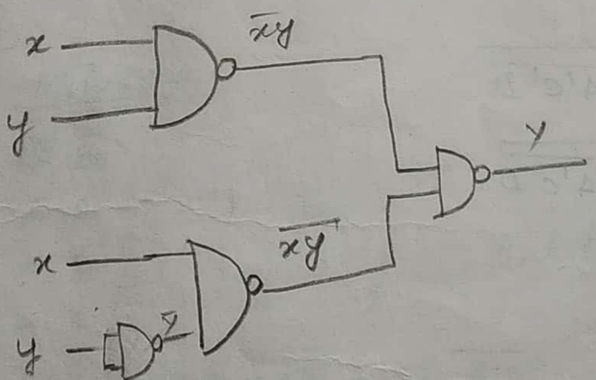


NAND

$Y = \overline{\overline{Y}} = \overline{\overline{xy + xy'}}$

$= \overline{\overline{xy} \cdot \overline{xy'}}$

NAND ⟺ NOR



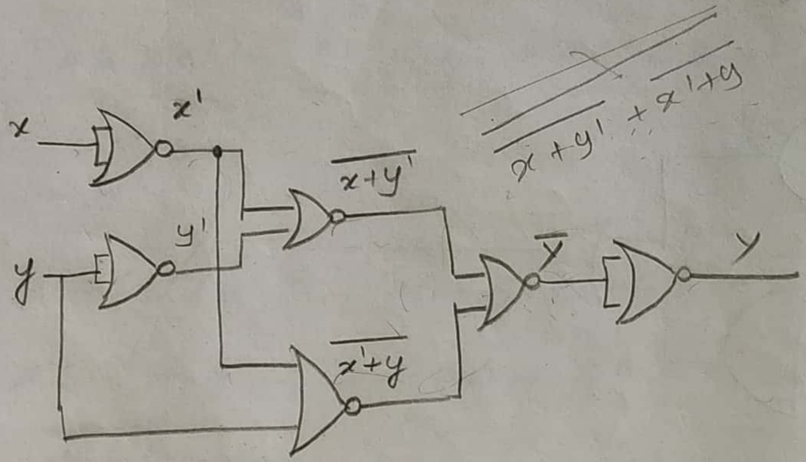
NOR.

[avoid multiplication]

$$Y = \overline{\overline{xy} \cdot \overline{xy'}}$$

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

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



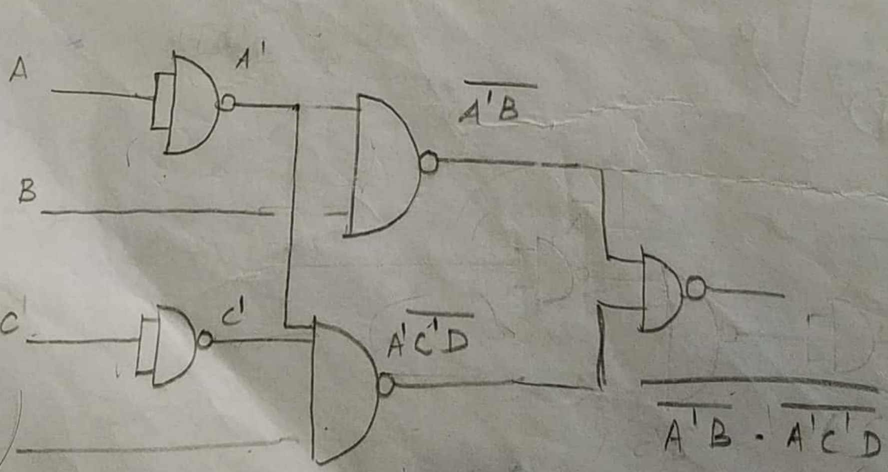
A'(B+C'D) only NAND and only NOR.

⇒ only NAND

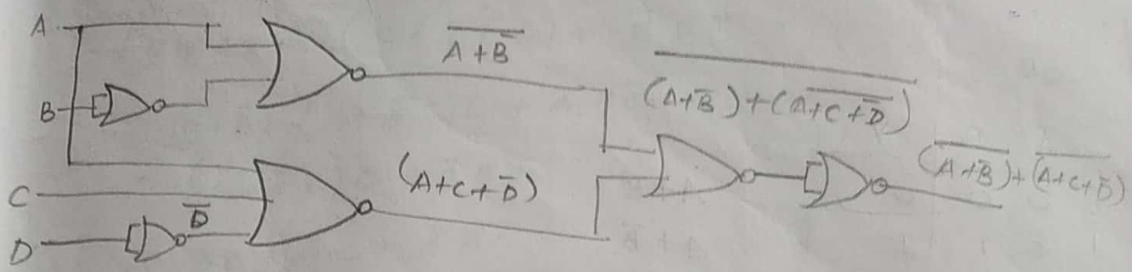
$$Y = A'B + A'C'D$$

$$Y = \overline{\overline{Y}} = \overline{\overline{A'B + A'C'D}}$$

$$= \overline{\overline{A'B} \cdot \overline{A'C'D}}$$



only NOR



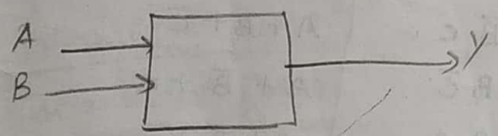
$$Y = \overline{\overline{A'B} \cdot \overline{A'C'D}}$$

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

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

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

13.07.18 **Maxterms and Minterms.**



OR

A	B	Y	
0	0	0	0
0	1	1	1
1	0	1	2
1	1	1	3

Min term:

$\bar{A}\ \bar{B}$

$\bar{A}\ B$

$A\ \bar{B}$

$A\ B$

0 → complemented
> $\bar{A}$ (or) $\bar{B}$

canonical form → A (or) B

$Y = \bar{A}B + A\bar{B} + AB$ (sum of pdts)

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

$= B + A\bar{B}$

$= (B+A)\ \cancel{(B+\bar{B})}$, 1

$= A+B$ → standard form.

→ consider only ones

Maxterms:

Sum of literals/variables

$0 \rightarrow A$ uncomplemented

$1 \rightarrow \bar{A}$ complemented (or) $\bar{B}$

OR

	A	B	y	
0	0	0	0	$A+B$
1	0	1	1	$A+\bar{B}$
2	1	0	1	$\bar{A}+B$
3	1	1	1	$\bar{A}+\bar{B}$

$Y = A+B$ (prdt of sum)

→ consider zeros.

Q)

	A	B	C	y	Min	Max
0	0	0	0	0	$\bar{A}\bar{B}\bar{C}$	$A+B+C$
1	0	0	1	1	$\bar{A}\bar{B}C$	$A+B+\bar{C}$
2	0	1	0	1	$\bar{A}B\bar{C}$	$A+\bar{B}+C$
3	0	1	1	1	$\bar{A}BC$	$A+\bar{B}+\bar{C}$
4	1	0	0	0	$A\bar{B}\bar{C}$	$\bar{A}+B+C$
5	1	0	1	0	$A\bar{B}C$	$\bar{A}+B+\bar{C}$
6	1	1	0	0	$AB\bar{C}$	$\bar{A}+\bar{B}+C$
7	1	1	1	1	ABC	$\bar{A}+\bar{B}+\bar{C}$

$$Y = \bar{A}\bar{B}C + \underline{\bar{A}B\bar{C}} + \underline{\bar{A}BC} + \underline{ABC}$$

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

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

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

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

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

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

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

$\rightarrow A$ uncomplemented
$\rightarrow \bar{A}$ complemented (or) $\bar{B}$

Max:

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

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

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

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

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

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

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

$$\boxed{=BC+\bar{A}B+\bar{A}C.} \rightarrow \text{std form sum of pdt}$$

Max:

$$\boxed{(A+B+C)(\bar{A}+B+C)(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+C)} \rightarrow \text{canonical [pdt of max terms]}$$

1. canonical form:
   - → sum of minterms. [all the variables are present]
   - → Product of max terms.
2. standard form
   - sum of products
   - product of sums.

Q.

$y=(A+A\bar{B}) \rightarrow$ sum of pdt [std form]

missing terms B means take $B+\bar{B}$

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

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

$$=AB+A\bar{B} \rightarrow \text{sum of min terms [canonical form]}$$

$$=\Sigma(2,3)$$

2. $Y = BC + \bar{A}B + \bar{A}C$ → sum of pdt

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

$= BCA + BC\bar{A} + \bar{A}BC + \bar{A}B\bar{C} + \bar{A}CB + \bar{A}C\bar{B}$

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

$= \Sigma m(1, 2, 3, 7)$

$\Pi m = [(A+B+C)(\bar{A}+B+C)(\bar{A}+B+\bar{C})(\bar{A}+\bar{C}+\bar{B})]$

3. $Y = (\bar{A}+\bar{B})(A+B+\bar{C})(\bar{B}+C)$ → pdt of sum

missing variable → $C\bar{C} \Rightarrow 0$

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

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

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

$= \Pi M(1, 2, 6, 7)$

Q.4. $Y = (c'+d)(b+c')$

5. $Y = (b+cd)(c+bd)$

4. $Y = (c'+d)(b+c')$

$= \cancel{b\bar{b}+c}$

$= (\bar{c}+d+b\bar{b})(b+\bar{c}+d\bar{d})$

$= (\bar{c}+d+b)(\bar{c}+d+\bar{b})(b+\bar{c}+d)(b+\bar{c}+\bar{d})$

$= \underbrace{(b+\bar{c}+d)}_{2}\underbrace{(\bar{b}+\bar{c}+d)}_{6}\underbrace{(b+\bar{c}+d)}(b+\bar{c}+\bar{d})$ 3

$= \Pi m(2, 3, 6)$

$= \Sigma m = (0, 1, 4, 5, 7)$

5. $Y = (b+c$

$Y = (\cancel{bc}$

$= (b+c)$

$= (b+c$

$= (b+c+c$

$(\bar{b}+$

$= \pi($

$= \Sigma(3$

6. convert

6. convert

i) $f(x, y, z)$

(ii) $F(A,$

5. $y = (b+cd)(c+bd)$

$y = \cancel{\left(b(c+\bar{c})(d+\bar{d}) + cd(b+\bar{b})\right)}.$

$\cancel{\left((b+\bar{b})c(d+\bar{d}) + (c+\bar{c})bd\right)}$

$= (b+c)(b+d)(c+b)(c+d)$

$= (b+c+d\bar{d})(b+d+c\bar{c})(c+b+d\bar{d})(c+d+b\bar{b})$

$= \underset{0}{(b+c+d)}\,(b+c+\bar{d})\,\cancel{(b+c+d)}\,\underset{2}{(b+\bar{c}+d)}$

$\quad \cancel{(b+c+d)}\,(b+c+\bar{d})\,\cancel{(b+c+d)}\,\underset{4}{(\bar{b}+c+d)}$

$= \pi(0,1,2,4)$

$= \Sigma(3,5,6,7) = \pi(0,1,2,4)$

6. ~~convert~~

6. convert to other canonical form. 0 – 8

(i) $f(x,y,z) = \Sigma(1,3,5) \Rightarrow \pi(0,2,4,6,7,\cancel{8})$

$f(xyz) = (\underset{1}{\bar{x}\bar{y}z} + \underset{3}{\bar{x}yz} + \underset{5}{x\bar{y}z})$

(ii) $F(A,B,C,D) = \pi(3,5,8,11)$

$= \Sigma(0,1,2,4,6,7,9,10,12,13,14,15)$

$\pi \Leftrightarrow \Sigma$

complemental to each other

~~F(A,B,C,D)~~ $= \pi(3,5,8,11)$

Karnaugh Map (K-Map)

Variables-

A → MSB
B → LSB.

1) 2

$A \backslash B$	$\bar{B}$ (0)	B (1)
(0) $\bar{A}$	$\bar{A}\bar{B}$ 0	$\bar{A}B$ 1
(1) A	$A\bar{B}$ 2	AB 3

00
01
10
11

⇒ 2 variable K map

Q)

Truth table:

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

$A \backslash B$	0	1
0		1
1	1	1

min term. → ②

↓ ①

STEPS:

[consider adjacent one's]

⇒ only in vertical (or) horizontal way.

⇒ consider in powers of 2

(ie) 1, $\underbrace{2, 4, 8, 16}$ ....

⇒ group the higher no of adjacent one's.

① → A

② → B

Y = A+B

1			1
1		1	1

due to folding & combinations are possible ←

$F = \bar{C} + AB$

3 Variable form

[adjacent box → 1 bit variation]

AB \ C		

(or)

A \ BC	00	01	11	10
0 ($\bar{A}$)	$\bar{A}\bar{B}\bar{C}$ 0	$\bar{A}\bar{B}C$ 1	$\bar{A}BC$ 3	$\bar{A}B\bar{C}$ 2
1	$A\bar{B}\bar{C}$ 4	$A\bar{B}C$ 5	ABC 7	$AB\bar{C}$ 6

Q)

	A	B	C	Y
0	0	0	0	0
1	0	0	1	1
2	0	1	0	1
3	0	1	1	1
4	1	0	0	0
5	1	0	1	0
6	1	1	0	0
7	1	1	1	1

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
0	0	1 (1)	1 (3)	1 (2)
1	4	5	1 (7)	6

$$\boxed{Y = \bar{A}C + \bar{A}B + BC}$$

1. $F(x,y,z) = \Sigma(3,4,5,7)$

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	0	1	1 (3)	2
A 1	1 (4)	1 (5)	1 (7)	6

$$Y = BC + \overset{AC}{\cancel{AC}} + A\bar{B} + \cancel{AC}$$

including or excluding gives the same value

$\boxed{5 \quad 7}$ → redundant term

[not necessary]

4 Variable Map — 16 square boxes.

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	1 (0)	(1)	(3)	1 (2)
$\bar{A}B$ 01	1 (4)	(5)	1 (7)	(6)
AB 11	(12)	(13)	1 (15)	(14)
$A\bar{B}$ 10	1 (8)	(9)	(11)	1 (10)

$$Y = \bar{B}\bar{D} + \bar{A}\bar{C}\bar{D} + BCD.$$

17.07.18

Reduce the boolean expression using k-map.

1. $F(A,B,C,D) = \Sigma(0,1,3,5,7,8,9,11,13,14,15)$

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
00	1 (0)	1 (1)	1 (3)	(2)
01	(4)	1 (5)	1 (7)	(6)
11	(12)	1 (13)	1 (15)	1 (14)
10	1 (8)	1 (9)	1 (11)	(10)

$$Y = \bar{B}\bar{C} + D + ABC$$

2. $F(A,B,C,D) = \prod(5,6,7,9,10,11,13,15)$

$= \sum(0,1,2,3,4,8,12,14)$

AB \ CD	00	01	11	10
00	1 (0)	1 (1)	1 (3)	1 (2)
01	1 (4)	0 (5)	0 (7)	0 (6)
11	1 (12)	0 (13)	0 (15)	1 (14)
10	1 (8)	0 (9)	0 (11)	0 (10)

0000 — 0
0001 — 1
0010 — 2
0011 — 3
0100 — 4
0101 — 5
0110 — 6
0111 — 7
1000 — 8
1001 — 9
1010 — 10
1011 — 11
1100 — 12
1101 — 13
1110 — 14
1111 — 15

$= \cancel{\bar{A}\bar{B} + \bar{C}\bar{D} + AB\bar{D}}$

$= \cancel{BD + AD + A\bar{B}C + \bar{A}BC}$

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

3. $F(w,x,y,z) = w\bar{x}y + \bar{x}\bar{y}\bar{z} + y\bar{z} + \bar{w}\bar{z}$

wx \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{w}\bar{x}$ 00	1 (0)	(1)	(3)	1 (2)
$\bar{w}x$ 01	1 (4)	(5)	(7)	1 (6)
wx 11	(12)	(13)	(15)	1 (14)
$w\bar{x}$ 10	1 (8)	(9)	1 (11)	1 (10)

$\cancel{y = \bar{w}}$

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

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

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

$= w\bar{x}yz + w\bar{x}y\bar{z} + \bar{x}\bar{y}\bar{z}w + \bar{x}\bar{y}\bar{z}\bar{w} + (xw + x\bar{w} + \bar{x}w + \bar{x}\bar{w})y\bar{z} + \bar{w}\bar{z}(xy + x\bar{y} + \bar{x}y + \bar{x}\bar{y})$

$= w\bar{x}yz + w\bar{x}y\bar{z} + \bar{x}\bar{y}\bar{z}w + \bar{x}\bar{y}\bar{z}\bar{w} + xwy\bar{z} + x\bar{w}y\bar{z} + \bar{x}wy\bar{z} + \bar{x}\bar{w}y\bar{z} + \bar{w}\bar{z}xy + \bar{w}\bar{z}x\bar{y} + \bar{w}\bar{z}\bar{x}y + \bar{w}\bar{z}\bar{x}\bar{y}$

11, 5, 8, 0, 14, 6, 10, 2, 6, 4, 2, 0

(0, 2, 4, 6, 6, 8, 10, 11, 14)

4. $F = \Sigma(1,2,3,5,6,7,9,11,12,13,15)$

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	(0)	1 (1)	1 (3)	1 (2)
$\bar{A}B$ 01	(4)	1 (5)	1 (7)	1 (6)
AB 11	1 (12)	1 (13)	1 (15)	(14)
$A\bar{B}$ 10	(8)	1 (9)	1 (11)	(10)

$Y = D + \bar{A}C + AB\bar{C}$

20/08/18.

K-map with don't care "X".

1. F (   ) $= \Sigma m(2,5,7,9,11,12,14) + \Sigma d(3,4,6)$

don't care 'X'

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	(0)	(1)	X (3)	1 (2)
$\bar{A}B$ 01	X (4)	1 (5)	1 (7)	X (6)
AB 11	1 (12)	(13)	(15)	1 (14)
$A\bar{B}$ 10	(8)	1 (9)	1 (11)	(10)

X → may be 1 (or) 0

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

2.Q)

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

3Q. $F(ABCD) = \Sigma(0,6,8,13,14)$ -
$D(ABCD) = \Sigma(2,4,10)$

2Q). $F = \bar{x}yz + x\bar{y}\bar{z} + x\bar{y}z$

$x \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	1 1	1 3	2
x 1	1 4	1 5	7	6

$Y = x\bar{y} + \bar{x}yz$

3Q)

$AB \backslash CD$	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	1 0	1	3	X 2
$\bar{A}B$ 01	X 4	5	7	1 6
AB 11	12	1 13	15	1 14
$A\bar{B}$ 10	1 8	9	11	X 10

~~15, 18~~

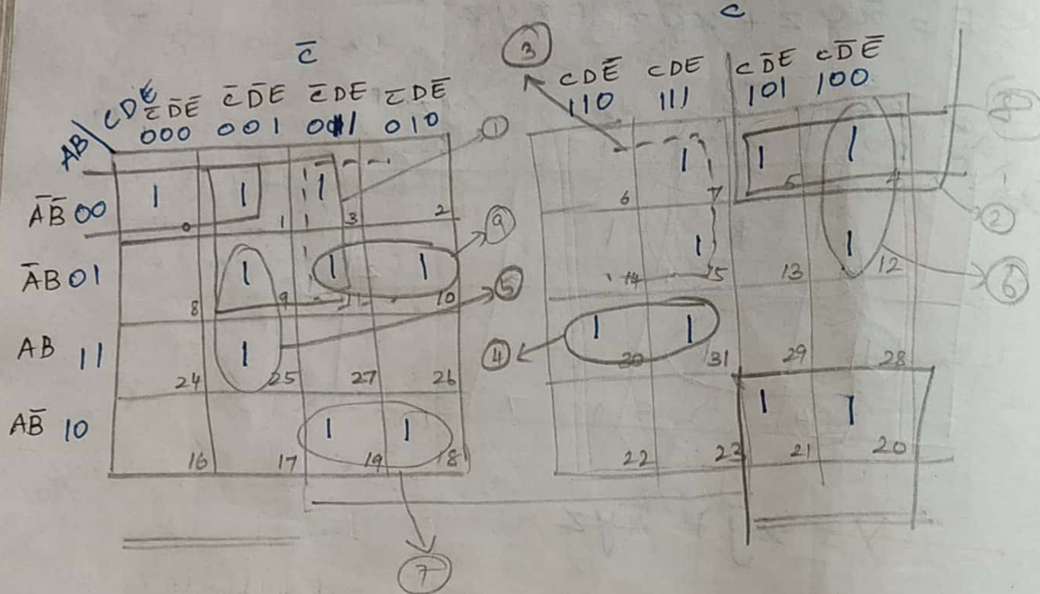
No need to map all x.

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

$Y = AB\bar{C}D + \bar{B}\bar{D} + \cancel{\bar{A}\bar{D}} + C\bar{D}$

5 VARIABLE MAP. (0-31)

Q. $F = \Sigma(0, 1, 3, 4, 5, 7, 9, 10, 11, 12, 15, 18, 19, 20, 21, 25, 30, 31)$



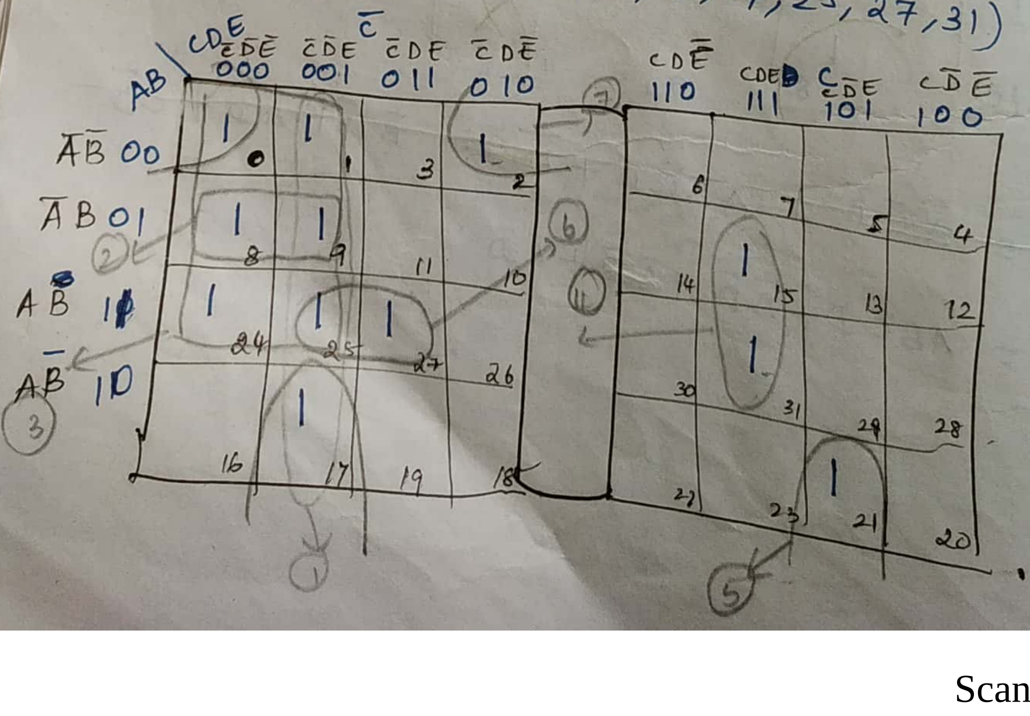
$$F = \bar{A}\bar{C}E + \bar{A}\bar{B}\bar{D} + \bar{A}DE + ABCD + B\bar{C}\bar{D}E + \bar{A}C\bar{D}\bar{E} + A\bar{B}\bar{C}D + \bar{B}C\bar{D} + \bar{A}B\bar{C}D$$

TABULATION METHOD

(Quine McKluskey Method)

5 Variable

Q). $F = \Sigma(0, 1, 2, 8, 9, 15, 17, 21, 24, 25, 27, 31)$



$F = \cancel{\bar{C}D\bar{E}} + \bar{A}$

(Q

Q.

Total 6 groups

0
1
2
8
9
17
24
21
25
15
27
31

Iteration

$F = \cancel{CDE} + \bar{A}\bar{C}\bar{D} + B\bar{C}\bar{D} + BCDE + A\bar{B}\bar{D}E + AB\bar{C}\bar{E} +$
$\bar{A}\bar{B}\bar{C}\bar{E}$

TABULATION METHOD

(Quine Mccluskey Method)

[consider the highest number
→ convert into binary
→ group with no of one
(—) → dont care symbol

Q.

Total 6 groups

	A	B	C	D	E	
0	0	0	0	0	0	✓
1	0	0	0	0	1	✓
2	0	0	0	1	0	✓
8	0	1	0	0	0	✓
9	0	1	0	0	1	✓
17	1	0	0	0	1	✓
24	1	1	0	0	0	✓
21	1	0	1	0	1	
25	1	1	0	0	1	✓
15	0	1	1	1	1	✓
27	1	1	0	1	1	✓
31	1	1	1	1	1	✓

Iteration -1

(0,1) 0000—
(0,2) 000—0
(0,8) 0—000
(1,9) 0—001
(1,17) —0001
(8,9) 0100—
(8,24) —1000
(9,25) —1001
(17,21) 10—01
(17,25) 1—001
(24,25) 1100—
(25,27) 110—1
(15,31) —1111
(27,31) 11—11

Iteration -2

Iteration - 1		Iteration 2	
(0,1)	0000 - ✓	(0,1,8,9)	0 _ 00 _
	A B C D E	~~(0,8,1,9)~~	~~0 _ 00 _~~
(0, 2)	000 - 0	(1,9,17,25)	- - 001
(0, 8)	0 - 000 ✓	~~(1,17,9,25)~~	~~- - 001~~
(1, 9)	0 - 001 ✓	(8, 9,24,25)	_ 100 _
(1, 17)	- 0001 ✓	~~(8,24,9,25)~~	~~_ 100 _~~
(8, 9)	0100 - ✓		
(8, 24)	- 1000		
(9,25)	_ 1001 ✓		
(17,21)	10 _ 01		
(17,25)	1 - 001 ✓		
(24,25)	1100 -		
(25,27)	110 _ 1		
(15,31)	_ 1111		
(27, 31)	11 - 11		

Prime Implicants)

(0,2) $\bar{A}\,\bar{B}\,\bar{C}\,\bar{E}$

(17, 21) $A\,\bar{B}\,\bar{D}\,E$

(25,27) $A\,\bar{B}\,\bar{C}\,E$

(15, 31) $B\,C\,D\,E$

(27, 31) $A\,B\,D\,E$

(0, 1, 8, 9) $\bar{A}\,\bar{C}\,\bar{D}$

(1, 9, 17, 25) $\bar{C}\,\bar{D}\,E$

(8, 9, 24, 25) $B\,\bar{C}\,\bar{D}$

P. Implicants	Minterm	0 ✓	1 ?	2 ✓	8 ✓	9 ✓	15 ✓	17 ✓	21 ✓	24 ✓	25 ✓	27 ?	31 ✓
$\bar{A}\bar{B}\bar{C}\bar{E}$	(0,2) ⊙	X	*	X									
$A\bar{B}\bar{D}E$	(17,21) ⊙							X	X				
$A\bar{B}\bar{C}E$	(25,27)										X	X	
$BCDE$	(15,31) ⊙						X						X
$ABDE$	(27,31)											X	X
$\bar{A}\bar{C}\bar{D}$	(0,1,8,9)	X	X		X	X							
$\bar{C}\bar{D}E$	(1,9,17,25)		X			X		X			X		
$B\bar{C}\bar{D}$	(8,9,24,25) ⊙				X	X				X	X		

$$P = \bar{A}\bar{B}\bar{C}\bar{E} + A\bar{B}\bar{D}E + BCDE + A\bar{B}\bar{C}E + \bar{A}\bar{C}\bar{D} + B\bar{C}\bar{D}$$

steps

1. single entry from each column should be selected as essential P.I
2. They have to be marked & put a tick mark
3. their min terms are selected and ticked [on the top]
4. The left over values are denoted as (?) [ie] 1, 27

Scanned by CamScanner

2. $F = \Sigma(1, 3, 4, 5, 10, 11, 12, 13, 14, 15)$

	A	B	C	D
1	0	0	0	1
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

[separate according to no of 1's]

	A	B	C	D
✓1	0	0	0	1
✓4	0	1	0	0
✓3	0	0	1	1
✓5	0	1	0	1
✓10	1	0	1	0
✓12	1	1	0	0
✓11	1	0	1	1
✓13	1	1	0	1
✓14	1	1	1	0
✓15	1	1	1	1

Iteration-I (A B C D)

- (1,3) 00–1
- (1,5) 0–01
- (4,5) 010– ✓
- (4,12) –100 ✓
- (3,11) –011
- (5,13) –101 ✓
- (10,11) 101– ✓
- (10,14) 1–10 ✓
- (12,13) 110– ✓
- (12,14) 11–0 ✓
- (11,15) 1–11 ✓
- (13,15) 11–1 ✓
- (14,15) 111– ✓

Iteration-2 (A B C D)

- (4,5,12,13) –10–
- ~~(4,12,5,13) –10–~~
- (10,11,14,15) 1–1–
- ~~(10,14,11,15) 1–1–~~
- (12,13,14,15) 11––
- ~~(12,14,13,15) 11––~~

PRIME impli...

(4,5,12,1...

(10,11,14,...

(12,13,14...

(1,3) –

(1,5) –

(3,11)

P.I	Mint...
$\bar{A}\bar{B}D$	(1...
$\bar{A}\bar{C}D$	(...
$\bar{B}CD$	(...
$B\bar{C}$	(...
AC	(...
AB	(...

PRIME implicants.-

$(4, 5, 12, 13) \rightarrow B\bar{C}$

$(10, 11, 14, 15) \rightarrow AC$

$(12, 13, 14, 15) \rightarrow AB$

$(1, 3) \longrightarrow \bar{A}\bar{B}D$

$(1, 5) \longrightarrow \bar{A}\bar{C}D$

$(3, 11) \longrightarrow \bar{B}CD$

1
3
4
5
10
11
12
13
14
15

P.I	Minterm.	? 1	? 3	4	5	10	11	12	13	14	15
$\bar{A}\bar{B}D$	(1, 3)	x	x								
$\bar{A}\bar{C}D$	(1, 5)	x			x						
$\bar{B}CD$	(3, 11)		x				x				
$\boxed{B\bar{C}}$	(4, 5, 12, 13)			x	x			x	x		
$\boxed{AC}$	(10, 11, 14, 15)					x	x			x	x
AB	(12, 13, 14, 15)							x	x	x	x

$\Rightarrow \bar{A}\bar{B}D + B\bar{C} + AC$

27.7.18

HW

Q. $F = (A,B,C,D) = \Sigma m\,(0,6,8,13,14)$

$d\,(A,B,C,D) = \Sigma d\,(2,4,10)$

Follow the same procedure for both Σ

Exclude don't care in PI table.

		Iteration - I	Iteration - 2
0	0000	(0,2) 00_0 ✓	(0,2,4,6) 0__0
2	0010	(0,4) 0_00 ✓	(0,2,8,10) _0_0
4	0100	(0,8) _000 ✓	~~(0,4,2,6) 0__0~~
8	1000	(2,6) 0_10 ✓	
		(2,10) _010 ✓	~~(0,8,2,10) _0_0~~
6	0110	(4,6) 01_0 ✓	(2,6,10,14) __10
10	1010	(8,10) 10_0 ✓	
		(6,14) _110 ✓	~~(2,10,6,14) __10~~
$\boxed{13}$	$\boxed{1101}$	(10,14) 1_10 ✓	
14	1110		

(Neglect the don't care terms in the table)

P.I

$(0,2,4,6) \longrightarrow \bar{A}\bar{D}$

$(0,2,8,10) \longrightarrow \bar{B}\bar{D}$

$(2,6,10,14) \longrightarrow C\bar{D}$

0, ~~2~~, ~~4~~, 6, 8, ~~10~~, 14

P.I	Minterms	0 ✓	6 ✓	8 ✓	14 ✓	13 ✓
$\bar{A}\bar{D}$	(0,2,4,6)	X	X			
$\bar{B}\bar{D}$	(0,2,8,10)	X		X		
$C\bar{D}$	(2,6,10,14)		X		X	
$AB\bar{C}D$	13					X

$AB\bar{C}D + \bar{A}\bar{D} + \bar{B}\bar{D} + C\bar{D}$

7.7.18

Tutorial. on Unit-1.

I.

1. Do the following conversion:

A. convert $(27.315)_{10}$ to binary

B. $(C3DF)_{16}$ to binary

C. $(26.24)_8$ to decimal.

D. $(DADA.B)_{16}$ to decimal.

2. Obtain 1's and 2's complement of the number.

A. 11011010

B. 1010.1101

3. Perform subtraction using 2's complement of the subtrahend

A. 1001 − 110101

B. 101000 − 10101

4. ~~convert~~ Perform the binary equivalent of 49 and 29 (of base 10) using signed 2's complement representation. Then perform

(i) $(-29)+(+49)$

(ii) $(-29)+(-49)$

convert the answer back to decimal and verify the result.

5. convert the binary 110111 0 to gray code.

6. Reduce the boolean expression using boolean law.

A. $(A'+C)(A'+C')(A+B+C'D)$

For the reduced eqn draw circuit using universal gates.

7. Express the function $(cd+b'c+bd')(b+d)$ sum of min terms & pdt of max terms (canonical form)

8. ~~Express~~ convert A. $F(x,y,z) = \Sigma(1,3,5)$ to other canonical form.

B. $F(A,B,C,D) = \Pi(3,5,8,11)$

9. Convert :-

A. $(u+xw)(x+u'v)$ into sum of pdt and pdt of sum (standard form)

10. Reduce using k-map

A. $F(w,x,y,z) = \Sigma(2,3,12,13,14,15)$

B. $F = w'z + xz + x'y + wx'z$

C.

11. Using Tabulation method find the reduced expression

A. $F = \Sigma(1,3,4,5,10,11,12,13,14,15)$

B. $F = \Sigma(5,6,7,12,14,15)$

$d = \Sigma(3,9,11,15)$

Verify the results using k-map.

A. $(27.315$

$2 \mid 27$
$2 \mid 13$ –
$2 \mid 6$ –
$2 \mid 3$ –
$\mid 1$ –

$.315 \times 2$
$.63 \times 2$
$.26 \times 2$
$.52 \times$
$.04 \times$

$(27.31$

B. $((3$

12

12

ANSWERS. for Tutorial on Unit - 1

1. A. $(27.315)_{10} \longrightarrow (11011.01010)_2$

2	27
2	13 - 1
2	6 - 1
2	3 - 0
	1 - 1

$.315 \times 2 = 0.63$

$.63 \times 2 = 1.26$

$.26 \times 2 = 0.52$

$.52 \times 2 = 1.04$

$.04 \times 2 = 0.08$

$(27.315)_{10} \Rightarrow (11011.01010)_2$

B. $(C3DF)_{16}$ to binary.

A	B	C	D	E	F
10	11	12	13	14	15

12 3 13 15

$15 \times 16^0 = 15$

$13 \times 16^1 = 240$

$3\cancel{15} \times 16^2 = 3840$

$1\cancel{0} \times 16^3 =$

12 3 13 15

$15 \times 16^0 = 15$

$13 \times 16^1 = 208$

$3 \times 16^2 = 768$

$12 \times 16^3 = 49,152$

$(50143)_{10}$

(or) $(1100\ 0011\ 1101\ 1111)_2$

c. $(26.24)_8$ to decimal:

26

$6 \times 8^0 \Rightarrow 6$

$2 \times 8^1 \Rightarrow 16$

$\overline{\quad 22 \quad}$

.24

$4 \times 8^{-1} = 0.5$

$2 \times 8^{-2} = 0.03125$

$\overline{\quad 0.53125 \quad}$

$(26.24)_8 = (22.53125)_{10}$

D. $(DADA.B)_{16}$ to decimal:

D A D A . B

$10 \times 16^0 = 10$ $\qquad 11 \times 16^{-1}$

$\qquad\qquad 0.6875$

$13 \times 16^1 = 208$

$10 \times 16^2 = 2560$

$13 \times 16^3 = 53,248$

$\overline{\quad 56,027. \quad}$

$(DADA.B)_{16} = (56027.6875)_{10}$

9-53

1's & 2's con

A. 1101101

1's →

2's →

B. 1010.11

1's →

2's

3. Subtrac

A. 1001

0

(+) 0

0

B. 1010

(+) 0

1

2. 1's & 2's complement.

A. 11011010

1's → 00100101

2's → + 1

00100110

B. 1010.1101

1's → 0101.0010

+ 1 + 1

2's

0110 .0010

0101.0010

+ 1

0101.0011

3. Subtraction

Answer

A. 1001 − 0110101 ⇒ 2's → 1001011

9 53

(+) 0001001

9 − 53 = −44

1010100

64 32 16 8 4 2 1

32 16 8 4 2 1

001001

(+) 0010001

010100

0001001

1001011

1010100

2's 0101011

+ 1

0101100

$\cancel{64+16+4}$

32 + 8 + 4 = 44

101011

B. 101000 − 010101 ⇒ 2's → 101010

+ 1

101011

16 8 4 2 1

10100

(+) 01011

11111

101000

(+) 101011

100011

101000

− 10101

010011

(without 2's complement)

Note:

1's complement

$$\boxed{r^n - r^{-m} - N}$$

For 2's complement

$$\boxed{r^n - N}$$

Using 2's complement:

```
        101000
2's →   101011
       1010011
```

4. Binary equivalence of 49 & 29.

```
2 | 49
2 | 24 - 1
2 | 12 - 0
2 |  6 - 0
2 |  3 - 0
     1 - 1
```

```
2 | 29
2 | 14 - 1
2 |  7 - 0
2 |  3 - 1
     1 - 1
```

$(49)_{10} \rightarrow (110001)_2$ $\quad$ $(29)_{10} \rightarrow (11101)_2$

Sign Magnitude Form.

	Sign Mag.	1's	2's
49	00110001		
+49	00110001	00110001	00110001
-49	10110001	11001110	11001111
29	00011101		
+29	00011101	00011101	00011101
-29	10011101	11100010	11100011

(i) (−29) + (+49)

−29 → 11100011

+49 → 00110001 (+)

100010100

49
−29
20

(ii) (−29) + (−49)

−29 → 11100011

−49 → 11001111

110110010

Verification

110110010

1's 00100 1101
+1

2's 00100 1110

(−29) + (+49) ⇒ 20 [To verify (i)]

00010100

$0 \times 2^0 = 0$

$0 \times 2^1 = 0$

$1 \times 2^2 = 4$

$0 \times 2^3 = 0$

$1 \times 2^4 = 16$

$\boxed{20}$ → (i) is verified

(−29) + (−49) ⇒ 01001110

29
+49
78

0×2^0

$1 \times 2^1 \Rightarrow 2$

$2^2 \Rightarrow 4$

$2^3 \Rightarrow 8$

0×2^4

0×2^5

$64 \Leftarrow 1 \times 2^6$

$\boxed{2+4+8+64 = 78 \longrightarrow \text{(ii) is verified.}}$

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Note: (2m)

BINARY TO GRAY

1 1 1 0

↓ ⊕ ↓ ⊕ ↓ ⊕ ↓

1 0 0 1

→ 1st no as it is

→ next nos take X-OR

GRAY TO BINARY

1 1 1 0

↓ ⊕ ⊕ ⊕

1 0 1 1

→ next ~~no~~ ans value take X-OR.

5. convert binary 1101110 ⇒ gray code

1 1 0 1 1 1 0

↓

1 0 1 1 0 0 1 ⇒ gray code.

6. Reduce the boolean expression using boolean law.

A. $(A'+C)(A'+C')(A+B+C'D)$

Using distribution law

$(A'+\cancel{CC'})(A+B+C'D)$ $\quad (A'+CC') \Downarrow (A'+C)(A'+C')$

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

$= \cancel{A'A} + A'B + A'C'D$

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

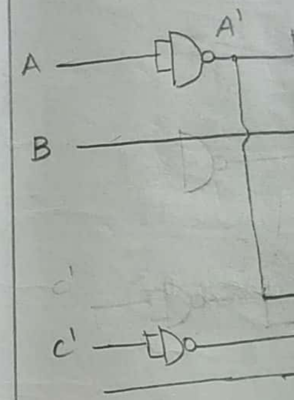
$= A'(B+C'D)$

implementation

ONLY US

$Y = A'B +$

$\overline{\overline{Y}} = \overline{A'}$



⇒

$Y = A'B$

$Y = A$

$Y = ($

=

=

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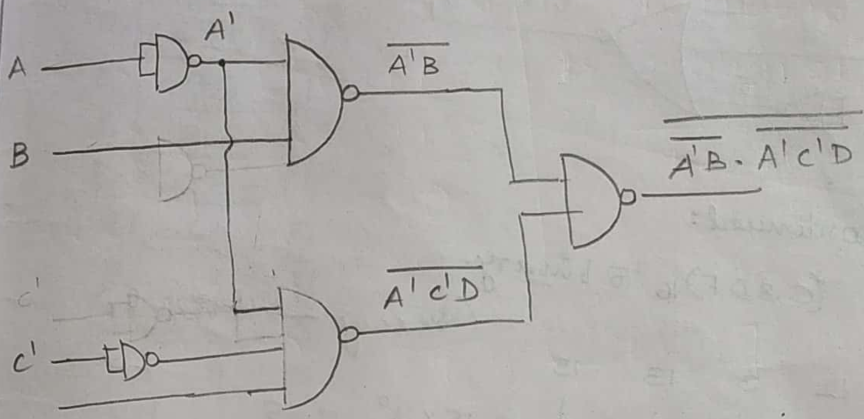
implementation using universal logic gates:

ONLY USING $\boxed{\text{NAND}}$ AND $\boxed{\text{NOR}}$

~~Us~~ $Y = A'B + A'C'D$

$\bar{\bar{Y}} = \overline{\overline{A'B} \cdot \overline{A'C'D}}$ ⇒ only using NAND



⇒ only using NOR

$$Y = A'B + A'C'D$$

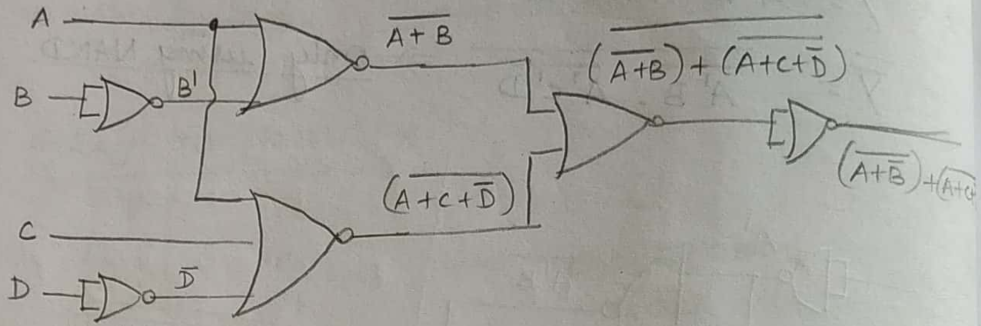
$$Y = \overline{\overline{A'B} \cdot \overline{A'C'D}}$$

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

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

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

$Y = \overline{(A+\overline{B})} + (\overline{A+C+\overline{D}})$



1. (B) continued:

$(C3DF)_{16}$ to binary.

(hexa → decimal)

12 3 13 15

$15 \times 16^0 = 15$

$13 \times 16 = 208$

$3 \times 16^1 = 768$

$12 \times 16^2 = 49,152$

$(50143)_{10}$

(decimal → binary)

- Repeated division by 2.

2 | 50143

Ans ⇒ $(1100\ 0011\ 1101\ 1111)_2$

decimal to binary

$$
\begin{array}{r|l}
2 & 50143 \\
2 & 25071 - 1 \\
2 & 12535 - 1 \\
2 & 6267 - 1 \\
2 & 3133 - 1 \\
2 & 1566 - 1 \\
2 & 783 - 0 \\
2 & 391 - 1 \\
2 & 195 - 1 \\
2 & 97 - 1 \\
2 & 48 - 1 \\
2 & 24 - 0 \\
2 & 12 - 0 \\
2 & 6 - 0 \\
2 & 3 - 0 \\
 & 1 - 1
\end{array}
$$

$\Rightarrow (1100001111011111)_2$

7. Express the function $(cd + b'c + bd')(b+d)$ sum of min terms & pdt of max terms (CANONICAL FORM)

$\Rightarrow (cd + b'c + bd')(b+d)$

Sum of min terms :-

$F = bcd + \cancel{bb'c}^{\,0} + bd' + cd + b'cd + \cancel{bdd'}^{\,0}$

$= bcd + b(c+c')d' + (b+b')cd + b'cd$

$= bcd + bcd' + bc'd' + \cancel{bcd} + b'cd + \cancel{b'cd}$

$\underset{7}{111} \quad \underset{6}{110} \quad \underset{4}{100} \quad \underset{3}{011}$

$\Sigma m(3, 4, 6, 7)$

Pdt of max terms:-

$= bcd + bcd' + bc'd' + b'cd$

$= cd(b+b') + bd'(c+c')$

$= cd + bd'$

$\Rightarrow bd' + cd$ By distributive law.

$= (bd'+c)(bd'+d)$

$= (b+c)(d'+c)(b+d)(\cancel{d+d'})$

$= (b+c+dd')(bb'+c+d')(b+cc'+d)$

$= (b+c+d)(\cancel{b+c+d'})$

$(b+c+d')(b'+c+d')$

$(\cancel{b+c+d})(b+c'+d)$

$= (b+c+d)(b+c+d')(b'+c+d')(b+c'+d)$

$\quad 000 \quad\quad 001 \quad\quad 101 \quad\quad 010$

$\quad 0 \quad\quad 1 \quad\quad 5 \quad\quad 2$

$= \Pi m(0,1,2,5)$

8. Convert

A) $F(x,y,z) = \Sigma(1,3,5)$

$= \Pi(0,2,4,6,7)$

B) $F(A,B,C,D) = \Pi(3,5,8,11)$

$= \Sigma(0,1,2,4,6,7,9,10,12,13,14,15)$

$= \Sigma(0,1,2,4,6,7,9,A,C,D,E,F)$

9. convert:

A. $(u+xw)(x+u'v)$ into sum of pdt and pdt of sum [standard form]

<u>sum of pdt:</u>

$(u+xw)(x+u'v)$

$= \cancel{ux+x'}\ ux + \cancel{uu'}^{0}v + xwx + xwu'v$

$= ux + xwu'v + xw \Leftarrow$ sum of pdt.

<u>Pdt of sum:</u>

$(u+xw)(x+u'v)$ <u>Using distribution law,</u>

$\cancel{(u+xwu'v)(x+xwu'v)}$

$\Rightarrow \cancel{(u+x)(u+w)(u+u')^{0}(u+v)(x+x)(x+w)(x+u')(x+v)}$

$\Rightarrow (u+x)(u+w)(u+v)(x+w)(x+u')(x+v)(x+x)$

$\Downarrow$

$\Rightarrow (u+x)(u+w)(x+u')(x+V)$ Pdt of sum.

10. <u>Reduced using k-map.</u>

A. $F(w,x,y,z) = \Sigma(2,3,12,13,14,15)$

$wx \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{w}\bar{x}$ 00	0	1	1 (3)	1 (2)
$\bar{w}x$ 01	4	5	7	6
wx 11	1 (12)	1 (13)	1 (15)	1 (14)
$w\bar{x}$ 10	8	9	11	10

$F(w,x,y,z) = wx + \bar{w}\bar{x}y.$

B. $F = w'z + xz + x'y + wx'z$

wx \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{w}\bar{x}$ 00		1	1	1
$\bar{w}x$ 01		1	1	
wx 11		1	1	
$w\bar{x}$ 10		1	1	1

$x'yz'$

$F(w,x,y,z) = z + x'y$

11. Using tabulation method find the reduced expression:-

A. $F = \Sigma(1,3,4,5,10,11,12,13,14,15)$

	A	B	C	D	
1	0	0	0	1	0
3	0	0	1	1	- 2
4	0	1	0	0	0
5	0	1	0	1	- 2
10	1	0	1	0	- 2
11	1	0	1	1	- 3
12	1	1	0	0	- 2
13	1	1	0	1	- 3
14	1	1	1	0	- 3
15	1	1	1	1	- 4

	A	B	C	D
1	0	0	0	1
4	0	1	0	0
3	0	0	1	1
5	0	1	0	1
10	1	0	1	0
12	1	1	0	0
11	1	0	1	1
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Iteration-I

(1,3) 00–1
(1,5) 0–01
(4,5) 010–
(4,12) –100
(3,11) –011
(5,13) –101
(10,11) 101–
(10,14) 1–10
(12,13) 110–
(12,14) 11–0
(11,15) 1–11
(13,15) 11–1
(14,15) 111–

Iteration-II

ABCD
(4,12,5,13) –10–
(10,11,14,15) 1–1–
~~(10,14,11,15) 1–1–~~
~~(4,5,12,13) –10–~~
(12,13,14,15) 11––
~~(12,14,13,15) 11––~~

PRIME IMPLICANTS:

(1,3) – $\bar{A}\bar{B}D$
(1,5) – $\bar{A}\bar{C}D$
(3,11) – $\bar{B}CD$
(4,12,5,13) – $B\bar{C}$
(10,11,14,15) – AC
(12,13,14,15) – AB

Min terms	P.I	1	3	4	5	10	11	12	13	14	15
(1,3)	$\bar{A}\bar{B}D$	×	×								
1,5	$\bar{A}\bar{C}D$	×			×						
3,11	$\bar{B}CD$		×				×				
4,12,5,13	$B\bar{C}$			×	×			×	×		
10,11,14,15	AC					×	×			×	×
12,13,14,15	AB							×	×	×	×

$F = \bar{A}\bar{B}D + B\bar{C} + AC.$

$F = \bar{A}\bar{B}D + B\bar{C} + AC.$

Verification using K-map :- $F = \Sigma(1,3,4,5,10,11,12,13,14,15)$

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	0	1 (1)	1 (3)	2
$\bar{A}B$ 01	1 (4)	1 (5)	7	6
AB 11	1 (12)	1 (13)	1 (15)	1 (14)
$A\bar{B}$ 10	8	9	1 (11)	1 (10)

$$\boxed{F = B\bar{C} + AC + \bar{A}\bar{B}D}$$

Hence verified.

B. $F = \Sigma(5,6,7,12,14,15)$
$d = \Sigma(3,9,11)$

	A B C D
3	0 0 1 1
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
9	1 0 0 1
11	1 0 1 1
12	1 1 0 0
14	1 1 1 0
15	1 1 1 1

5,10,11,12,13,14,15

	A B C D
3	0 0 1 1 ✓
5	0 1 0 1 ✓
6	0 1 1 0 ✓
9	1 0 0 1 ✓
12	1 1 0 0 ✓
7	0 1 1 1 ✓
11	1 0 1 1 ✓
14	1 1 1 0 ✓
15	1 1 1 1 ✓

Iteration-1

(3,7) 0-11 ✓
(3,11) -011 ✓
(5,7) 01-1
(6,7) 011- ✓
(6,14) -110 ✓
(9,11) 10-1
(12,14) 11-0
(7,15) -111 ✓
(11,15) 1-11 ✓
(14,15) 111- ✓

Iteration-2

(3,7,11,15) --11 (A B C D)
(3,11,7,15) --11
(6,7,14,15) -11-
(6,14,7,15) -11-

PRIME IMPLICANTS.

(5,7) $\bar{A}BD$
(9,11) ~~$A\bar{B}$~~ $A\bar{B}D$
(12,14) $AB\bar{D}$
(3,7,11,15) → CD
(6,7,14,15) → BC

Min terms	P.I	~~3~~	5 ✓	6 ✓	7 ✓	~~9~~	~~11~~	12 ✓	14 ✓	15 ✓
✓ 5,7	$\bar{A}BD$		X		X					
9,11	$A\bar{B}D$									
✓ 12,14	$AB\bar{D}$							X	X	
3,7,11,15	CD				X					X
✓ 6,7,14,15	BC			X	X				X	X

$F = \bar{A}BD + AB\bar{D} + BC$

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	0	1	3	2
$\bar{A}B$ 01	4	1 (5)	1 (7)	1 (6)
AB 11	1 (12)	X (13)	1 (15)	1 (14)
$A\bar{B}$ 10	8	X (9)	X (11)	10

verification using K-map.

$$\boxed{F = BC + \bar{A}BD + AB\bar{D}}$$

Hence Verified.

31.07.18

Unit - II Combinational circuits.

Digital logic circuits

Combinational

o/p depends upon present i/p

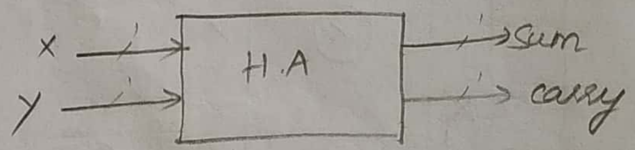
→ Half Adder
→ Full Adder.
→ Ripple carry adder (parallel adder)
→ Mux
→ De Mux
→ Decoder
→ Encoder
→ Comparator

Sequential.

(Flip flops)

→ Register
→ Counter
→ Shift register
→ ALU
→ Memory
→ control Unit

Eg:- 1. **Half Adder.**

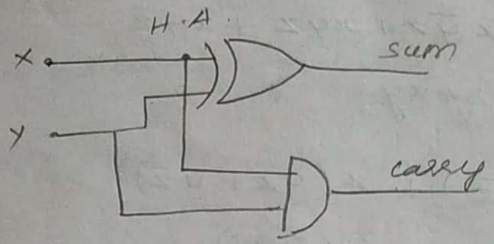


1 bit

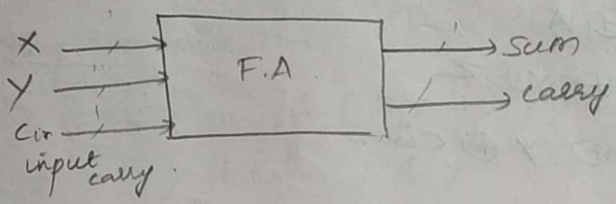
x	y	sum	carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

$$Sum = \overline{x}y + x\overline{y} = x \oplus y$$

$$carry = xy$$



Full Adder:



	x	y	cin	sum	carry
0	0	0	0	0	0
1	0	0	1	1	0
2	0	1	0	1	0
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	1	0	1
6	1	1	0	0	1
7	1	1	1	1	1

sum

x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	0	1 1	3	1 2
x 1	1 4	5	1 7	6

$F \Rightarrow sum \Rightarrow x\bar{y}\bar{z} + \bar{x}\bar{y}z + xyz + \bar{x}y\bar{z}$

x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	10 $y\bar{z}$
$\bar{x}$ 0	0	1	1 3	2
x 1	4	1 5	1 7	1 6

carry $\Rightarrow$ ~~$yz + xz + xy$~~
$yz + xz + xy$

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

carry: $yz + xz + xy$

sum:

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

$$\bar{x}(\underbrace{y \oplus z}_{A}) + x(\underbrace{y \odot z}_{\bar{A}})$$

$$= \bar{x}A + x\bar{A}$$

$$= x \oplus A$$

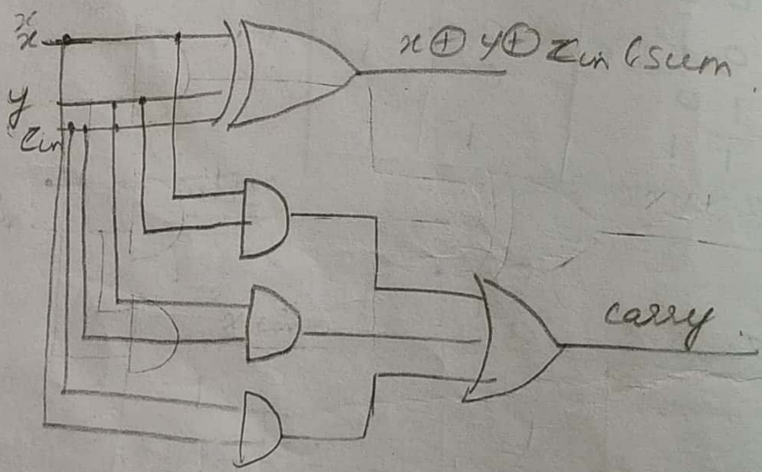
$$= x \oplus y \oplus z$$

$$= x \oplus y \oplus c_{in}.$$

carry: $yz + xz + xy$.

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

$$= xy + yc_{in} + xc_{in}.$$



Half Adder..

1. Full Adder using 2 half adder & one OR gate.

carry: $xy + y\,c_{in} + x\,c_{in}$.

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

$$= xy + xy\,c_{in} + \bar{x}y\,c_{in} + \cancel{xy\,c_{in}} + x\bar{y}\,c_{in}.$$

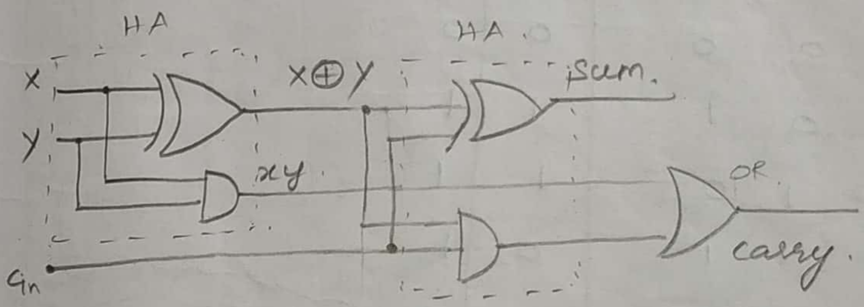
$$= \underbrace{xy + xy\,c_{in}} + \bar{x}\,y\,c_{in} + x\,\bar{y}\,c_{in}.$$

Using absorption law; $(A+AB=A)$

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

<u>carry</u> $= xy + c_{in}\,(x \oplus y)$

<u>sum</u> $= x \oplus y \oplus c_{in}$



2. <u>Half Subtractor.</u>

x	y	diff (D)	borrow (B)
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

<u>Difference:</u>

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

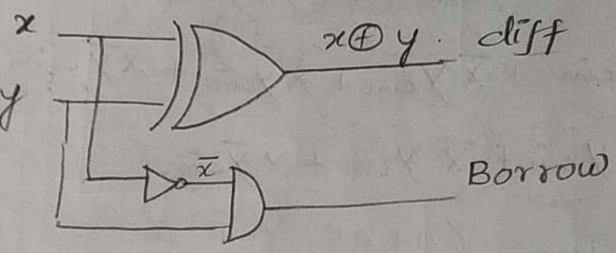
$$= x \oplus y$$

<u>Borrow</u>

$$B = \bar{x}\,y$$

Difference : $x \oplus y$

Borrow : $\bar{x} y$.



FULL SUBTRACTOR:

	x	y	Cin	D	B
0	0	0	0	0	0
1	0	0	1	1	1
2	0	1	0	1	1
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	1	0	0
6	1	1	0	0	0
7	1	1	1	1	1

D, B

10 $\cancel{0}$

-1

1

0

Difference

x \ y cin	$\bar{y}\bar{c}$ 00	$\bar{y}c$ 01	yc 11	$y\bar{c}$ 10
$\bar{x}$ 0	0	1 (1)	3	1 (2)
x 1	1 (4)	5	1 (7)	6

Difference $D = x\bar{y}\overline{cin} + \bar{x}\bar{y}\, cin + x y\, cin + \bar{x} y\, \overline{cin}$

$\boxed{D = x \oplus y \oplus cin}$

Borrow

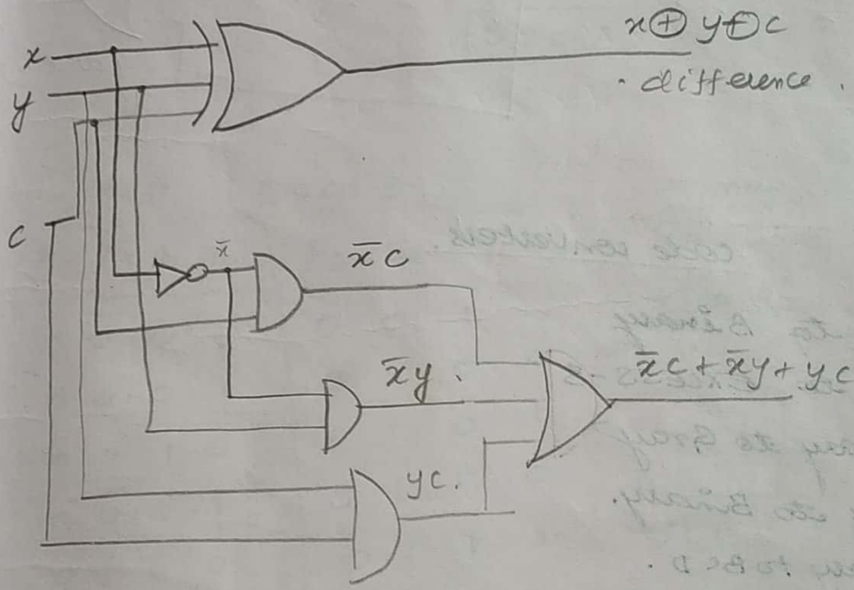
$x \backslash y\,c_{in}$	$\bar{y}\bar{c}$ 00	$\bar{y}c$ 01	yc 11	$y\bar{c}$ 10
$\bar{x}$ 0	0	1 (1)	1 (3)	1 (2)
x 1	4	5	1 (7)	6

$B = \bar{x}c_{in} + \bar{x}y + yc$

$$\boxed{B = \bar{x}c + \bar{x}y + yc}$$

$= \cancel{\bar{x}y + c(}$

2 half subt + R.



$B = \bar{x}c + \bar{x}y + yc$

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

$= \underbrace{\bar{x}y + \bar{x}yc}_{\bar{x}y(1+c)} + \bar{x}\bar{y}c + xyc + \cancel{\bar{x}yc}$

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

$\cancel{= \bar{x}y + c \odot xy + \bar{x}yc}$

$= \bar{x}y + \bar{x}\bar{y}c + xyc$

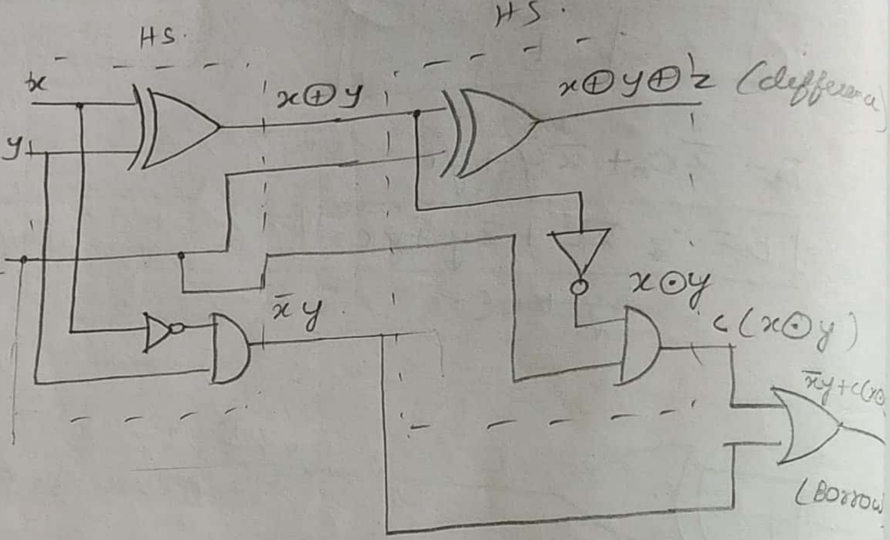
$= \bar{x}y + c(\bar{x}\bar{y} + xy)$

$\cancel{= \bar{x}y + c \odot \bar{x}y}$ $c(x \odot y)$

$B = \bar{x}y + c(x \odot y)$

$B = \bar{x}y + c(x \odot y)$

$D = x \oplus y \oplus c$.



07.08.18

Code converters.

1. BCD to Binary
2. BCD to EXCESS-3
3. Binary to Gray
4. Gray to Binary.
5. Binary to BCD.
6. Excess 3 to Binary.

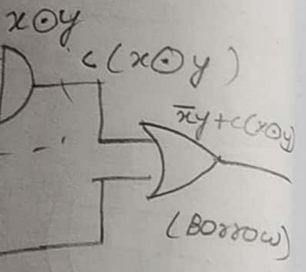
I.

	BCD				BINARY			
	A_3	A_2	A_1	A_0	B_3	B_2	B_1	B_0
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	0
3	0	0	1	1	0	0	1	1
4	0	1	0	0	0	1	0	0
5	0	1	0	1	0	1	0	1
6	0	1	1	0	0	1	1	0
7	0	1	1	1	0	1	1	1
8	1	0	0	0	1	0	0	0
9	1	0	0	1	1	0	0	1
	1	0	1	0				
	1	0	1	1				
	1	1	0	0				
	1	1	0	1				
	1	1	1	0				

Dont care nos.

0-15

$y \oplus' z$ (difference)



BCD				~~BINARY~~
A_3	A_2	A_1	A_0	
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0				

Draw k maps for B_3 B_2 B_1 B_0

For B_3

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	0	0	0	0
01	0	0	0	0
A_3A_2 11	x	x	x	x
$A_3\bar{A}_2$ 10	1	1	x	x

$\boxed{B_3 = A_3}$.

$B_2 = A_2$

$B_1 = A_1$

$B_0 = A_0$

	BCD	Excess 3.
	A_3 A_2 A_1 A_0	E_3 E_2 E_1 E_0
0	0 0 0 0	0 0 1 1
1	0 0 0 1	0 1 0 0
2	0 0 1 0	0 1 0 1
3	0 0 1 1	0 1 1 0
4	0 1 0 0	0 1 1 1
5	0 1 0 1	1 0 0 0
6	0 1 1 0	1 0 0 1
7	0 1 1 1	1 0 1 0
8	1 0 0 0	1 0 1 1
9	1 0 0 1	1 1 0 0.

K map

E_3

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	0	0	0	0
01	0	1	1	1
11	x	x	x	x
10	1	1	x	x

$E_3 = A_3 + A_2A_0 + A_2A_1$

$= A_3 + A_2(A_0 + A_1)$

K map for E_2.

$A_3A_2 \backslash A_1A_0$	$\bar{A}_1\bar{A}_0$ 00	$\bar{A}_1A_0$ 01	A_1A_0 11	$A_1\bar{A}_0$ 10
$\bar{A}_3\bar{A}_2$ 00	0	1	1	1
$\bar{A}_3A_2$ 01	1	0	0	0
A_3A_2 11	X	X	X	X
$A_3\bar{A}_2$ 10	0	1	X	X

$$\boxed{E_2 = \cancel{A_3}A_0 + \bar{A}_2A_1 + \cancel{\bar{A}_3\bar{A}_2}\; A_0\bar{A}_2 + A_2\bar{A}_1\bar{A}_0}$$

Scanned by CamScanner

K map for E_0

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	1	0	0	1
01	1	0	0	1
11	X	X	X	X
10	1	0	X	X

$$E_0 = \bar{A}_1\bar{A}_0 + A_1\bar{A}_0$$

$$E_0 = \bar{A}_0(\bar{A}_1 + A_1)$$

K map for E_1

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	1	0	1	0
01	1	0	1	0
11	X	X	X	X
10	1	0	X	X

$$E_1 = \bar{A}_1\bar{A}_0 + A_1A_0 = A_1 \odot A_0$$

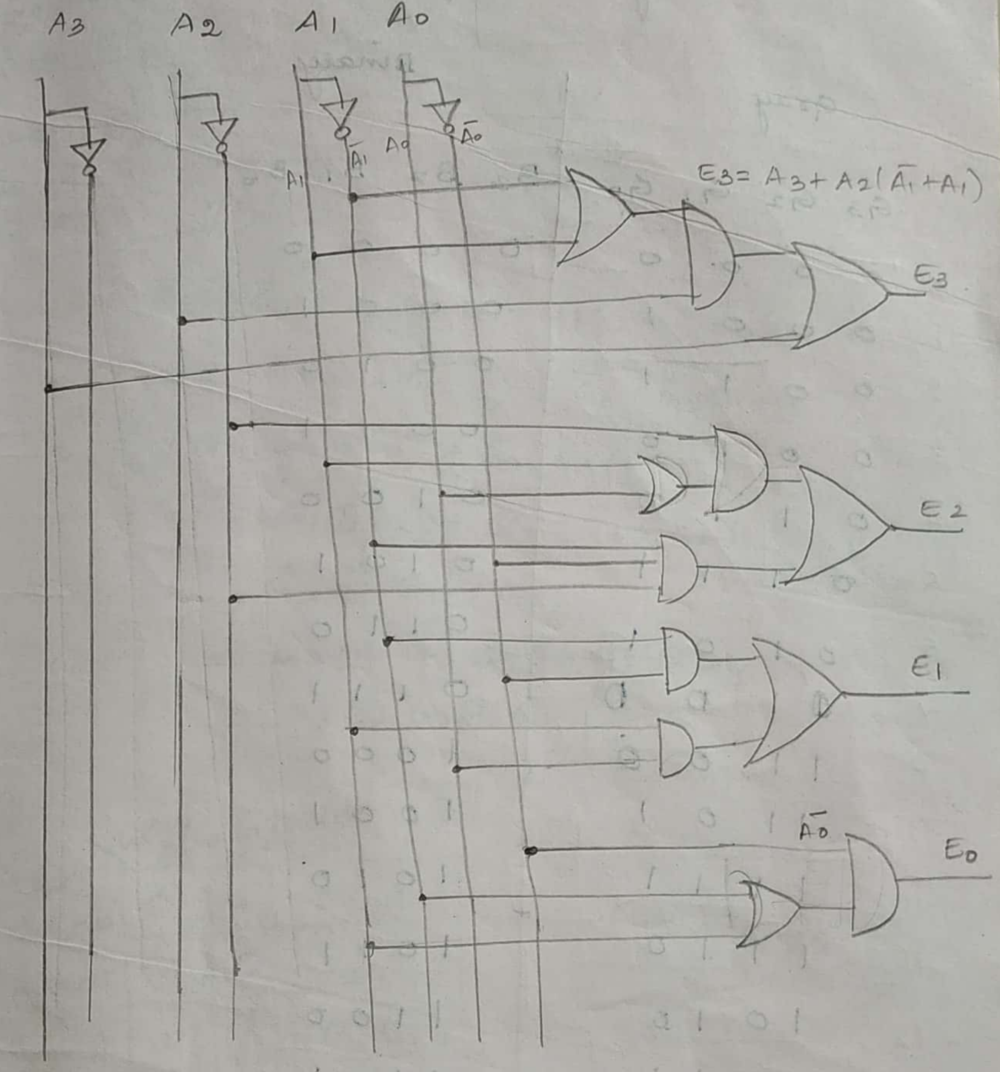
$$E_3 = A_3 + A_2(\bar{A}_1 + A_1)$$

$$E_2 = \bar{A}_2(A_1 + A_0) + \bar{A}_1\bar{A}_0A_2$$

$$E_1 = \bar{A}_1\bar{A}_0 + A_1A_0$$

$$E_0 = \bar{A}_0(\bar{A}_1 + A_1)$$

LOGIC DIAGRAM:



$E_3 = A_3 + A_2(\bar{A_1} + A_1)$

$E_2 = \bar{A_2}(A_1 + A_0) + \bar{A_1}\bar{A_0}A_2$

$E_1 = \bar{A_1}\bar{A_0} + A_1 A_0$

$E_0 = \bar{A_0}(\bar{A_1} + A_1)$

Using this logic diagram is drawn above

Scanned by CamScanner

Gray to Binary

	Gray				Binary			
	G_3	G_2	G_1	G_0	B_3	B_2	B_1	B_0
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	1	0	0	1	0
3	0	0	1	0	0	0	1	1
4	0	1	1	0	0	1	0	0
5	0	1	1	1	0	1	0	1
6	0	1	0	1	0	1	1	0
7	0	1	0	0	0	1	1	1
8	1	1	0	0	1	0	0	0
9	1	1	0	1	1	0	0	1
10	1	1	1	1	1	0	1	0
11	1	1	1	0	1	0	1	1
12	1	0	1	0	1	1	0	0
13	1	0	1	1	1	1	0	1
14	1	0	0	1	1	1	1	0
15	1	0	0	0	1	1	1	1

B_2

$G_3G_2 \backslash G_1G_0$	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	0	0	0	0
10	1	1	1	1

$\boxed{B_3 = G_3}$

$B_2 = \bar{G}_3 G_2 + G_3 \bar{G}_2$

$\boxed{B_2 = G_3 \oplus G_2.}$

$\underline{\underline{B_1}}$

$G_3G_2 \backslash G_1G_0$	$\bar{G_1}\bar{G_0}$ 00	$\bar{G_1}G_0$ 01	G_1G_0 11	$G_1\bar{G_0}$ 10
$\bar{G_3}\bar{G_2}$ 00	0	0	1	1
$\bar{G_3}G_2$ 01	1	1	0	0
G_3G_2 11	0	0	1	1
$G_3\bar{G_2}$ 10	1	1	0	0

$$B_1 = G_3\bar{G_2}\bar{G_1} + G_3G_2G_1 + \bar{G_3}\bar{G_2}G_1 + \bar{G_3}G_2\bar{G_1}$$

$$= G_3(\bar{G_2}\bar{G_1} + G_2G_1) + \bar{G_3}(\bar{G_2}G_1 + G_2\bar{G_1})$$

$$= G_3(G_2 \odot G_1) + \bar{G_3}(G_1 \oplus G_2)$$

$$= \bar{G_3}(G_1 \oplus G_2) + G_3(\overline{G_1 \oplus G_2})$$

$$= \bar{G_3} \oplus G_1 \oplus G_2$$

$$= \cancel{G_3 \oplus G\ \ G_1 \oplus G_2 \oplus G_3}$$

$$= G_3 \oplus G_2 \oplus G_1$$

$\underline{\underline{B_0}}$

$G_3G_2 \backslash G_1G_0$	$\bar{G_1}\bar{G_0}$ 00	$\bar{G_1}G_0$ 01	G_1G_0 11	$G_1\bar{G_0}$ 10
$\bar{G_3}\bar{G_2}$ 00	0	1	0	1
$\bar{G_3}G_2$ 01	1	0	1	0
G_3G_2 11	0	1	0	1
$G_3\bar{G_2}$ 10	1	0	1	0

$$B_0 = \bar{G_3}\bar{G_2}\bar{G_1}G_0 + \bar{G_3}\bar{G_2}G_1\bar{G_0} + \bar{G_3}G_2\bar{G_1}\bar{G_0} + \bar{G_3}G_2G_1G_0 + G_3G_2\bar{G_1}G_0 + G_3G_2G_1\bar{G_0} + G_3\bar{G_2}\bar{G_1}\bar{G_0} + G_3\bar{G_2}G_1G_0$$

$$= \bar{G_3}\bar{G_2}(\bar{G_1}G_0 + G_1\bar{G_0}) + \bar{G_3}G_2(\bar{G_1}\bar{G_0} + G_1G_0) + G_3G_2(\bar{G_1}G_0 + G_1\bar{G_0}) + G_3\bar{G_2}(\bar{G_1}\bar{G_0} + G_1G_0)$$

$$= \bar{G_3}\bar{G_2}(G_1 \oplus G_0) + \bar{G_3}G_2(G_1 \odot G_0) + G_3G_2(G_1 \oplus G_0) + G_3\bar{G_2}(G_1 \odot G_0)$$

$$= (\bar{G_3}\bar{G_2} + G_3G_2)(G_1 \oplus G_0) + (\bar{G_3}G_2 + \bar{G_2}G_3)(G_1 \odot G_0)$$

$$= (G_3 \odot G_2)(G_1 \oplus G_0) + \cancel{G_3G_2}(G_3 \oplus G_2)(G_1 \odot G_0)$$

$$= (G_3 \odot G_2)(G_1 \oplus G_0) + \overline{(G_3 \oplus G_2)}\ \overline{(G_1 \odot G_0)}$$

$$= (G_3 \odot G_2)(G_1 \oplus G_2) + \overline{(G_3 \odot G_2)} + \overline{(G_1 \oplus G_0)}$$

$$\cancel{AB + \bar{A}\bar{B}}$$

$$= \cancel{G_3 \odot G_2 \odot G_1}$$

$$= (G_3 \odot G_2)(G_1 \oplus G_0) + \overline{(G_3 \odot G_2)}\ (\overline{G_0 \oplus G_1})$$

$$\quad A \qquad\quad B \qquad\qquad \bar{A} \qquad\qquad \bar{B}$$

$$\cancel{(G_3 \odot G_2) \odot G_1 \oplus G_0}$$

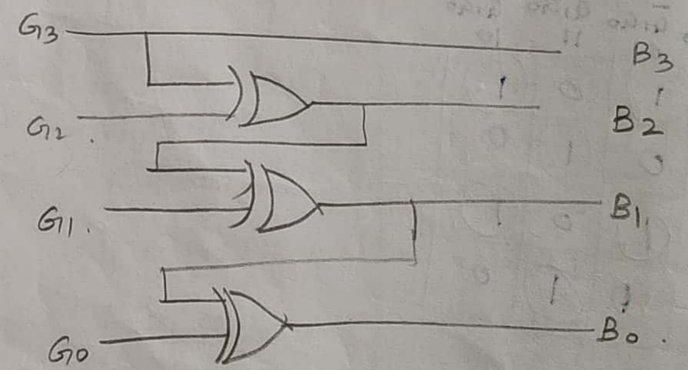
$$= (\overline{G_3 \oplus G_2})(G_1 \oplus G_0) + (\overline{G_0 \oplus G_1})(G_2 \oplus G_3)$$

$$\quad \bar{A} \qquad\qquad B \qquad\qquad \bar{B} \qquad\qquad A$$

$$= G_3 \oplus G_2 \oplus G_1 \oplus G_0$$

$$B_0 = G_0 \oplus B_2 \oplus G_1$$

Design:-



Excess -3

E3 E2

Excess 3 to Binary

Excess - 3 (E_3 E_2 E_1 E_0)	B_3	B_2	B_1	B_0	
	0	0	0	0	0
	0	0	0	1	
	0	0	1	0	2
	0	0	1	1	3
	0	1	0	0	4
	0	1	0	1	5
	0	1	1	0	6
	0	1	1	1	7
	1	0	0	0	8
	1	0	0	1	
	1	0	1	0	10
	1	0	1	1	11
	1	1	0	0	12
	1	1	0	1	13
X	1	1	1	0	14
X	1	1	1	1	15
X					

Dont cares

10.8.18

Binary parallel Adders.

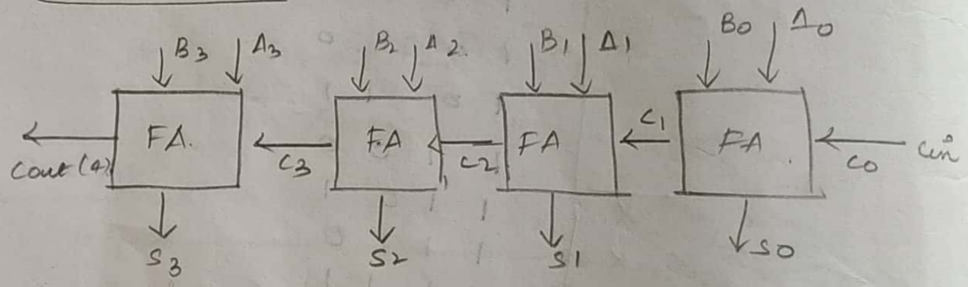
Half adders – 2 bits } each input
Full adder – 3 bits } 1 bits.

1. Ripple carry Adder (carry propagate Adder)
2. carry look ahead adder.

1. Ripple carry Adder:
(made of full adders)

If n bits are required, the n-number of full adders are required.

4-bit RCA.



$A = A_3 A_2 A_1 A_0 = 1101$

$B = B_3 B_2 B_1 B_0 = 1001$

Initially i/p carry is zero.

$C_3 \quad C_2 \quad C_1 \quad C_0 = 0$

$A = A_3 \; A_2 \; A_1 \; A_0$ — 3 inputs are added

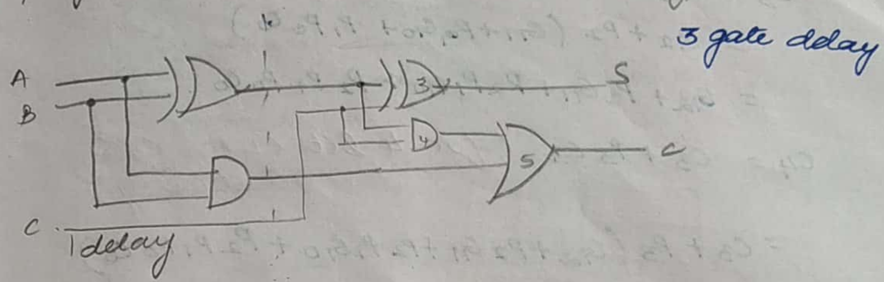
$B = B_3 \; B_2 \; B_1 \; B_0$ ∴ full adders are used

$S_3 \; S_2 \; S_1 \; S_0$

C_4
Cout

Propagation delay: (Generally in nano second)
Time Delay between the input arrivals to the gate & the generation of carry.

Propagation delay depends upon the gate.



In full adder → 2 gate delay. (in general)

Disadvantage:

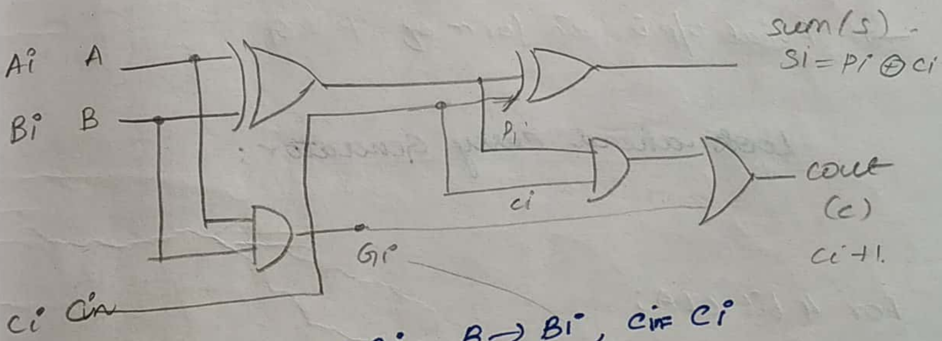
Longest propagation delay.

2. Carry Look ahead adder: (high speed parallel adder)

All the carry are generated simultaneously.

We modify based on full adder

[consider it as single bit]



Assume $A \to A_i$, $B \to B_i$, $c_{in} = c_i$

$P_i \to$ Propagate function $= A_i \oplus B_i$ (for i/p)

$G_i \to$ Generate function $= A_i B_i$ (And combination of inputs)

$$c_{i+1} = G_i + P_i C_i$$

apply $i=0$

$\rightarrow C_1 = G_0 + P_0 C_0$, where $C_0 \to$ input carry.

when $i=2$

$\rightarrow C_2 = G_1 + P_1 C_1$

sub c_1 in c_2

$\rightarrow C_2 = G_1 + P_1(G_0 + P_0 C_0)$

$= G_1 + P_1 G_0 + P_1 P_0 C_0$

$C_3 = G_2 + P_2 C_2$
$= G_2 + P_2 (G_1 + P_1 G_0 + P_1 P_0 C_0)$
$= G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_0$.

$C_4 = C_3 + P_3 C_3$ (for 4 bit CLA, C_4 is the final carry)

$= C_3 + P_3 (G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_0)$

$= C_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0 + P_3 P_2 P_1 P_0 C_0$

$C_n = G_{n-1} + P_{n-1} G_{n-2} + P_{n-1} P_{n-2} G_{n-3} + \dots \dots + (P_{n-1} P_{n-2} \dots P_1 P_0 C_0)$

For 8 bit CLA:

$C_{out} = C_7 = G_7 + P_7 G_6 + P_7 P_6 G_5 + P_7 P_6 P_5 G_4 + P_7 P_6 P_5 P_4 G_3 + P_7 P_6 P_5 P_4 P_3 G_2 + P_7 P_6 P_5 P_4 P_3 P_2 G_1 + P_7 P_6 P_5 P_4 P_3 P_2 P_1 G_0 + P_7 P_6 P_5 P_4 P_3 P_2 P_1 P_0 \underline{\underline{C_0}}$ ↗ input carry

→ Final o/p is in form of P & G

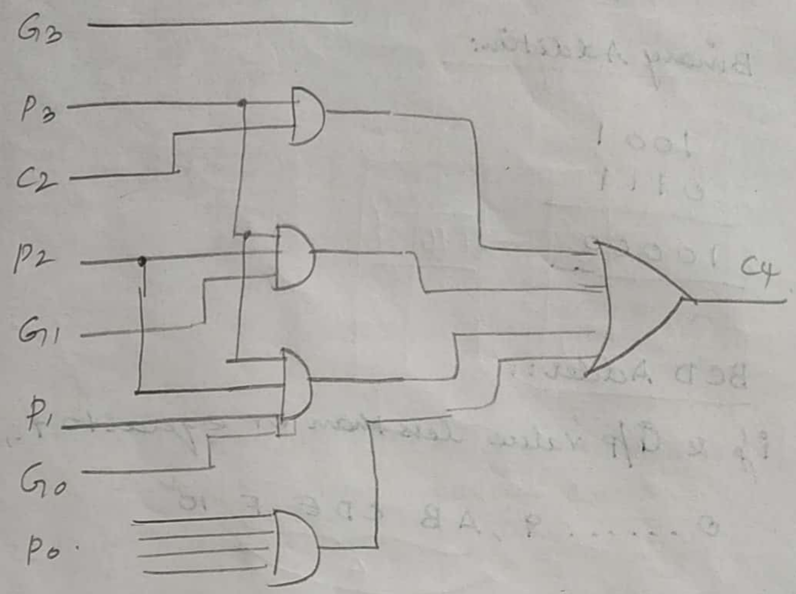
Look ahead carry Generator:

⟹

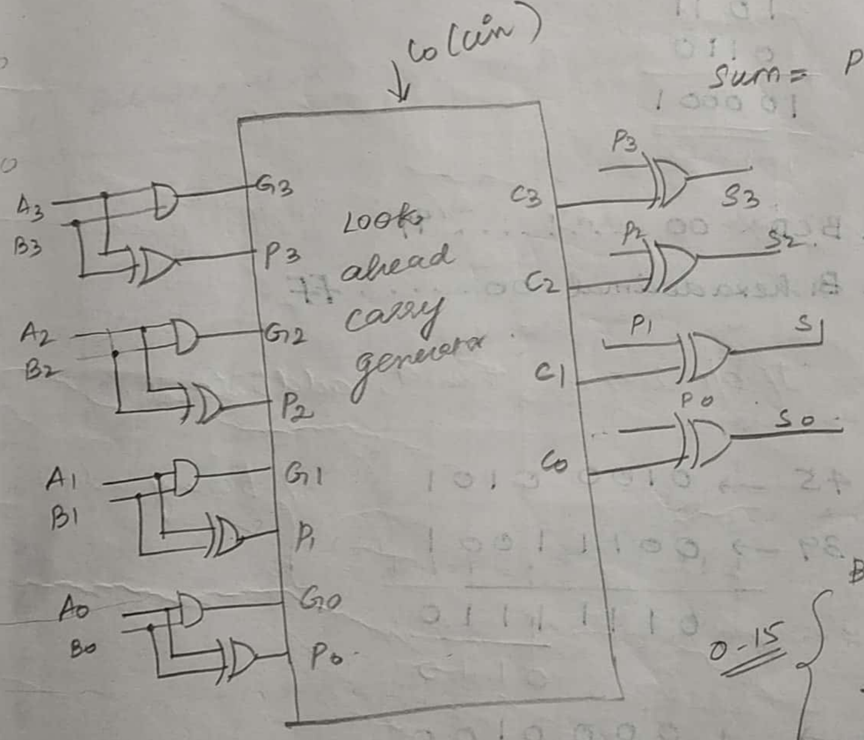
For 4 bit CLA;
we get 4 gate delay (fixed) from i/p to output sum.
(Very high speed parallel adder)

to generate G, P → 1 gate
to generate sum = 1 gate.

Look ahead carry generator



$Sum = P_i \oplus C_i$



Binary add

0-15
```
 1001
 0111
------
10000
```
(16)

BCD addition

0 to 9

From 10 it repeats.

BCD Adder. (4 bit)

Binary Addition:

```
  1001
  0111
 -----
 10000  -> 16
```

BCD Adder:

i/p & o/p value less than or equal to 9.

0 ...... 9 , $\underbrace{A\ B\ C\ D\ E\ F}_{6}$ 10

add 6

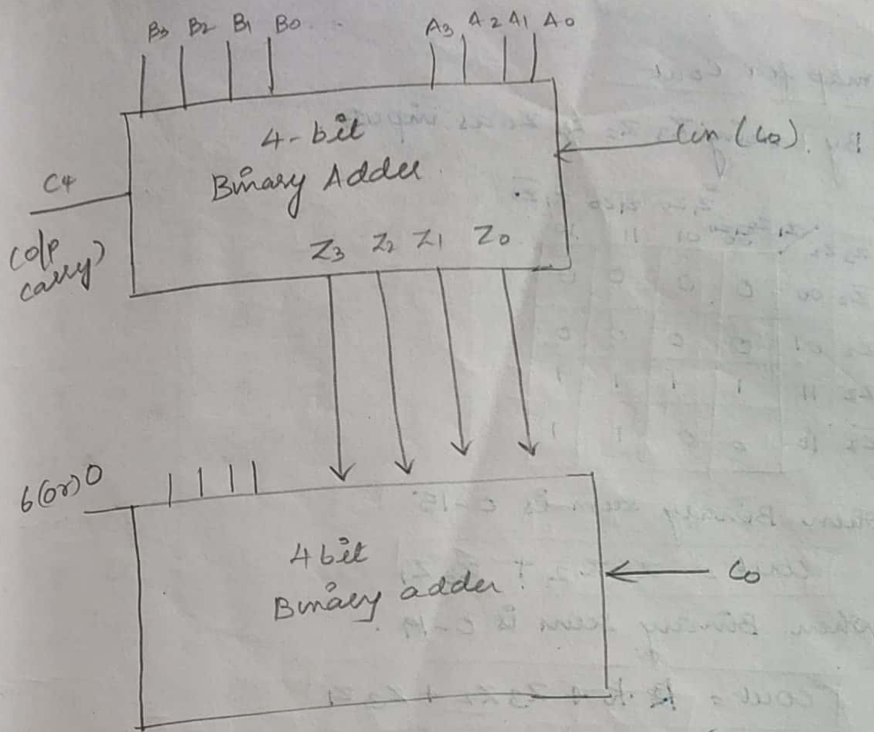
```
  1011
  0110
 ------
 100001
```

In BCD 00 .... 99 } highest value

In Bi hexadecimal 00 ..... FF

If o/p is greater than 9, add 6 to it.

```
45 -> 0100 0101
39 -> 0011 1001  (+)   } binary addition
      ---------
      0111 1110
           0110
      ---------
84 -> 1000 0100
```



DECIMAL	Binary Sum					BCD Sum				
	K	Z_3	Z_2	Z_1	Z_0	Cout	S_3	S_2	S_1	S_0
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	1
2	0	0	0	1	0	0	0	0	1	0
3	0	0	0	1	1	0	0	0	1	1
4	0	0	1	0	0	0	0	1	0	0
5	0	0	1	0	1	0	0	1	0	1
6	0	0	1	1	0	0	0	1	1	0
7	0	0	1	1	1	0	0	1	1	1
8	0	1	0	0	0	0	1	0	0	0
9	0	1	0	0	1	0	1	0	0	1
10	0	1	0	1	0	1	0	0	0	0
11	0	1	0	1	1	1	0	0	0	1
12	0	1	1	0	0	1				
13	0	1	1	0	1	1				
14	0	1	1	1	0	1				
15	0	1	1	1	1	1				
⋮										
19.										

Scanned by CamScanner

K map for Cout

By taking $Z_3\, Z_2\, Z_1\, Z_0$ as inputs.

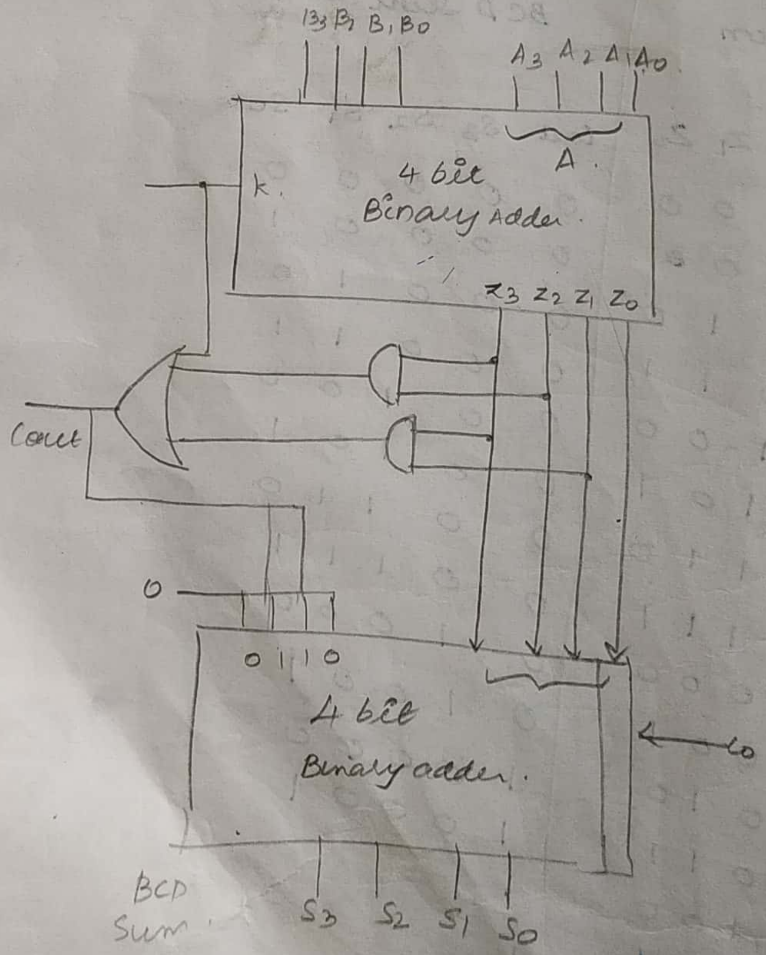
$Z_3Z_2 \backslash Z_1Z_0$	00 ($\bar{Z}_1\bar{Z}_0$)	01 ($\bar{Z}_1Z_0$)	11 (Z_1Z_0)	10 ($Z_1\bar{Z}_0$)
$\bar{Z}_3\bar{Z}_2$ 00	0	0	0	0
$\bar{Z}_3Z_2$ 01	0	0	0	0
Z_3Z_2 11	1	1	1	1
$Z_3\bar{Z}_2$ 10	0	0	1	1

When Binary sum is 0-15

$$\boxed{Cout = Z_3Z_2 + Z_3Z_1}$$

When Binary sum is 0-19.

$$\boxed{Cout = K + Z_3Z_2 + Z_3Z_1}$$



./08/18

Magnitude comparator

Inputs				Outputs			
A		B					
A_1	A_0	B_1	B_0	A > B	A = B	A < B	
0	0	0	0	0	1	0	0
0	0	0	1	0	0	1	1
0	0	1	0	0	0	1	2
0	0	1	1	0	0	1	3
0	1	0	0	1	0	0	4
0	1	0	1	0	1	0	5
0	1	1	0	0	0	1	6
0	1	1	1	0	0	1	7
1	0	0	0	1	0	0	8
1	0	0	1	1	0	0	9
1	0	1	0	0	1	0	10
1	0	1	1	0	0	1	11
1	1	0	0	1	0	0	12
1	1	0	1	1	0	0	13
1	1	1	0	1	0	0	14
1	1	1	1	0	1	0	15

K map

(i) A > B

A_1A_0 \ B_1B_0	$\bar B_1 \bar B_0$ 00	$\bar B_1 B_0$ 01	$B_1 B_0$ 11	$B_1 \bar B_0$ 10
$\bar A_1 \bar A_0$ 00	0 (0)	0 (1)	0 (3)	0 (2)
$\bar A_1 A_0$ 01	1 (4)	0 (5)	0 (7)	0 (6)
$A_1 A_0$ 11	1 (12)	1 (13)	0 (15)	1 (14)
$A_1 \bar A_0$ 10	1 (8)	1 (9)	0 (11)	0 (10)

$\boxed{A > B}$

$$= A_0 \bar B_1 \bar B_0 + A_1 A_0 \bar B_0 + A_1 \bar B_1$$

(ii) A = B

A = B

A_1A_0 \ B_1B_0	00	01	11	10
00	1 (0)	0 (1)	0 (3)	0 (2)
01	0 (4)	1 (5)	0 (7)	0 (6)
11	0 (12)	0 (13)	1 (15)	0 (14)
10	0 (8)	0 (9)	0 (11)	1 (10)

$$\boxed{A=B} = \bar{A_1}\bar{A_0}\bar{B_1}\bar{B_0} + \bar{A_1}A_0\bar{B_1}B_0 + A_1A_0B_1B_0 + A_1\bar{A_0}B_1\bar{B_0}$$

(iii) A < B

A_1A_0 \ B_1B_0	00 ($\bar{B_1}\bar{B_0}$)	01 ($\bar{B_1}B_0$)	11 (B_1B_0)	10 ($B_1\bar{B_0}$)
$\bar{A_1}\bar{A_0}$ 00	0 (0)	1 (1)	1 (3)	1 (2)
$\bar{A_1}A_0$ 01	0 (4)	0 (5)	1 (7)	1 (6)
A_1A_0 11	0 (12)	0 (13)	0 (15)	0 (14)
$A_1\bar{A_0}$ 10	0 (8)	0 (9)	1 (11)	0 (10)

$$\boxed{A<B} = \bar{A_1}B_1 + \bar{A_1}\bar{A_0}B_0 + \bar{A_0}B_1B_0$$

Case(i) : $\boxed{A>B}$

$$A>B = A_1\bar{B_1} + A_0\bar{B_1}\bar{B_0} + A_1A_0\bar{B_0}$$

$$= A_1\bar{B_1} + (A_1+\bar{A_1})A_0\bar{B_1}\bar{B_0} + A_1A_0(B_1+\bar{B_1})\bar{B_0}$$

$$= A_1\bar{B_1} + A_1A_0\bar{B_1}\bar{B_0} + \bar{A_1}A_0\bar{B_1}\bar{B_0} + A_1A_0B_1\bar{B_0} + \cancel{A_1A_0\bar{B_1}\bar{B_0}}$$

$$= A_1\bar{B_1} + A_1A_0\bar{B_1}\bar{B_0} + A_0\bar{B_0}(\bar{A_1}\bar{B_1} + A_1B_1)$$

$$= \underbrace{A_1\bar{B_1} + A_1A_0\bar{B_1}\bar{B_0}}_{\text{use adsorption law}} + (A_1 \odot B_1)A_0\bar{B_0}$$

$$= A_1\bar{B_1}(1 + A_0\bar{B_0}) + (A_1 \odot B_1)A_0\bar{B_0}$$

$$\boxed{A>B = A_1\bar{B_1} + (A_1 \odot B_1)A_0\bar{B_0}}$$

From (i), (ii) and (iii) cases:-

1101
1101

$$(A=B) = x_1x_0$$

$$(A>B) = A_1\bar{B_1} + x_1A_0\bar{B_0}$$

$$(A<B) = \bar{A_1}B_1 + x_1\bar{A_0}B_0$$

Scanned by CamScanner

case (iii): $\boxed{A < B}$

$$A<B = \bar{A}_1 B_1 + \bar{A}_1 \bar{A}_0 B_0 (B_1 + \bar{B}_1) + \bar{A}_0 B_1 B_0 (A_1 + \bar{A}_1)$$

$$= \bar{A}_1 B_1 + \bar{A}_1 \bar{A}_0 B_0 \bar{B}_1 + \bar{A}_1 \bar{A}_0 \bar{B}_1 B_0 + A_1 \bar{A}_0 B_1 B_0 + \bar{A}_1 \bar{A}_0 B_1 B_0$$

$$= \bar{A}_1 B_1 (1 + \bar{A}_0 B_0) + \bar{A}_0 B_0 (\bar{A}_1 \bar{B}_1 + A_1 B_1)$$

$$= \bar{A}_1 B_1 + \bar{A}_0 B_0 \underbrace{(A_1 \odot B_1)}_{X_1} = \bar{A}_1 B_1 + \bar{A}_0 B_0 X_1$$

From ①

case(ii) $\boxed{A = B}$:-

$$= \bar{A}_1 \bar{A}_0 \bar{B}_1 \bar{B}_0 + \bar{A}_1 A_0 \bar{B}_1 B_0 + A_1 A_0 B_1 B_0 + A_1 \bar{A}_0 B_1 \bar{B}_0$$

$$= \bar{A}_1 \bar{B}_1 (\bar{A}_0 \bar{B}_0 + A_0 B_0) + A_1 B_1 (A_0 B_0 + \bar{A}_0 \bar{B}_0)$$

$$= \bar{A}_1 \bar{B}_1 (A_0 \odot B_0) + A_1 B_1 (A_0 \odot B_0)$$

$$= (A_0 \odot B_0)(\bar{A}_1 \bar{B}_1 + A_1 B_1)$$

$$= (A_0 \odot B_0)(A_1 \odot B_1)$$

$$= \cancel{X_0 X_0 +} X_1 X_0$$

Let $X_1 = A_1 \odot B_1$
$X_0 = A_0 \odot B_0$ } → ①

similarly $\boxed{X_i = A_i \odot B_i}$

While comparing:
LHS → RHS
left to Right.

eg:- $X > Y$

$X = 53432178$

$Y = 53421787$

1101
1101

4-bit

$A = A_3\, A_2\, A_1\, A_0$

$B = B_3\, B_2\, B_1\, B_0$

$(A > B) = A_3\overline{B_3} + X_3 A_2 \overline{B_2} + X_3 X_2 A_1 \overline{B_1} + X_3 X_2 X_1 A_0 \overline{B_0}$

$(A < B) = \overline{A_3} B_3 + X_3 \overline{A_2} B_2 + X_3 X_2 \overline{A_1} B_1 + X_3 X_2 X_1 \overline{A_0} B_0$

$(A = B) = X_3 X_2 X_1 X_0$

21.08.18.

1Q. Design a combinational circuit with 3 inputs and 1 output. The output is 1, ~~when~~ when the binary value of input is less than 3. The output is 0 otherwise.

$2^3 \rightarrow 8$ combination

Full adder

$\Rightarrow$

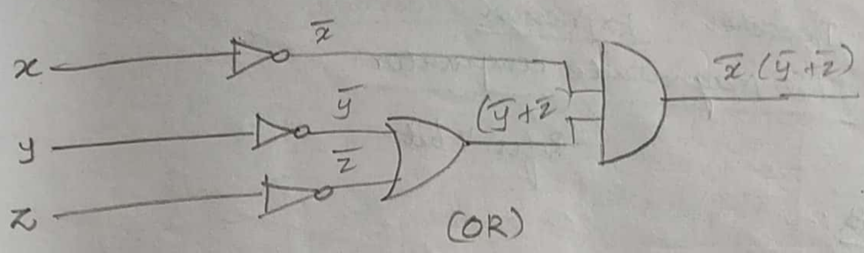
	x	y	z	o/p
0	0	0	0	1
1	0	0	1	1
2	0	1	0	1
3	0	1	1	0
4	1	0	0	0
5	1	0	1	0
6	1	1	0	0
7	1	1	1	0

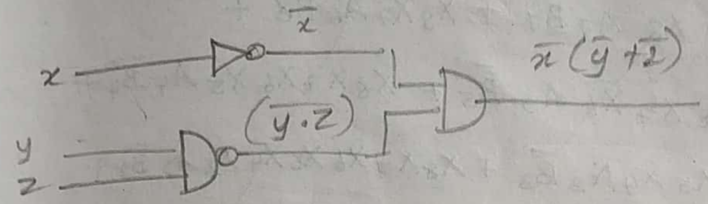
x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	1 (0)	1 (1)	0 (3)	1 (2)
x 1	0 (4)	0 (5)	0 (7)	0 (6)

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

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

2.Q)



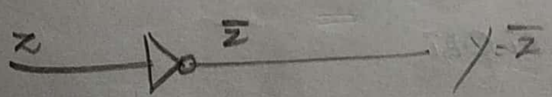


2. Q) Design a combinational circuit with 3 i/p and 1 output. The output is 1 when the binary value of i/p is even no & otherwise 0.

	x	y	z	o/p
0	0	0	0	1
1	0	0	1	0
2	0	1	0	1
3	0	1	1	0
4	1	0	0	1
5	1	0	1	0
6	1	1	0	1
7	1	1	1	0

x \ yz	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
$\bar{x}$ 0	1 (0)	0 (1)	0 (3)	1 (2)
x 1	1 (4)	0 (5)	0 (7)	1 (6)

$= \bar{z}$



28.08.18

~~Decoder.~~ Expression

8bit Magnitude comparator:

Refer 4 bit.

$\Rightarrow$ **A>B :-**

$$= A_8\bar{B_8} + x_8 A_7\bar{B_7} + x_8x_7A_6\bar{B_6} +$$
$$x_8x_7x_6A_5\bar{B_5} + x_8x_7x_6x_5A_4\bar{B_4} +$$
$$x_8x_7x_6x_5x_4A_3\bar{B_3} + x_8x_7x_6x_5x_4x_3A_2\bar{B_2} +$$
$$x_8x_7x_6x_5x_4x_3x_2A_1\bar{B_1} + x_8x_7x_6x_5x_4x_3x_2x_1A_0$$

$\Rightarrow$ ~~A<~~ **A>B**

$$= A_7\bar{B_7} + x_7A_6\bar{B_6} + x_7x_6A_5\bar{B_5} +$$
$$x_7x_6x_5A_4\bar{B_4} + x_7x_6x_5x_4A_3\bar{B_3} +$$
$$x_7x_6x_5x_4x_3A_2\bar{B_2} + x_7x_6x_5x_4x_3x_2A_1\bar{B_1} +$$
$$x_7x_6x_5x_4x_3x_2x_1A_0\bar{B_0}$$

$\Rightarrow$ **A<B**

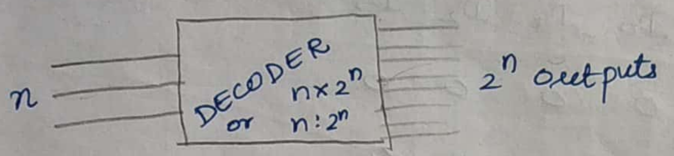
$$= \bar{A_7}B_7 + x_7\bar{A_6}B_6 + x_7x_6\bar{A_5}B_5 +$$
$$x_7x_6x_5\bar{A_4}B_4 + x_7x_6x_5x_4\bar{A_3}B_3 +$$
$$x_7x_6x_5x_4x_3\bar{A_2}B_2 + x_7x_6x_5x_4x_3x_2\bar{A_1}B_1 +$$
$$x_7x_6x_5x_4x_3x_2x_1\bar{A_0}B_0$$

$\Rightarrow$ **A = B**

$$x_7x_6x_5x_4x_3x_2x_1x_0$$

$$x_i = A_i \odot B_i$$

DECODER



n	2^n
2	$2^2 = 4$
3	$2^3 = 8$
4	$2^4 = 16$

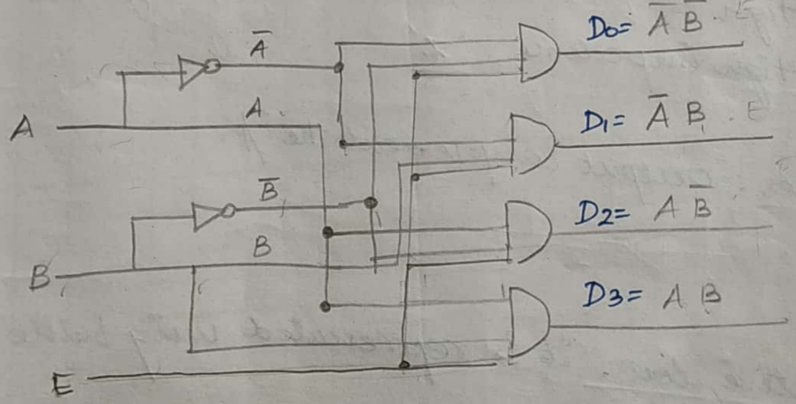
example :-

2 : 4
3 : 8
4 : 16
input output

Accepts n inputs and gives 2^n outputs.
Mostly we use AND gates.

if 4 outputs are required, we use 4 and gates.

2 to 4 Decoder :



Truth table.

i/p	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

[Decoder generates 1 in one of the bits]

Use :-
Interconnecting ~~proc~~ components bet i/p and processor

(At the time any 1 of the o/p generates!)

E → enable

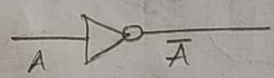
E	A	B	D_0	D_1	D_2	D_3
0	0	0	0	0	0	0
1	0	0	1	0	0	0
1	0	1	0	1	0	0
1	1	0	0	0	1	0
1	1	1	0	0	0	1

E is the extra bit given to i/p

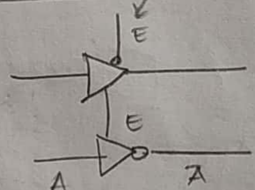
The above concept represents
<u>TRISTATE device</u>.

1. Low → If enable is properly given <u>'0'</u>
2. High → If the enable is not properly given <u>'1'</u>
3. High impedence. <u>'Z'</u>

<u>Inverter</u>: Output complements the i/p.



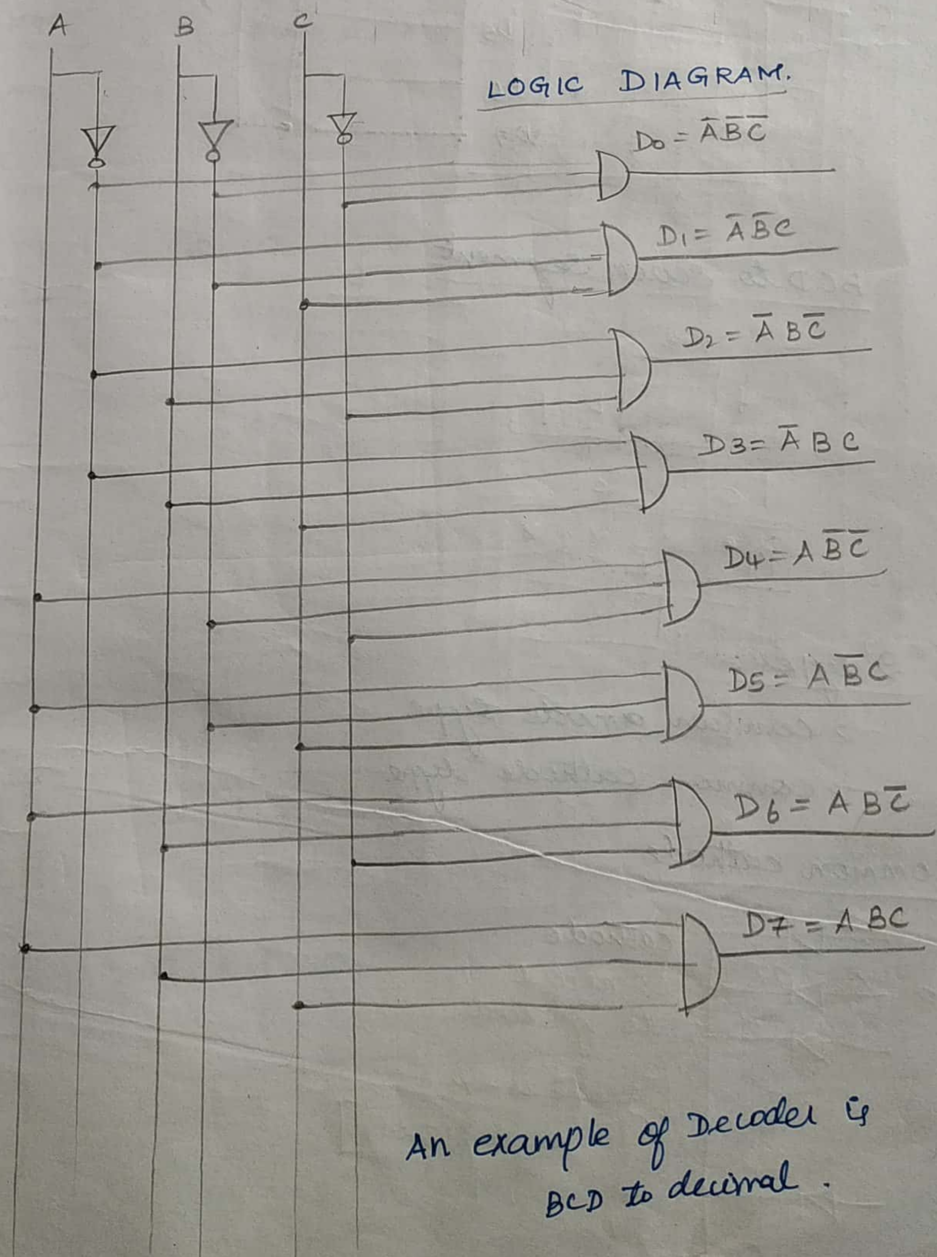
If <u>active low</u>, it is represented using bubble.



3 to 8 is widely used. $\boxed{74LS138}$

3 to 8 decoder without Enable

i/p			o/p							
A	B	C	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

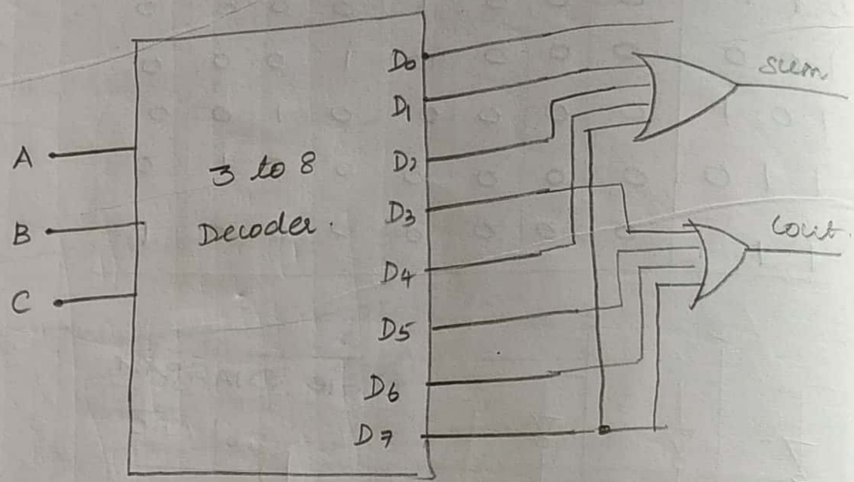


An example of Decoder is BCD to decimal.

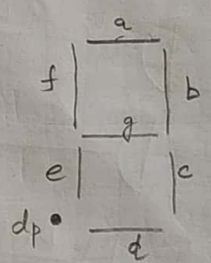
Full adder using Decoder.

$$Sum = \Sigma(\overset{D_1}{1}, \overset{D_2}{2}, \overset{D_4}{4}, \overset{D_7}{7})$$

$$Cout = \Sigma(\overset{D_3}{3}, \overset{D_5}{5}, \overset{D_6}{6}, \overset{D_7}{7})$$



BCD to Seven segment.

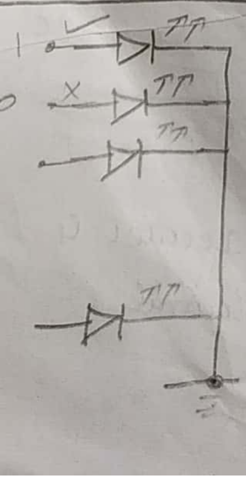


2 types :-

→ common anode type

→ common cathode type.

* common cathode



cathode connected to ground

[(Anode is +ve forward biased)]

* common

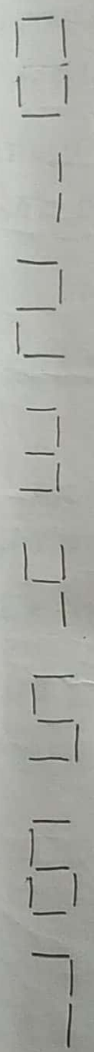
HW

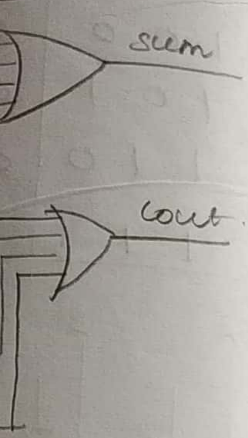
Q) How wil

1.08.18

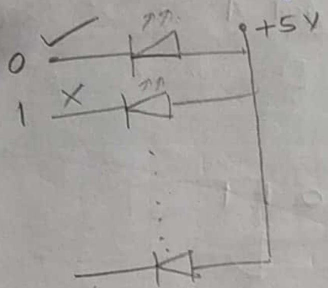
Digit

DIGIT





* common anode type:



HW

Q) How will you design 7-segment display

31.08.18

Digit ~~abcde~~

DIGIT	A_3 A_2 A_1 A_0	a b c d e f g
0	0 0 0 0	1 1 1 1 1 1 0
1	0 0 0 1	0 1 1 0 0 0 0
2	0 0 1 0	1 1 0 1 1 0 1
3	0 0 1 1	1 1 1 1 0 0 1
4	0 1 0 0	0 1 1 0 0 1 1
5	0 1 0 1	1 0 1 1 0 1 1
6	0 1 1 0	1 0 1 1 1 1 1
7	0 1 1 1	1 1 1 0 0 0 0

Digit	$A_3\,A_2\,A_1\,A_0$	a b c d e f g
	1 0 0 0	1 1 1 1 1 1 1
	1 0 0 1	1 1 1 0 0 1 1

Kmap for a:

A_3A_2 \ A_1A_0	$\bar{A}_1\bar{A}_0$ 00	$\bar{A}_1A_0$ 01	A_1A_0 11	$A_1\bar{A}_0$ 10
$\bar{A}_3\bar{A}_2$ 00	1 (0)	0 (1)	1 (3)	1 (2)
$\bar{A}_3A_2$ 01	0 (4)	1 (5)	1 (7)	1 (6)
A_3A_2 11	X (12)	X (13)	X (15)	X (14)
$A_3\bar{A}_2$ 10	1 (8)	1 (9)	X (11)	X (10)

$$a = A_3 + A_1 + A_2A_0 + A_3\bar{A}_0$$

For b:

A_3A_2 \ A_1A_0	$\bar{A}_1\bar{A}_0$ 00	$\bar{A}_1A_0$ 01	A_1A_0 11	$A_1\bar{A}_0$ 10
$\bar{A}_3\bar{A}_2$ 00	1 (0)	1 (1)	1 (3)	1 (2)
$\bar{A}_3A_2$ 01	1 (4)	0 (5)	1 (7)	0 (6)
A_3A_2 11	X (12)	X (13)	X (15)	X (14)
$A_3\bar{A}_2$ 10	1 (8)	1 (9)	X (11)	X (10)

$$b = A_3 + \bar{A}_2 + \bar{A}_1\bar{A}_0 + A_1A_0$$

For c:

For d:

For e:

e =

For c:

A_3A_2 \ A_1A_0	00 ($\bar{A}_1\bar{A}_0$)	01 ($\bar{A}_1A_0$)	11 (A_1A_0)	10 ($A_1\bar{A}_0$)
$\bar{A}_3\bar{A}_2$ 00	1 (0)	1 (1)	1 (3)	0 (2)
$\bar{A}_3A_2$ 01	1 (4)	1 (5)	1 (7)	1 (6)
A_3A_2 11	X (12)	X (13)	X (15)	X (14)
$A_3\bar{A}_2$ 10	1 (8)	1 (9)	X (11)	X (10)

$A_2 + \bar{A}_1 + A_1A_0 = c$

For d:

A_3A_2 \ A_1A_0	00 ($\bar{A}_1\bar{A}_0$)	01 ($\bar{A}_1A_0$)	11 (A_1A_0)	10 ($A_1\bar{A}_0$)
$\bar{A}_3\bar{A}_2$ 00	1 (0)	0 (1)	1 (3)	1 (2)
$\bar{A}_3A_2$ 01	0 (4)	1 (5)	0 (7)	1 (6)
A_3A_2 11	X	X	X	X
$A_3\bar{A}_2$ 10	1 (8)	0 (9)	X	X

$\bar{A}_2\bar{A}_1$

$d = A_1\bar{A}_0 + \bar{A}_2\bar{A}_0 + \cancel{\bar{A}_2\bar{A}_0} +$
$A_2\bar{A}_1A_0$

For e:

A_3A_2 \ A_1A_0	00 ($\bar{A}_1\bar{A}_0$)	01 ($\bar{A}_1A_0$)	11 (A_1A_0)	10 ($A_1\bar{A}_0$)
$\bar{A}_3\bar{A}_2$ 00	1 (0)	0 (1)	0 (3)	1 (2)
$\bar{A}_3A_2$ 01	0 (4)	0 (5)	0 (7)	1 (6)
A_3A_2 11	X	X	X	X
$A_3\bar{A}_2$ 10	1 (8)	0 (9)	X	X

$e = \bar{A}_2\bar{A}_0 + A_1\bar{A}_0$

For f

A_3A_2 \ A_1A_0	00	01	11	10
00	1 (0)	0 (1)	0 (3)	0 (2)
$\bar{A}_3A_2$ 01	1 (4)	1 (5)	0 (7)	1 (6)
A_3A_2 11	X	X	X	X
10	1 (8)	1 (9)	X	X

$A_2\bar{A}_1$

$\bar{A}_1\bar{A}_0 + A_3 + \cancel{\bar{A}_1\bar{A}_0\bar{A}_2} +$
$A_2\bar{A}_0 \Rightarrow f$

For g

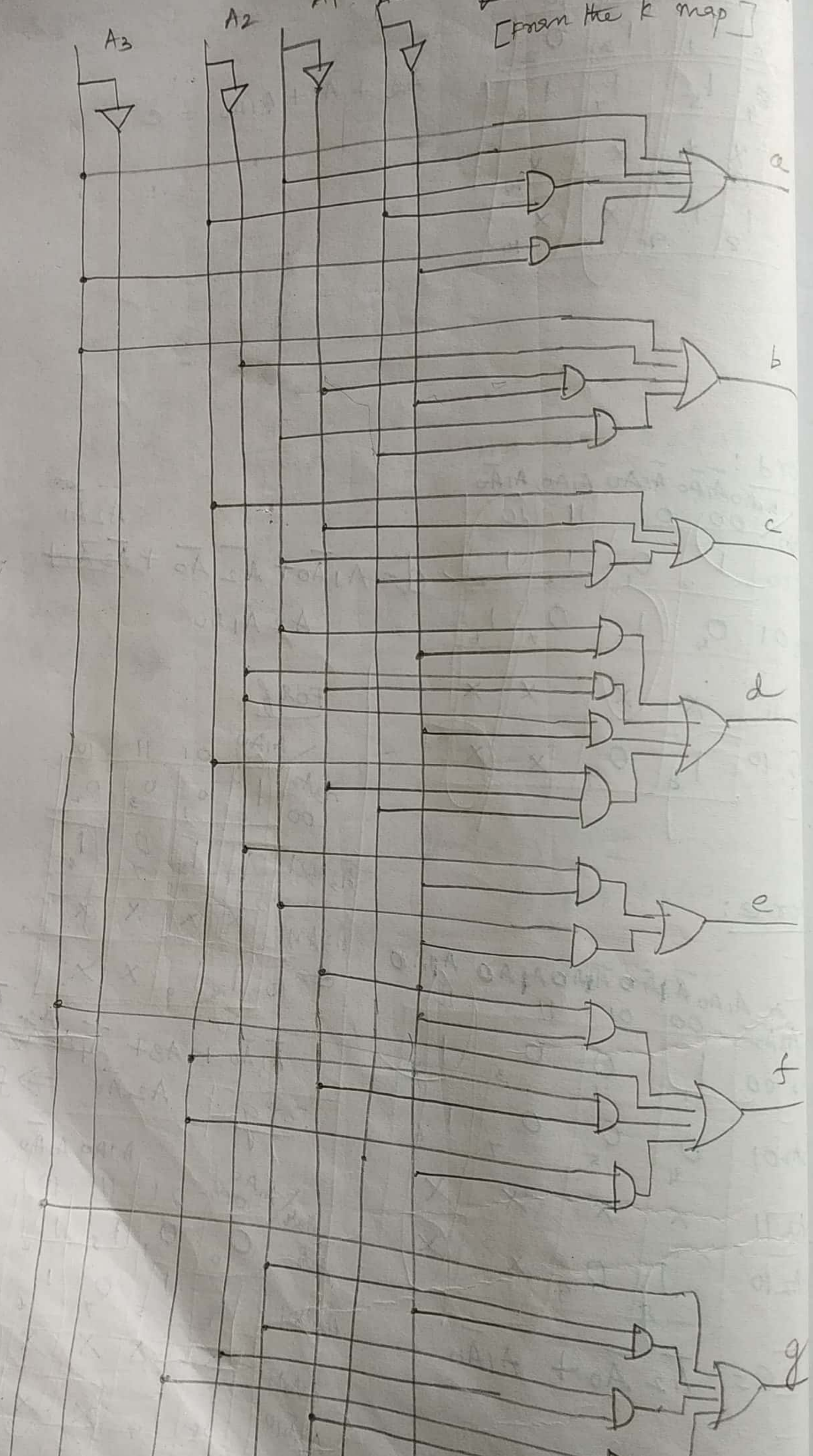
A_3A_2 \ A_1A_0	00	01	11 (A_1A_0)	10 ($A_1\bar{A}_0$)
$\bar{A}_3\bar{A}_2$ 00	0 (0)	0 (1)	1 (3)	1 (2)
$\bar{A}_3A_2$ 01	1 (4)	1 (5)	0 (7)	1 (6)
A_3A_2 11	X	X	X	X
$A_3\bar{A}_2$ 10	1 (8)	1 (9)	X	X

$g = A_3 + A_1\bar{A}_0 + A_1\bar{A}_2 +$
$A_2\bar{A}_1$

LOGIC DIAGRAM

for 7 segment display

[From the k map]



2^n inputs

4

Inputs

D0	D1
1	0
0	1
0	0
0	0

D0

D1

D2

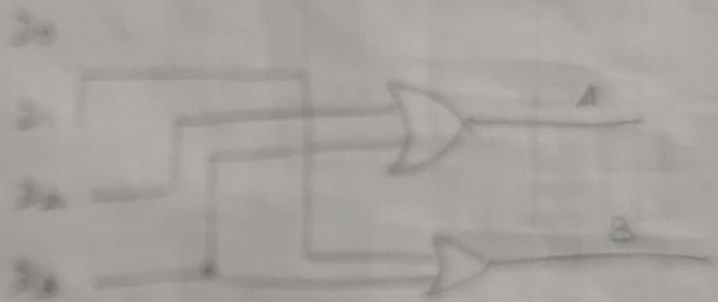
D3

Encoder

2^n inputs and n outputs

4:2 Encoder

Inputs				Outputs		
D_0	D_1	D_2	D_3	A	B	B
1	0	0	0	0	0	
0	1	0	0	0	1	
0	0	1	0	1	0	
0	0	0	1	1	1	



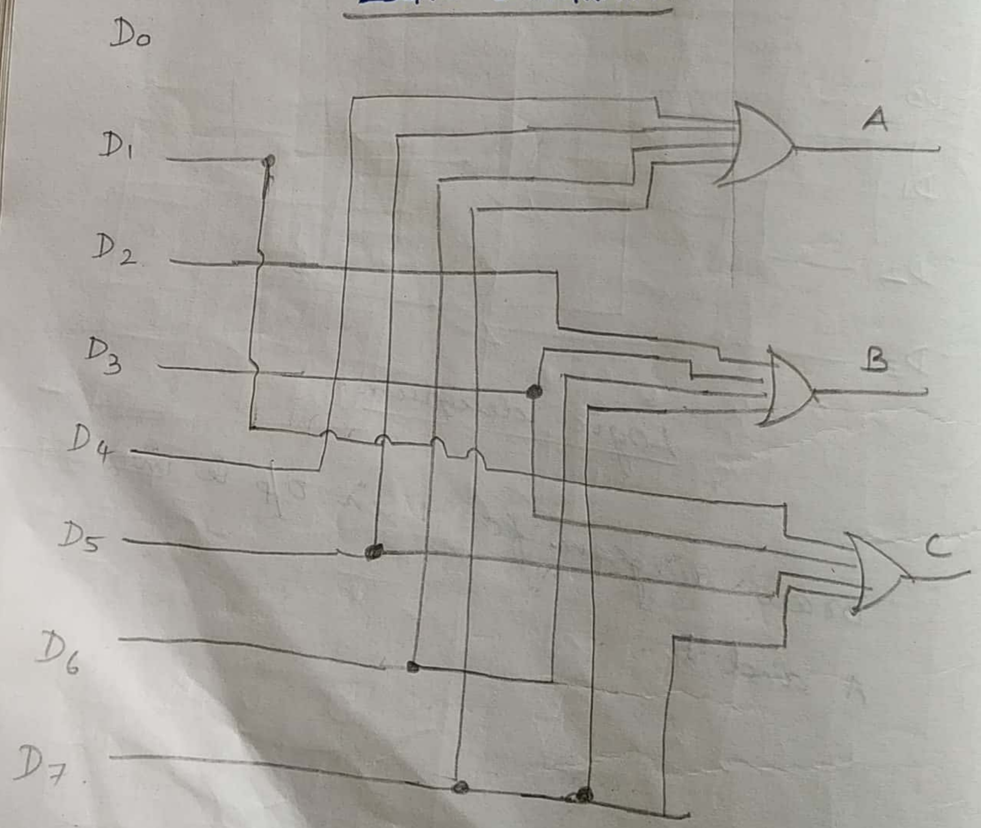
Logic diagram.

Draw diagram for 1 in o/p i.e in A and B.

8:3 Encoder:

D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	A	B	C
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

LOGIC DIAGRAM.

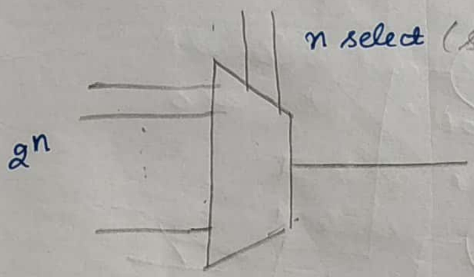


Multiplexer (or) Mux

2^n inputs 1 output

& has n number of select lines

Also called as Data Selector

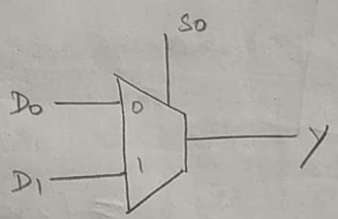


examples

Mux	select lines
2 : 1	1
4 : 1	2
8 : 1	3
16 : 1	4

examples :

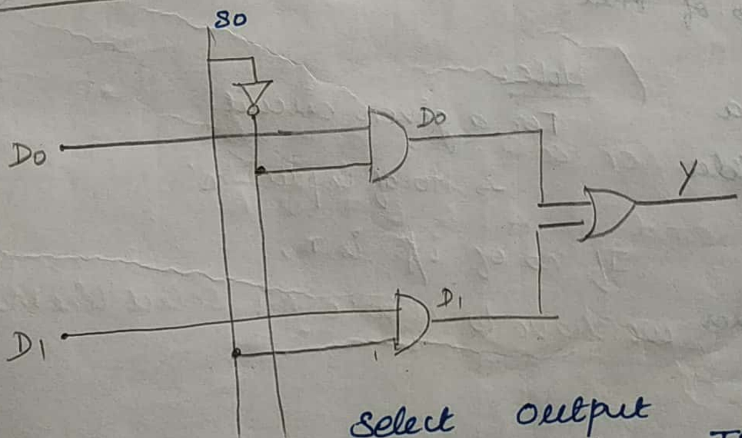
1 ⟹ 2:1 Mux



$S_0 = 0$ $y = D_0$

$S_0 = 1$ $y = D_1$

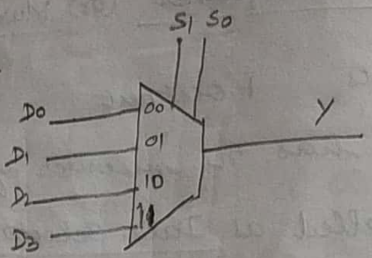
LOGIC DIAGRAM:

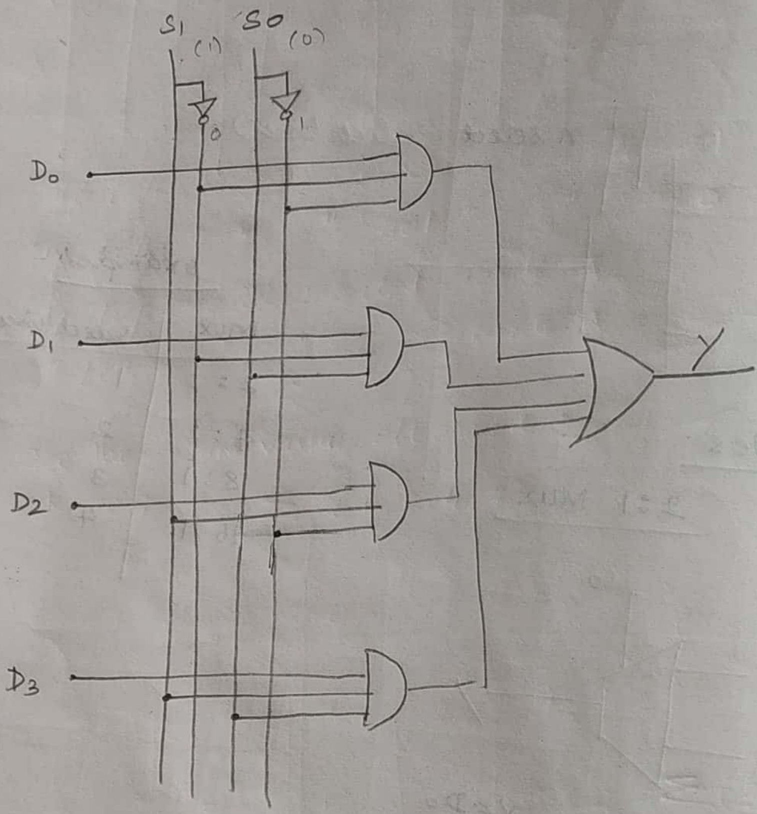


Select	Output
S_0	y
0	D_0
1	D_1

TRUTH TABLE

2 ⇒ 4 : 1 MUX





Advantage:

We can design any digital ckt with the help of Mux

Q. Design a full adder using Multiplexer

(Note:
For a given circuit
→ No of inputs 'n'
If no of i/p is n,
we have to choose n-1 select line Mux)

Θ

From the Truth table of full adder

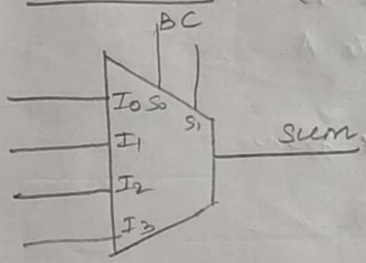
$$Sum = \Sigma(1, 2, 4, 7)$$

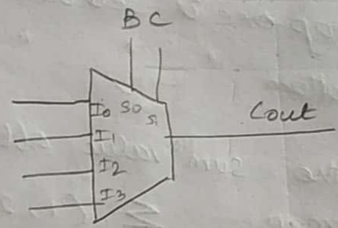
$$Cout = \Sigma(3, 5, 6, 7)$$

i/p → 3	output
(A B C)	sum, carry.

2 select lines → so choose 4:1 MUX (they have 2 select lines)

4:1 MUX (we use separate mux for sum & carry)





For Implementation table draw the truth table of full adder first.

		A	B (select lines)	C (select lines)	Sum	carry
$\bar{A}$	0	0	0	0	0	0
	1	0	0	1	1	0
	2	0	1	0	1	0
	3	0	1	1	0	1
A	4	1	0	0	1	0
	5	1	0	1	0	1
	6	1	1	0	0	1
	7	1	1	1	1	1

Implementation table for sum.

	I_0	I_1	I_2	I_3
$\bar{A}$	0	1	2	3
A	4	5	6	7
	A	$\bar{A}$	$\bar{A}$	A

② If both the nos are circled write as 1
If both " " " not " " as 0
If top one is selected write $\bar{A}$
" bottom " " " write A

① See the sum value obtained from k map $\Sigma(1, 2, 4, 7)$

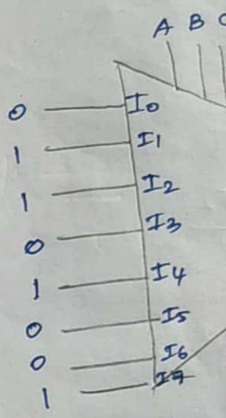
Implementation table for carry

	I_0	I_1	I_2	I_3
$\bar{A}$	0	1	2	3
A.	4	5	6	7
	0	A	A	1

$\Sigma(3, 5, 6, 7)$
(from full addr

always for a 0, 1 2 3 is A
and 4 5 6 7 is $\bar{A}$

Using 8



Q. $F_1 = \Sigma(0, 1$
$F_2 = \Sigma(1$

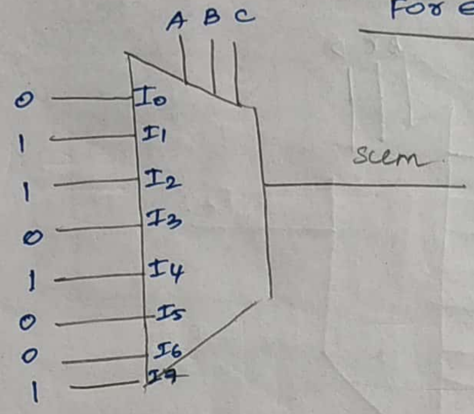
$\Rightarrow$ i/p —

8:1 Mu

		A	B	C
$\bar{A}$	0	0	0	0
	1	0	0	0
	2	0	0	1
	3	0	0	1
	4	0	1	0
	5	0	1	0
	6	0	1	1
	7	0	1	1
A	8	1	0	0
	9	1	0	0
	10	1	0	1
	11	1	0	
	12	1	1	0
	13	1	1	0
	14	1	1	
	15	1	1	

Using 8:1 MUX

For example



Q. $F_1 = \Sigma(0, 1, 3, 5, 7, 9, 11, 12)$

$F_2 = \Sigma(1, 5, 7, 11, 12, 13, 15)$

$\Rightarrow$ i/p $\rightarrow$ 4 $\Rightarrow n$

no of select lines $n-1 = 3$

(choose 8:1 MUX)

8:1 MUX

		A	B	C	D
$\bar{A}$	0	0	0	0	0
	1	0	0	0	1
	2	0	0	1	0
	3	0	0	1	1
	4	0	1	0	0
	5	0	1	0	1
	6	0	1	1	0
	7	0	1	1	1
A	8	1	0	0	0
	9	1	0	0	1
	10	1	0	1	0
	11	1	0	1	1
	12	1	1	0	0
	13	1	1	0	1
	14	1	1	1	0
	15	1	1	1	1

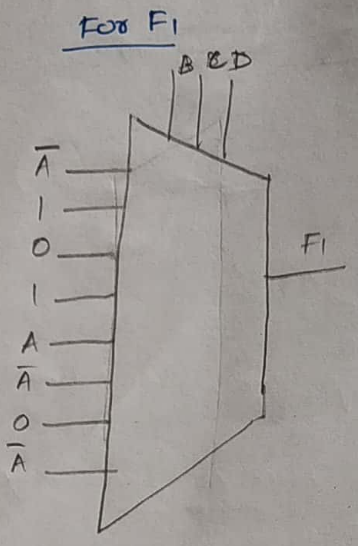
For F_1

	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7
$\bar{A}$	0	1	2	3	4	5	6	7
A	8	9	10	11	12	13	14	15
	$\bar{A}$	1	0	1	A	$\bar{A}$	0	$\bar{A}$

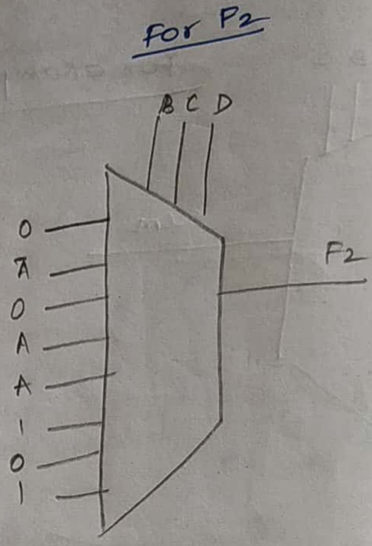
For F_2

	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7
$\bar{A}$	0	1	2	3	4	5	6	7
A	8	9	10	11	12	13	14	15
	0	$\bar{A}$	0	A	A	1	0	1

For F_1



For F_2



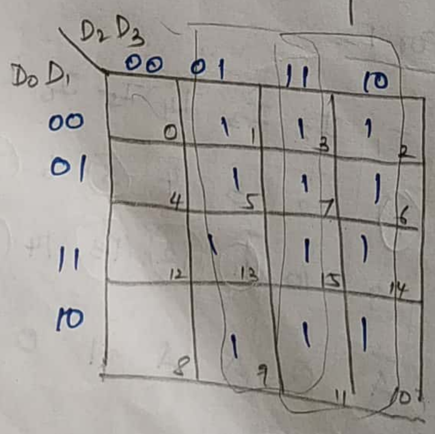
4/9/18

Priority Encoder.

4:2

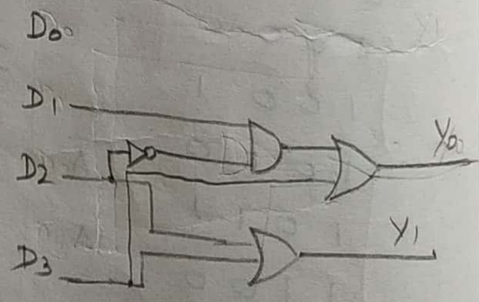
	D_0	D_1	D_2	D_3	Y_1	Y_0
8	1	0	0	0	0	0
4, 12	X	1	0	0	0	1
2, 6, 10, 14	X	X	1	0	1	0
1, 3, 5, 7, 9, 11, 13, 15.	X	X	X	1	1	1

$Y_1 \Rightarrow$

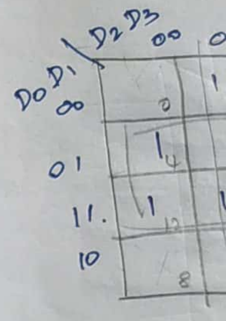


$Y_1 = D_3 + D_2$

LOGIC Diagram



For Y_0



$\Rightarrow$ 8:3 P

	D_0	D_1	D_2
	1	0	0
	X	1	0
	X	X	1
3	X	X	X
4	X	X	X
5	X	X	X
6	X	X	X
7	X	X	X

$Y_2 = \Sigma$

$= D$

$Y_1 = \Sigma(2,$

$= D_2 \bar{D}$

$Y_0 = \Sigma($

$= D_7$

Draw

For Y_0

D_0D_1 \ D_2D_3	00	01	11	10
00	(0)	1 (1)	1 (3)	(2)
01	1 (4)	1 (5)	1 (7)	(6)
11	1 (12)	1 (13)	1 (15)	(14)
10	(8)	1 (9)	1 (11)	(10)

~~0x0~~ in priority encoder we get simultaneous encoder

$$Y_0 = D_3 + D_1\overline{D_2}$$

⇒ **8 : 3 PE**

001

	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	Y_2	Y_1	Y_0
	128	64	32	16	8	4	2	01			
0	1	0	0	0	0	0	0	0	0	0	0
1	X	1	0	0	0	0	0	0	0	0	1
2	X	X	1	0	0	0	0	0	0	1	0
3	X	X	X	1	0	0	0	0	0	1	1
4	X	X	X	X	1	0	0	0	1	0	0
5	X	X	X	X	X	1	0	0	1	0	1
6	X	X	X	X	X	X	1	0	1	1	0
7	X	X	X	X	X	X	X	1	1	1	1

$$Y_2 = \Sigma(4, 5, 6, 7)$$

expression write from MSB

$$= D_4 + D_5\overline{D_6}\,\overline{D_7} + D_6\overline{D_7} + D_7$$

$$Y_1 = \Sigma(2, 3, 6, 7)$$

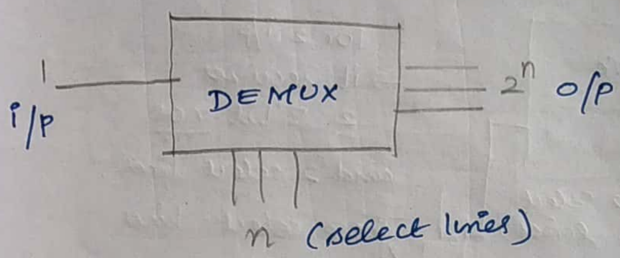
$$= D_2\overline{D_3}\,\overline{D_4}\,\overline{D_5}\,\overline{D_6}\,\overline{D_7} + D_3\overline{D_4}\,\overline{D_5}\,\overline{D_6}\,\overline{D_7} + D_6\overline{D_7} + D_7$$

$$Y_0 = \Sigma(1, 3, 5, 7)$$

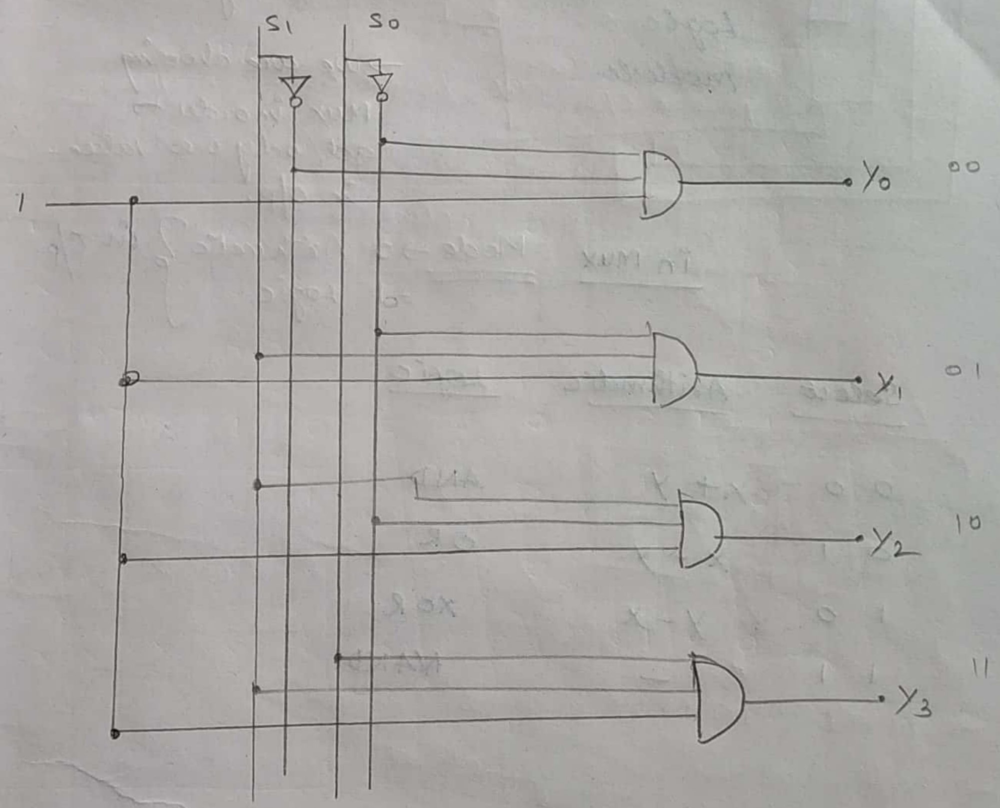
$$= D_7 + D_5\overline{D_6}\,\overline{D_7} + D_3\overline{D_4}\,\overline{D_5}\,\overline{D_6}\,\overline{D_7} + D_1\overline{D_2}\,\overline{D_3}\,\overline{D_4}\,\overline{D_5}\,\overline{D_6}\,\overline{D_7}$$

Draw logic diagram:-

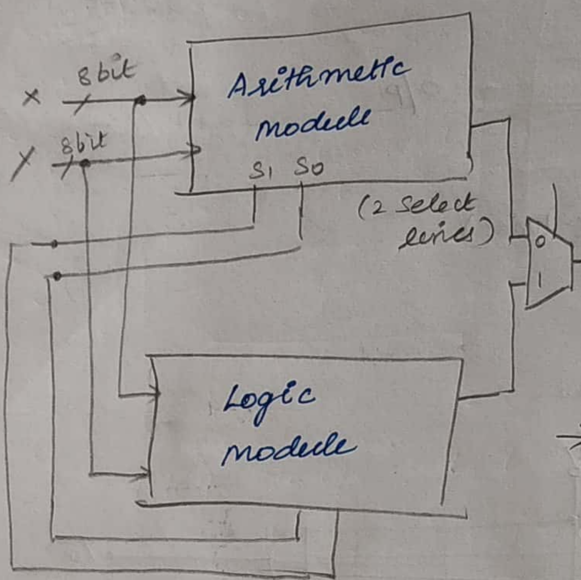
Demultiplexer



1:4 Demux



8-bit ALU:-



For 2 i/p
→ it receives 2 8'bit nos
and 2 select lines
These select lines are fed to the select lines of Logic module.

→ We are choosing Mux inorder to get only one value in o/p.

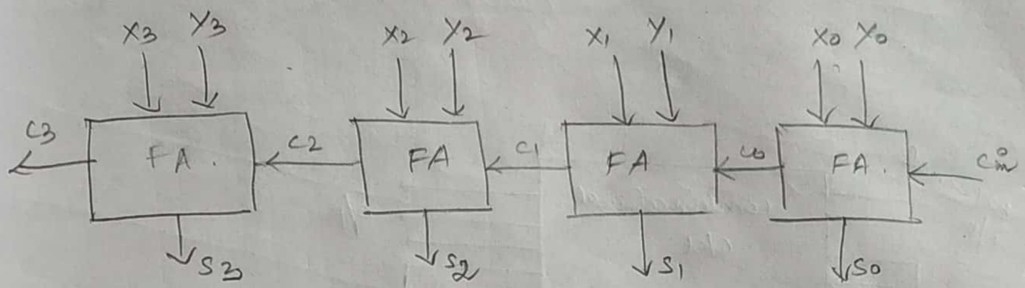
in Mux Mode → 0 Arithmetic
= 1 Logic
in o/p

Select	Arithmetic	Logic
0 0	x + y	AND
0 1	x − y	OR
1 0	y − x	XOR
1 1	—	NAND

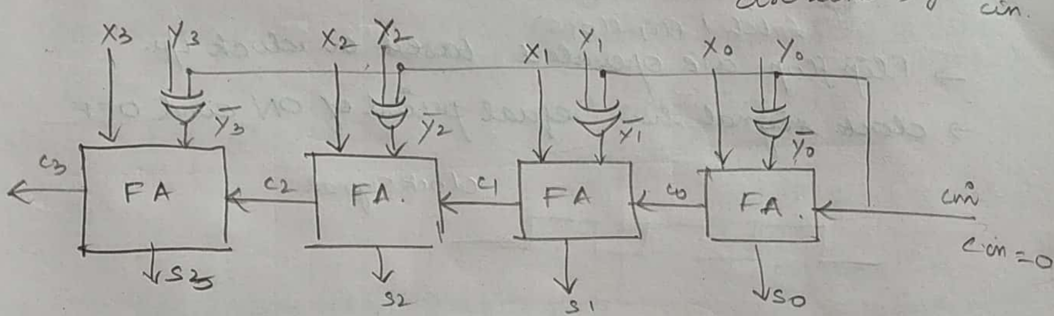
For performing Arithmetic operations :
x + y and x − y.

Using 4 bit → construct 4 F.A
(RCA)

4 bit Adder & Subtractor



For X+Y & X-Y



	cin	y	o/p
x+y	0	0	0
	0	1	1
x−y	1	0	1
	1	1	0

when cin = 0

$x + y + 0$

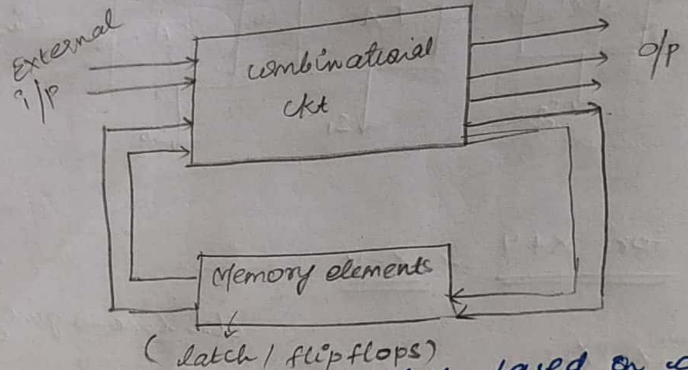
when cin = 1

$x + \bar{y} + 1$ → 2's complement

$= x - y$

7.9.18

UNIT - 3 SYNCHRONOUS SEQUENTIAL CIRCUITS.



→ Flip flops are operated based on clock i/p.

→ clock signal has equal period of ON and OFF

clock signal.

LATCHES:-

→ Does not have clock signal

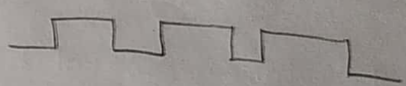
→ It has Combination of gates

→ They are mostly used as feed back elements in asynchronous ckt

→ LEVEL TRIGGERED signals (Latches)

→ o/p responds during the level

→ Flip flops are edge triggered clock signal.



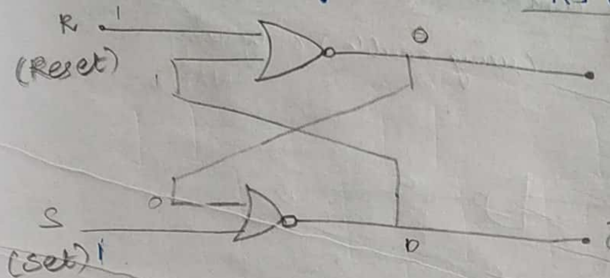
* SR latch (Basic latch)

↙ ↘

NOR NAND

Using NOR

RS (or) Set Reset Latch



* When i/p is 0,0 the it will retain the previous o/p.

* If we give 1,0, it will change the previous

NOR

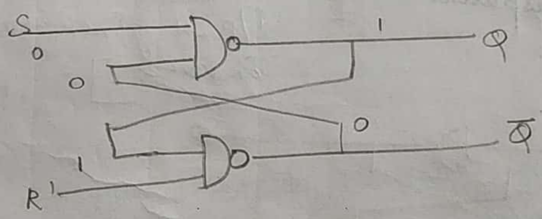
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Truth table from the above diagram

R	S	Q	$\overline{Q}$	
0	1	1	0	
0	0	1	0	(the value is retained)
1	0	0	1	
0	0	0	1	
$\boxed{1}$	$\boxed{1}$	$\boxed{0}$	$\boxed{0}$	(invalid)

(in flip flop, it is indetermined state)

SR latch using NAND gate



initial case assume 0,1; depending upon o/p change the previous value.

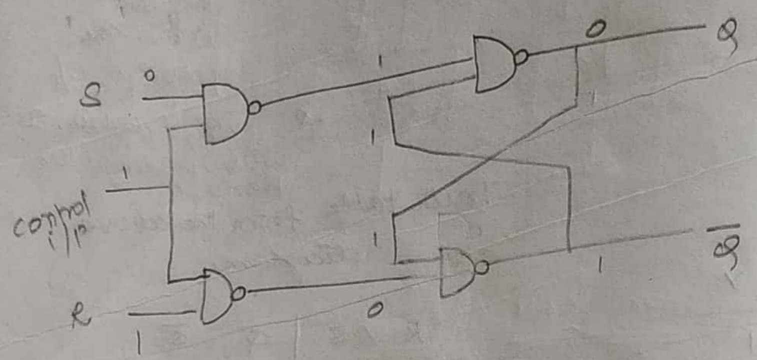
NAND

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

S	R	Q	$\overline{Q}$	
0	1	1	0	
1	1	1	0	(retain the previous value)
		0	1	
1	0			
1	1	0	1	
0	0	1	1	invalid

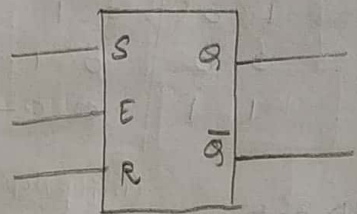
SR latch using controls.

(using enable) only using NAND.

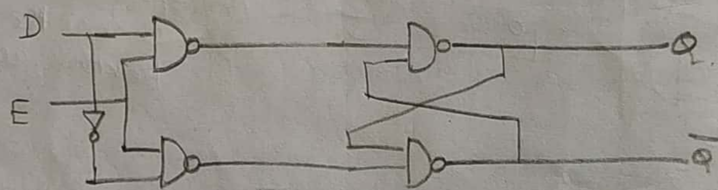


symbol of Latch

For '0' we put bubble



D LATCH :- (Transparent latch) [In SR latch, one i/p is given to inverter.]



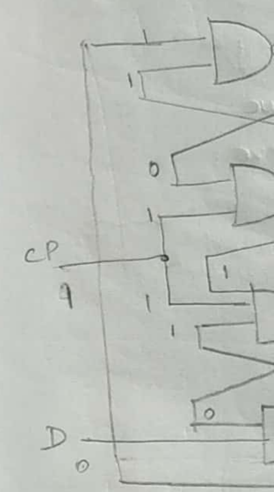
(Mostly 'D' flipflops is used for designing)

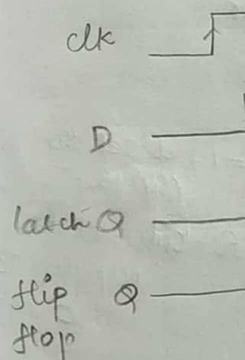
* Respond to changes given to level (in lab)

* concept of latch & D-flipflop is it follows the i/p (o/p follows i/p)

if D is 1, Q is 1	if E is 0, $\overline{Q}$ is 0
if " " 0, " " 0	if " " 1, $\overline{Q}$ " 1

Positive edg





→ C

the o/p

TRU

D
0
0

enable) only using NAND.

r '0' we
put bubble

R latch, one
i/p is given to
nverter.]

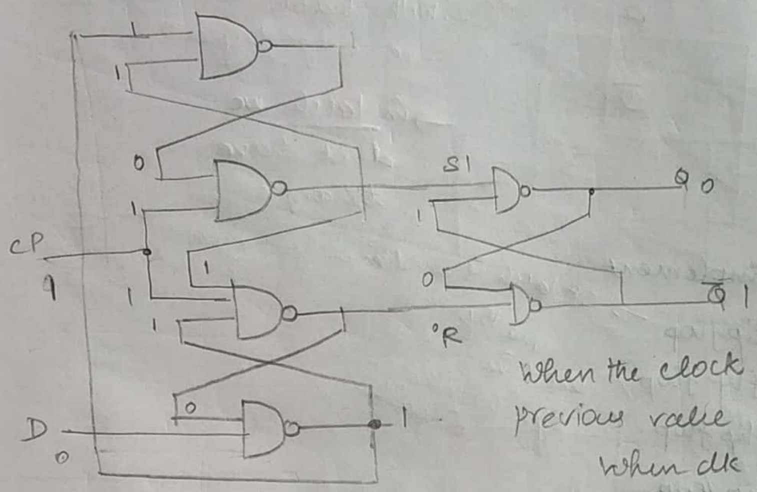
tly 'D' flipflops
used for
signing)
(in lab)

follows the i/p

Positive edge triggered D-flip flop.

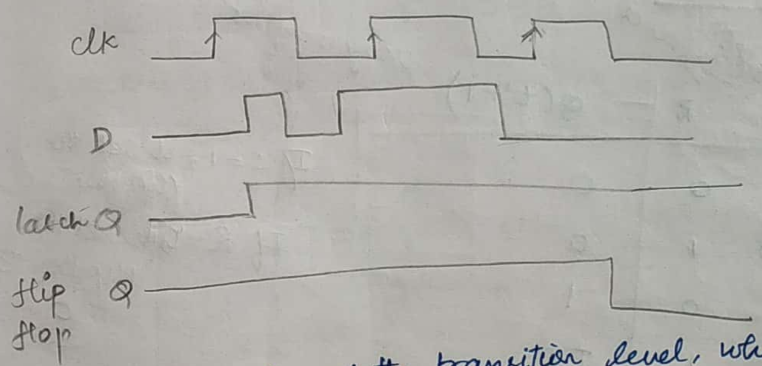
→ one of i/p is 0, the o/p is 1 (first part)

both i/p ⇒ 1 o/p is 0



When the clock pulse is 0, previous value is retained

when clk pulse is 1 there is a change, output follows the i/p



→ Only at the transition level, when the o/p changes, it is called as flipflop.

TRUTH TABLE. for D flip flop (characteristic Table)

D	Q
0	0
1	1

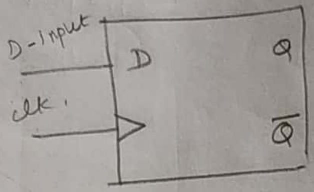
before clock

assume clk transition is from low to high

Q(t)	D	Q(t+1)
0	0	0
0	1	1
1	0	0
1	1	1

D value retains as it is.

SYMBOL



→ Without bubble +ve edge trigger

→ With bubble -ve edge trigger.

→ in latch we dont have triangle

We can implement

S-R flipflop → SR latch is used in asynchronous circuit.

J-K flip flop } mostly used in synchronous circuits.

(Toggle) T flip flop.

D flip flop

SR FLIP FLOP

Using NOR gate.

Q	S (set)	R (Reset)	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	I.D.
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	I.D

If S=1, it set the flip flop

If R=1, it reset the flipflop 0

General characteristic table of SR Latch.

S	R	Q(t)
0	0	Q(t)
0	1	0 → (Reset)
1	0	1 → set
1	1	Indetermined

JK FLIP flop

J	K	Q(t+1)
0	0	Q(t)
0	1	0
1	0	1
1	1	$\overline{Q(t)}$

Q	J	K	Q(t+1)	
0	0	0	0	0
0	0	1	0	1
0	1	0	1	2
0	1	1	1	3
1	0	0	1	4
1	0	1	0	5
1	1	0	1	6
1	1	1	0	7

T flipflop is implemented from JK flipflop to avoid racing condition (complemented form)

Apply k map for Q(t+1)

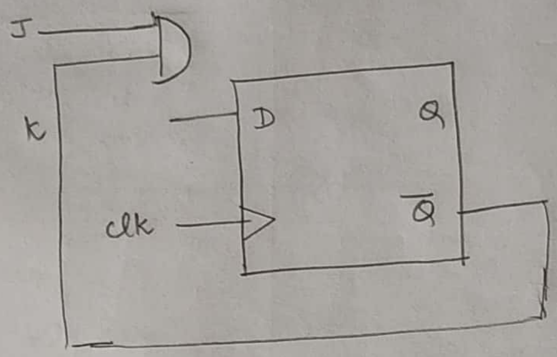
For J-K

Q \ JK	$\bar{J}\bar{K}$ 00	$\bar{J}K$ 01	JK 11	$J\bar{K}$ 10
$\bar{Q}$ 0	0 (0)	0 (1)	1 (3)	1 (2)
Q 1	1 (4)	0 (5)	0 (7)	1 (6)

$\Rightarrow \bar{Q}J + Q\bar{K}$ characteristic eqn of JK flip flop

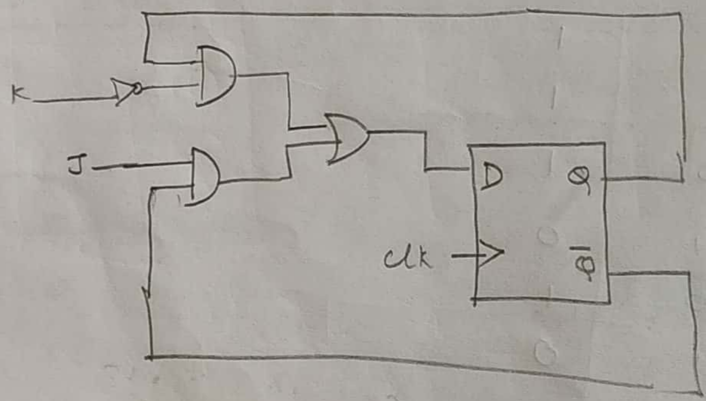
$\Rightarrow Q(t+1) = \overline{Q(t)}J + Q(t)\cdot\bar{K}$

$= \bar{Q}J + Q\bar{K}$



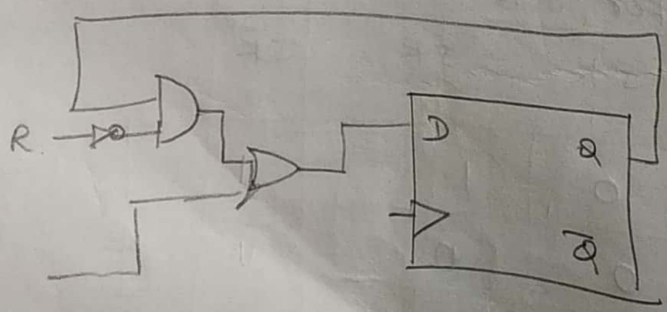
JK flip flop D-flip flop.

char eqn of D flip flop is D for $Q(t+1)$
(since it follows the i/p)



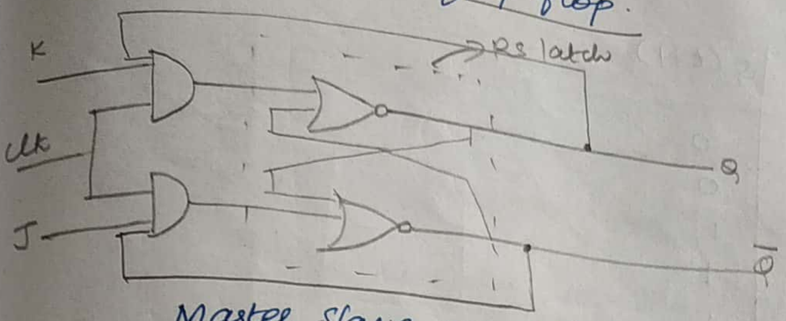
SR \ Q	$\bar{S}\bar{R}$	$\bar{S}R$	SR	$S\bar{R}$
$\bar{Q}$	0	1	x	1
Q	1		x	1

$Q(t+1) = S + Q\bar{R}$



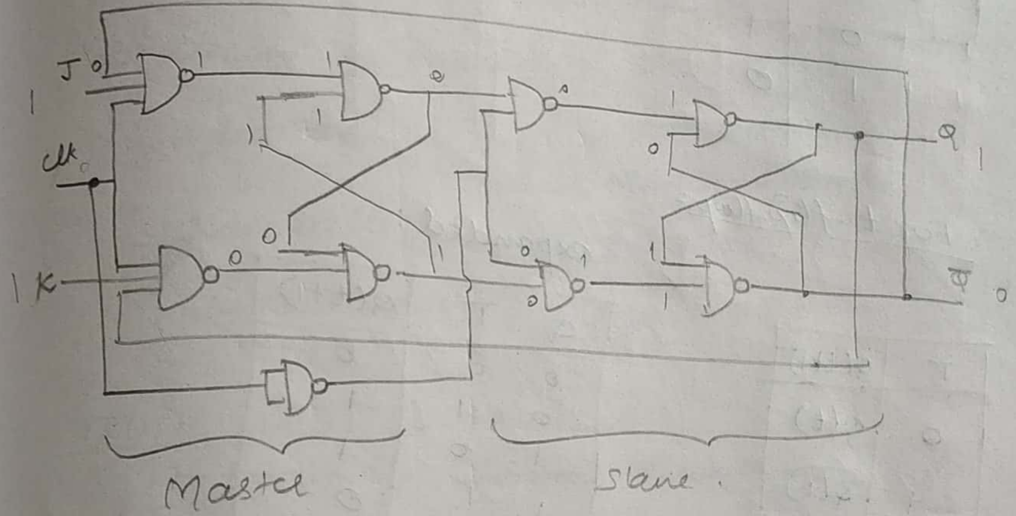
11.09.18

JK flip flop.



J	K	Q(t+1)
0	0	Q(t)
0	1	0
1	0	1
1	1	$\overline{Q(t)}$

Master slave JK flip flop.



→ Master receives external i/p
→ Mostly 1 1 condition is used to avoid racing condition
→ During -ve pulse cycle there is no change in the MASTER.

→ no change in slave (positive)
change in Master.

→ NO RACING CONDITION (negative)
No change in master
change in slave.

2 flip flop connected in cascade, it is master flip flop.

Q	J	K	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

For t flip flop:-

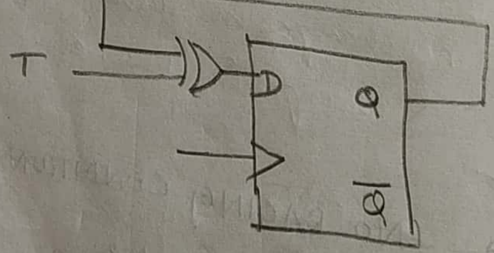
T	Q(t+1)
0	$Q(t)$
1	$\overline{Q(t)}$

expanded:

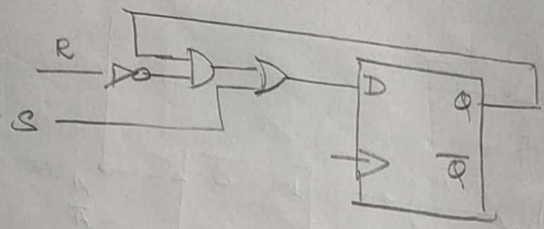
Q	T	Q(t+1)
0	0	0
0	1	1
1	0	1
1	1	0

$$Q(t+1) = \overline{Q}T + Q\overline{T}$$
$$= Q \oplus T$$

T flip flop from D flip flop.



SR from D



Synchronous seq. ckt.

Analysis
⇒ circuit or Equations
↓
Equations
↓
State table
↓
State diagram

Design
↓ (From problem specification)
State diagram
↓
State table
↓
Transition Table
↓
Equations
↓
logical Diagram

1. TRUTH TABLE:

For known i/p, ~~for gat~~ depending upon the type of gate o/p is generated

2. STATE TABLE:

o/p for various i/p + Present state, ~~past~~ next State is obtained.

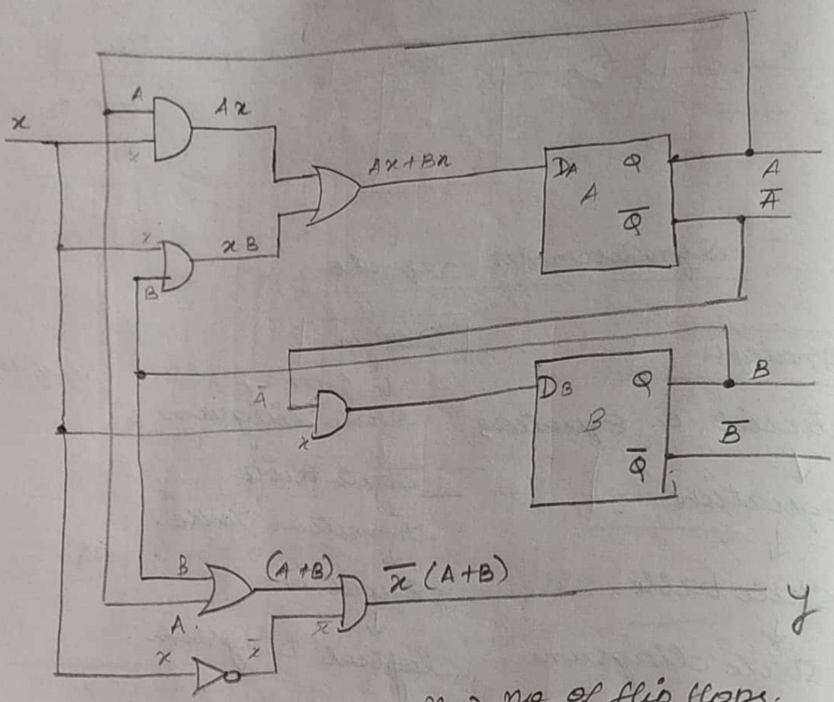
3. Transition table:

4. Excitation table: o/p is known, Q(t) and Q(t+1) is also known, flip flop inputs are found

$Q(t)$ = present state, $Q(t+1)$ = next state

5. Characteristic table:

Next state value, we have to find. i/p & present states are known.



$n \rightarrow$ no of flip flops.

$2^n \rightarrow$ no of states.

Equations.

State equations:

$$A(t+1) = D_A = xA + xB = x(A+B)$$

$$B(t+1) = D_B = x\bar{A}$$

Output Equation:

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

State table:

PS $\rightarrow$ Present state (depends on 2 flip flops)

00 → a
01 → b
10 → c
11 → d

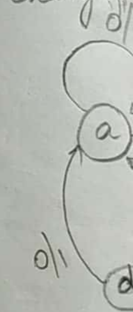
P (A)	S (B)	x	N.S A(t+1)	B(t+1)	output $y = \bar{x}(A+B)$
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	1	1	0
1	0	0	0	0	1
1	0	1	1	0	0
1	1	0	0	0	1
1	1	1	1	0	0

Final State tabl

P S (AB)	N S (x=0)
a	a
b	a
c	a
d	a

State Diagra

change



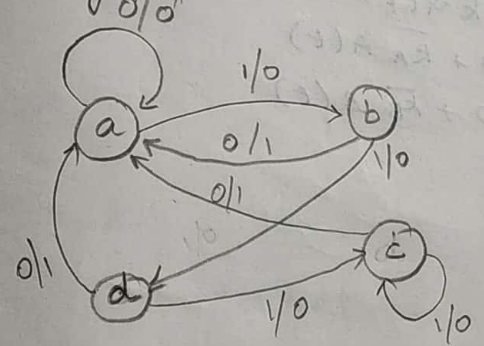
Final State table ⇒ Mealy

P S (AB)	N S $x=0$	N S $x=1$	Output y $x=0$	Output y $x=1$
a	a	b	0	0
b	a	d	1	0
c	a	c	1	0
d	a	c	1	0

00 → a
01 → b
10 → c
11 → d

State Diagram → Mealy state diagram (o/p depends on present state, i/p)
→ Moore state diagram (depends on present state)

change in state → arrow (represented)



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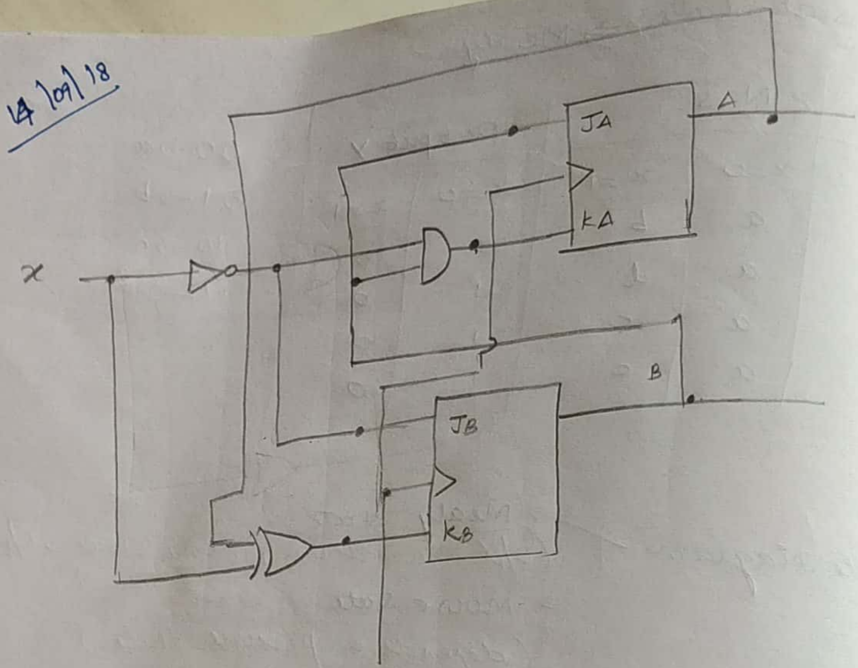


$Q(t+1) = J\bar{Q}(t) + \bar{K}Q(t)$

$A(t+1) = J_A\bar{A}(t) + \bar{K}_A A(t)$

$B(t+1) = J_B\bar{B}(t) + \bar{K}_B B(t)$

$J_A = B$

$J_B = \bar{x}$

$K_A = \bar{x}B$

$\overline{K_A} = \overline{\bar{x}B}$

$= x + \bar{B}$

$K_B = \cancel{\bar{x} \oplus \bar{A}} \quad x \oplus A$

$\overline{K_B} = \bar{x} \oplus \bar{A}$

$= xA + \bar{x}\bar{A}$

$$A(t+1) = B\bar{A}(t) + (x+\bar{B})A(t)$$

$$B(t+1) = \bar{x}\bar{B}(t) + (xA + \bar{x}\bar{A})B(t)$$

$$\begin{aligned} A(t+1) &= B\bar{A}(t) + (x+\bar{B})A(t) \\ &= B\bar{A}(t) + xA(t) + \bar{B}A(t) \\ &= B\bar{A}(t) + \bar{B}A(t) + xA(t) \\ &= \cancel{B\odot\bar{A}(t) + xA(t)} \\ &= B\oplus A(t) + xA(t) \end{aligned}$$

$$\begin{aligned} B(t+1) &= \bar{x}\bar{B}(t) + xAB(t) + \bar{x}\bar{A}B(t) \\ &= \bar{x}\bar{B}(t) + B(t)(x\odot A) \end{aligned}$$

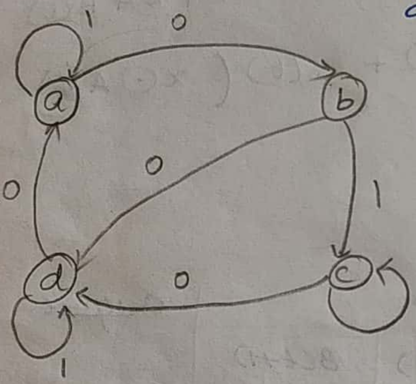
State Table:

PS		x	NS		~~Output~~
A	B	x	A(t+1)	B(t+1)	
0	0	0	0	1	
0	0	1	0	0	
0	1	0	1	1	
0	1	1	1	0	
1	0	0	1	1	
1	0	1	1	0	
1	1	0	0	0	
1	1	1	1	1	

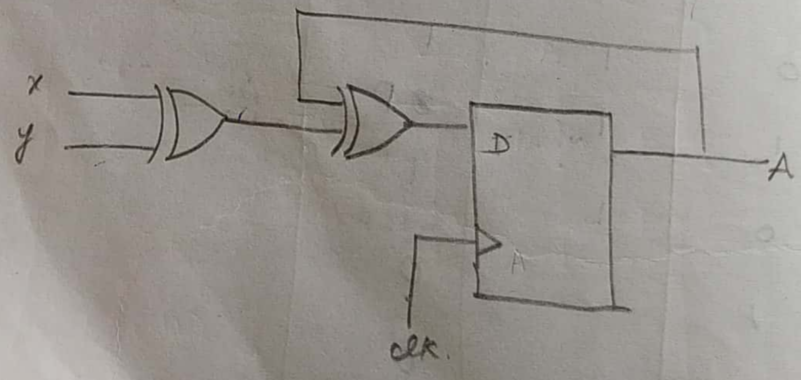
New state table:

P S	NS x=0	NS x=1
a	b	a
b	d	c
c	d	c
d	a	d

State diagram



2.



$A(t+1) = D$ D flip flop.

$D = (x \oplus y) \oplus A$

$= A \oplus (x \oplus y)$

$= A \oplus x \oplus y.$

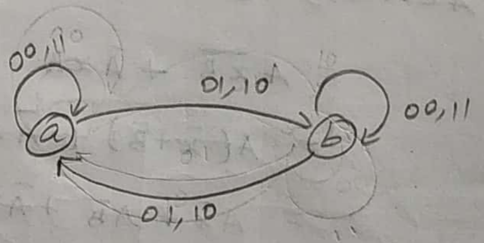
State Table:

	A	x	y	Q(t+1)=D
A	0	0	0	0
	0	0	1	1
	0	1	0	1
	0	1	1	0
B	1	0	0	1
	1	0	1	0
	1	1	0	0
	1	1	1	1

~~Final state~~:

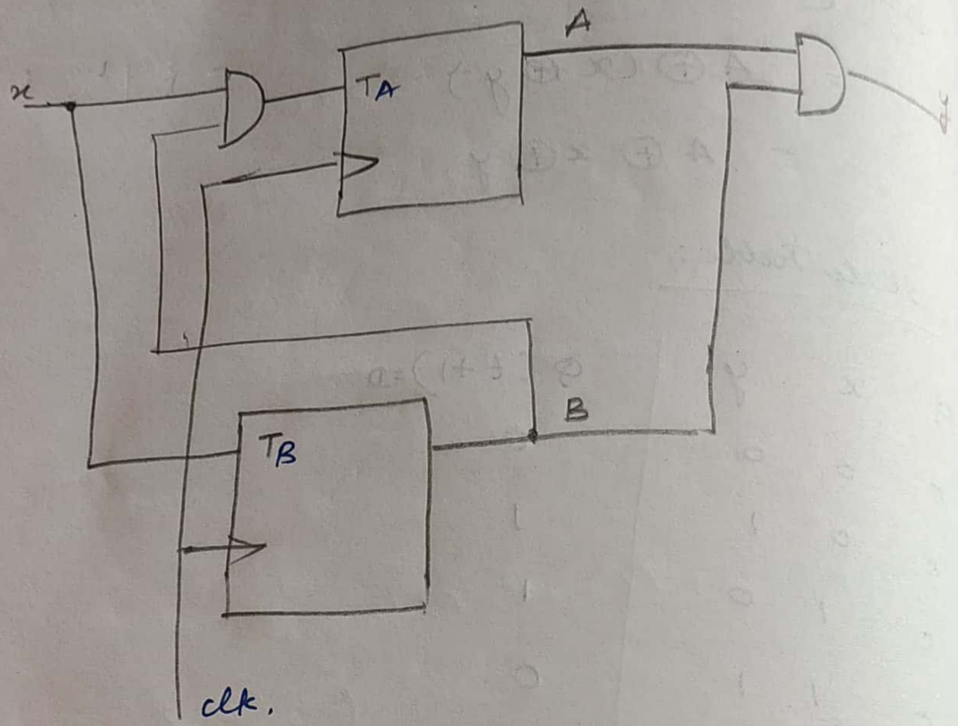
~~PS~~

State diagram



PS	NS			
A	xy=00	01	10	11
0	a	b	b	a
1	b	a	a	b

3.



$Q(t+1) = Q \oplus T$

$A(t+1) = A \oplus T_A$

$B(t+1) = B \oplus T_B$.

$T_A = xB$

$T_B = x$

$A(t+1) = A \oplus xB$

$= A\overline{xB} + \bar{A}xB$

$= A(\bar{x} + \bar{B}) + \bar{A}xB$

$= A\bar{x} + A\bar{B} + \bar{A}xB$.

$y = A \cdot B$

$B(t+1) = B \oplus x$

$= B\bar{x} + \bar{B}x$.

Moore's state Table : II

P	S	N.S		o/p y
A	B	x=0 A B	x=1 A B	
0	0	a	b	0
0	1	0 1 (b)	c	0
1	0	1 0	d	0
1	1	d	a	1

output is represented in moore's state table.

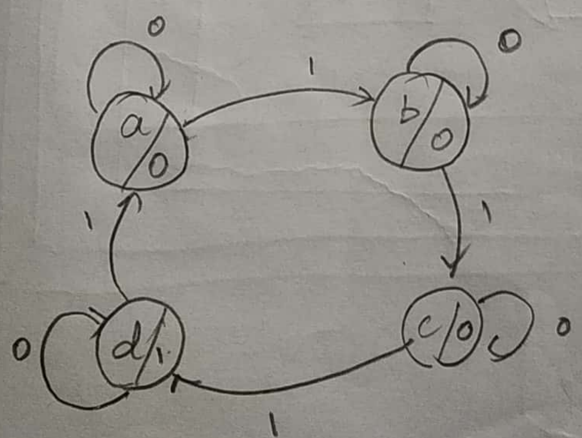
Table I.

P.S			N.S		
A	B	x	A(t+1)	B(t+1)	y = A . B
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	1	0
0	1	1	1	0	0
1	0	0	1	0	0
1	0	1	1	1	0
1	1	0	1	1	1
1	1	1	0	0	1

a { rows 1–2 }, b { rows 3–4 }, c { rows 5–6 }, d { rows 7–8 }

Moore's state diagram.

it depends only on B.



4. A sequential circuit has 2 JK flipflops 'A' and 'B', 2 inputs 'x' and 'y' and 1 output z. The flipflop i/p equations and ckt o/p eqns are

$$JA = \boxed{Bx + B'y'}$$

$$KA = B'xy'$$

$$JB = A'x$$

$$KB = A + xy'$$

$$z = Ax'y' + Bx'y' \Rightarrow (A+B)x'y'$$

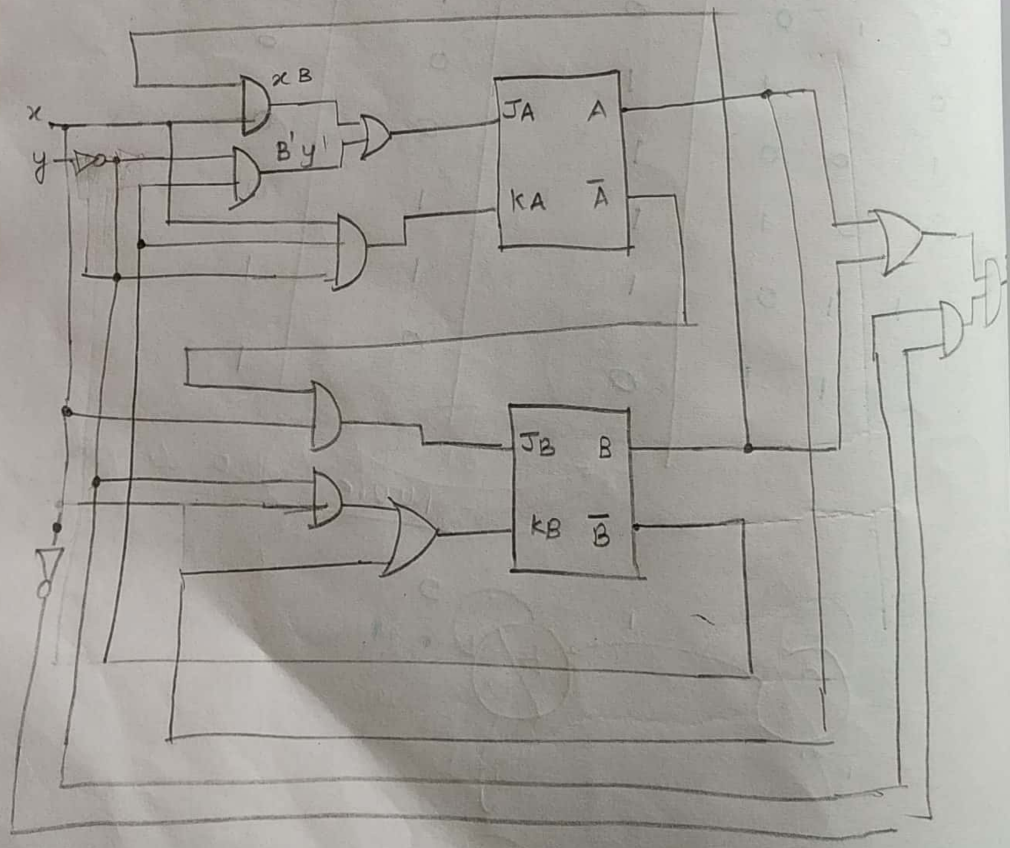
(i) Draw the logic diagram of the ckt

(ii) Tabulate the state table

(iii) Derive the state eqns for A and B.

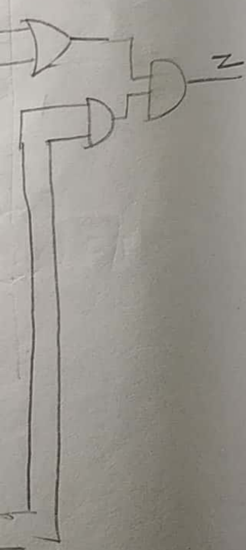
(iv) Draw the state diagram.

refer JK flip flop.



flops
and
ations

B .
JK flip flop.



A	B	x	y	A(t+1)	B(t+1)	z
0	0	0	0	1	0	0
0	0	0	1	0	0	0
0	0	1	0	1	1	0
0	0	1	1	0	1	0
0	1	0	0	0	1	1
0	1	0	1	0	1	0
0	1	1	0	1	0	0
0	1	1	1	1	1	0
1	0	0	0	1	0	1
1	0	0	1	1	0	0
1	0	1	0	1	0	0
1	0	1	1	1	0	0
1	1	0	0	0	0	0
1	1	0	1	0	0	1
1	1	1	0	0	0	0
1	1	1	1	0	0	0
					0	0

P S	N.S				O/P			
A B	xy	x=01	10	11	00	01	10	11
a	c	a	d	b	0	0	0	0
b	b	b	c	d	1	0	0	0
c	c	c	c	c	1	0	0	0
d	a	a	a	a	1	0	0	0

25/09/18

Design of clocked sequential logic circuit.

Problem statement . (no of i/p & o/p)

PROBLEM STATEMENT

↓

STATE DIAGRAM — Moore's & mealy

↓

REDUCE THE STATES — 1. Using Row elimination method 2. Implication table. (next chap)

↓

STATE TABLE

↓

BINARY CODED STATE TABLE.

↓

NO. OF FLIP FLOPS USED. — JK, D or T flipflop

↓

TRANSITION TABLE. FF i/p and o/p of the seq. ckt.

↓

FF i/p EQUATIONS. seq. ckt o/p equations.

↓

LOGICAL DIAGRAM.

Binary assignment.
1. Binary code
2. Gray code
3. One hot [only one 1 and other are 0]

Excitation table

State Reduction: by Row elim method

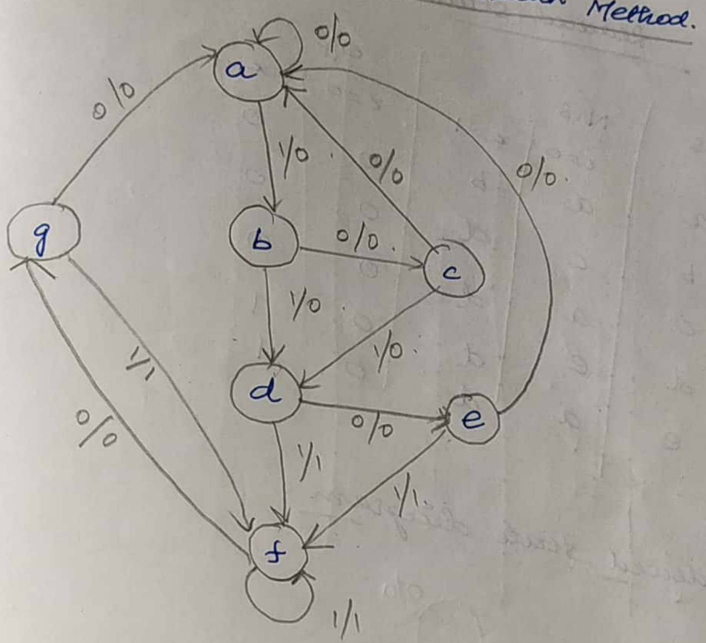
① → Assume some i/p
a → initial state

2. o/p → 2 values for each circle (ie) o/p (1 and 0)

3. For the given i/p 'x' find y and states.
assume initial state as 'a'.

4. check the o/p, if o/p are same for given i/p
if same next state & same o/p elim any 1

State Reduction: by Row elimination Method.



For example:

States	a	b	d	e	f	f	f	f	g	f	f	g
x	1	1	0	1	1	1	1	0	1	1	0	
y	0	0	0	1	1	1	1	0	1	1	0	

— I

convert into state table (obtain same O/P)

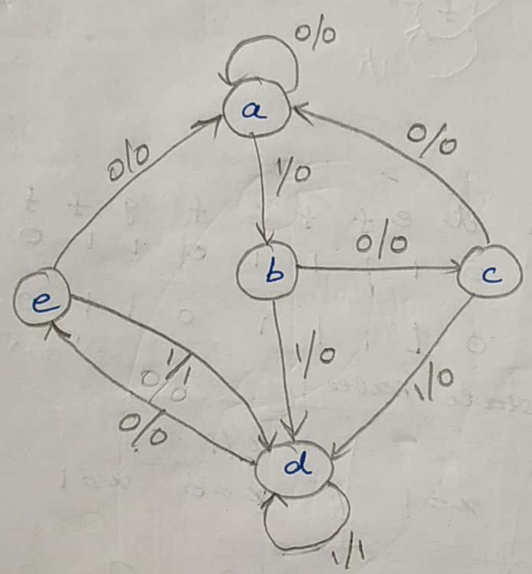
P.S	N.S x=0	N.S x=1	O/P x=0	O/P x=1
a	a	b	0	0
b	c	d	0	0
c	a	d	0	0
⇒ d	e	~~f~~ d	0	1
~~e~~	a	~~f~~ d	0	1
⇒ f	~~g~~ e	f	0	1
~~g~~	a	f	0	1

Retain the g with 'e', f is replace with d.

Reduced state table:

P.S	N.S x=0	N.S x=1	o/p x=0	o/p x=1
a	a	b	0	0
b	c	d	0	0
c	a	d	0	0
d	e	d	0	1
e	a	d	0	1

Reduced state diagram.



For the new state table take the same i/p combinations.

check whether (I) = (II)

states: a b d e d d d d e d d e

x = 1 1 0 1 1 1 1 0 1 1 0

y = 0 0 0 1 1 1 1 0 1 1 0 — II

I = II

The o/p of the original state table is equal to new state table.

Q.2)

P.S	N.S $x=0$	N.S $x=1$	o/p $x=0$	o/p $x=1$	
→ a	f	b	0	0	replace c by a
⇒ b	d	~~c~~ a	0	0	
→ ~~c~~	~~f~~	~~e~~ b	~~0~~	~~0~~	replace e by b
d	g	a	1	0	
⇒ ~~e~~	~~d~~	~~c~~ a	~~0~~	~~0~~	
f	f	b	1	1	replace h by d.
g	g	~~h~~ d	0	1	
~~h~~	~~g~~	~~a~~	~~1~~	~~0~~	

~~states a b c e g~~ ~~0 0 0 1 1 1 1 0~~

~~x = 0 1 1 1 0~~

~~o/p 0 0 0 0~~

States a f b c e d g g h a b c f

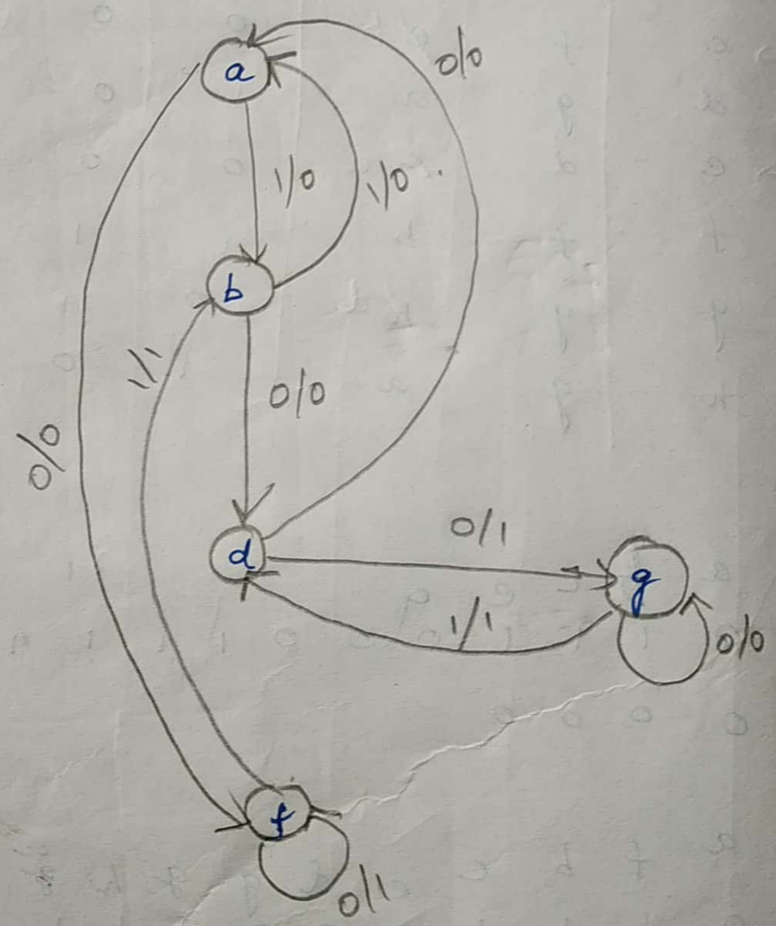
x 0 1 1 1 0 0 0 1 1 1 1 0 → ①

x 0 1 1 1 0 0 0 1 0 1 0 0 0 0

o/p 0 1 0 0 0 1 0

Reduced State table,

P.S	N.S $x=0$	N.S $x=1$	O/P $x=0$	O/P $x=1$
a	f	b	0	0
b	d	a	0	0
d	g	a	1	0
f	f	b	1	1
g	g	d	0	1



states	a	f	b	a	b	d	g	g	d	a	b	a	f
x	0	1	1	1	0	0	0	1	1	1	1	0	
o/p	0	1	0	0	0	1	0	1	0	0	0	0	

(I) = (II) → (II)

Binary Assignment

Binary

(depends on no of states)

n → no of bits

$5 \rightarrow 2^{n}$

so $n \Rightarrow 3$

Minimum bits required ⇒ 3

n = 2 (not possible)

Gray

[1 bit variation]

One hot

→ logic '1' represents hot bit

→ It consists of 'n' number of bits

→ consists of 1 hot bit

[we use 10 flip flop when $2^{n=10}$]

	Binary	Gray	One hot
a	0 0 0	0 0 0	0 0 0 0 1
b	0 0 1	0 0 1	0 0 0 1 0
c	0 1 0	0 1 1	0 0 1 0 0
d	0 1 1	0 1 0	0 1 0 0 0
e	1 0 0	1 1 0	1 0 0 0 0

[Here $\boxed{2^n = 5}$ ⇒ we need 5 flip flops]

Scanned by CamScanner

27/09/18

Excitation table.

① In SR flip flop. we have to find S, R values

R value can be anything

Q(t)	Q(t+1)	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0.

From JK flip flop.

char table:

②

Q(t)	J	K	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

JK ff

Q(t)	Q(t+1)	J	K.
0	0	0	X
0	1	1	X
1	0	X	1
1	1		

D ff char table:

Q(t)	D	Q(t+1)
0	0	0
0	1	1
1	0	0
1	1	1

In char table
o/p ⇒ D

D F-F

Q(t)	Q(t+1)	D
0	0	0
0	1	1
1	0	0
1	1	1

4. T flip flop char table.

Q(t)	T	Q(t+1)
0	0	1
0	1	0
1	0	1
1	1	0

T-ff

Q(t)	Q(t+1)	T
0	0	0
0	1	1
1	0	1
1	1	0

Q. Design a sequential logic circuit to detect the sequence of 3 consecutive one's or more. Use D flip flop. (6m)

[single i/p and single o/p ⇒ sequence detector]

soln:

1 1 1

seq detector

0 1 1 1 0 1 1 1 1 0 1 0 1 1 1 0

0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0

From LSB

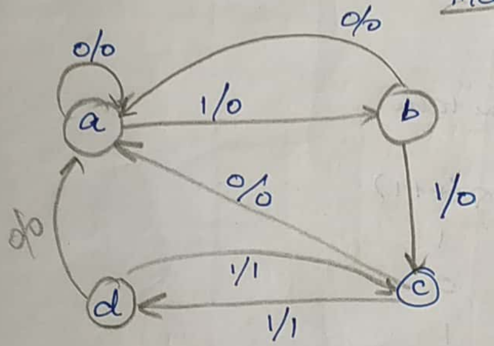
[for 3 and more than 3 1's it is written as 1 rest are 0]

Initial state assume as 'a'.

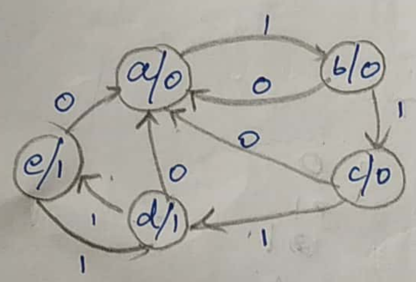
If it receives 1 → goes to new state

If it receives 0 → it is in its own state

Mealy state Diagram m/c



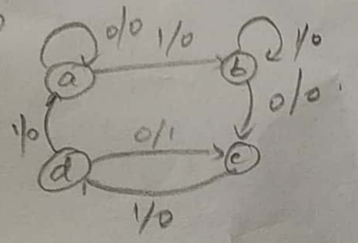
Moore state m/c.



1 1 1 1
1 1

For example → overlapping

1010



10 10 10
000101

From M...

State ta...

	PS		
	a 00		
	b 01		
	c 10		
	d 11		

Tran...

		P A(t)	S B
0	a	0	0
1	a	0	0
2	b	0	1
3	b	0	1
4	c	1	0
5	c	1	0
6	d	1	1
7	d	1	1

From Mealy state m/c.

Take i/p as x.

state table :-

PS	x	NS	output z
a	0	a	0
00	1	b	0
b	0	a	0
01	1	c	0
c	0	a	0
10	1	d	1
d	0	a	0
11	1	c	1

$2^n = 4$

$n \approx 2$

We assign 2 bit values

2 → no of flip flops

Transition table :

	P A(t)	S B(t)	x	NS A(t+1)	BS B(t+1)	o/p z	D_A	D_B
a	0	0	0	0	0	0	0	0
a	0	0	1	0	1	0	0	1
b	0	1	0	0	0	0	0	0
b	0	1	1	1	0	0	1	0
c	1	0	0	0	0	0	0	0
c	1	0	1	1	1	1	1	1
d	1	1	0	0	0	0	0	0
d	1	1	1	1	0	1	1	0

P S x as i/p draw 3 variable k map.

for z.

A(t) \ B(t) x	00	01	11	10
0	0	0	0	0
1	0	1	1	0

$$\boxed{Z = Ax.}$$

for D_A

A(t) \ B(t) x	00	$\bar{B} x$ 01	$B \bar{x}$ 11	$B\bar{x}$ 10
$\bar{A}$ 0	0	0	1	0
A 1	0	1	1	0

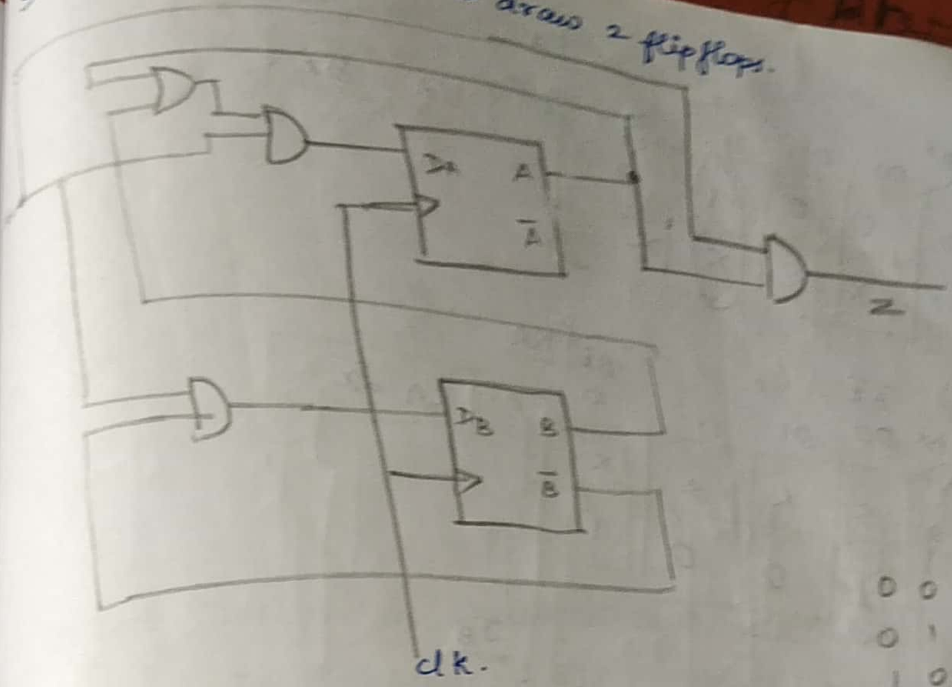
$$D_A = \cancel{\bar{A}(t)\, B(t)\, \bar{x} + B(t)\, \bar{x}}$$
$$= \cancel{A(t)\, B(t)}$$
$$= A(t)\, x + B x$$
$$= x\,(A + B)$$

for D_B

A(t) \ B(t) x	00	01	11	10
0	0	1	0	0
1	0	1	0	0

$$D_B = \bar{B}\, x.$$

since $n=2$, we have to draw 2 flipflops.



0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

By using ~~T~~ JK flipflop for same Q.

P A(t)	S B(t)	x	N A(t+1)	S B(t+1)	o/p Z	JA	KA	JB	KB	
0	0	0	0	0	0	0	X	0	X	0
0	0	1	0	1	0	0	X	1	X	1
0	1	0	0	0	0	0	X	X	1	2
0	1	1	1	0	0	1	X	X	1	3
1	0	0	0	0	0	X	1	0	X	4
1	0	1	1	1	1	X	0	1	X	5
1	1	0	0	0	0	X	1	X	1	6
1	1	1	1	0	1	X	0	X	1	7

JA:-

A \ Bx	00	01	11	10
0	0	0	1	0
1	X	X	X	X

$\boxed{JA = Bx}$

KA

A \ Bx	00 ($\bar{B}\bar{x}$)	01	11	10 ($B\bar{x}$)
$\bar{A}$ 0	X	X	X	X
A 1	1	0	0	1

$\boxed{KA = \bar{x}}$

J_B

A \ Bx	00	01	11	10
0	X	1	X	X
1	0	1	X	X

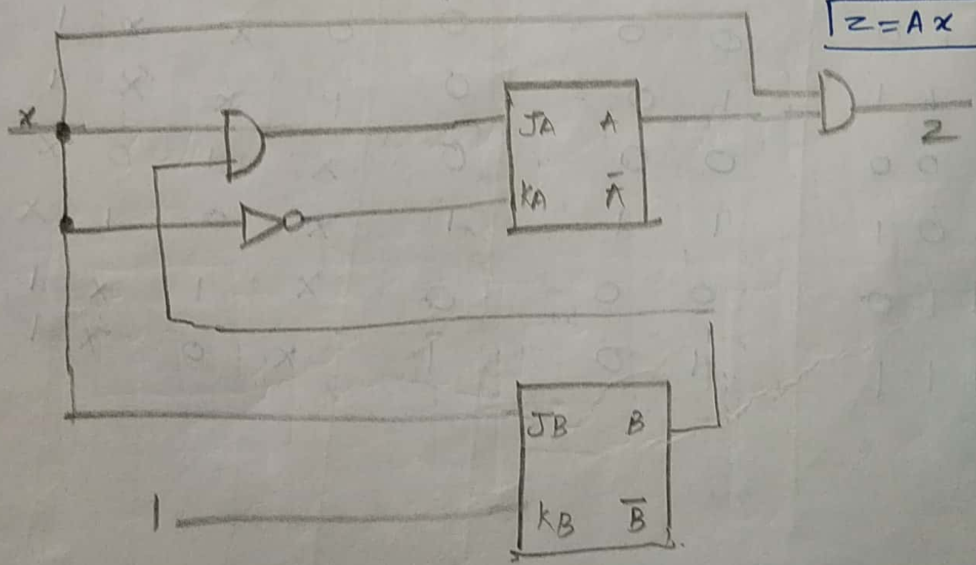
$\boxed{JB = x}$

KB

A \ Bx	00	01	11 (Bx)	10 ($B\bar{x}$)
$\bar{A}$ 0	X (0)	X (1)	1 (3)	1 (2)
A 1	X (4)	X (5)	1 (7)	1 (6)

$\boxed{KB = 1}$

$\boxed{Z = Ax}$



2.Q) De
sequ

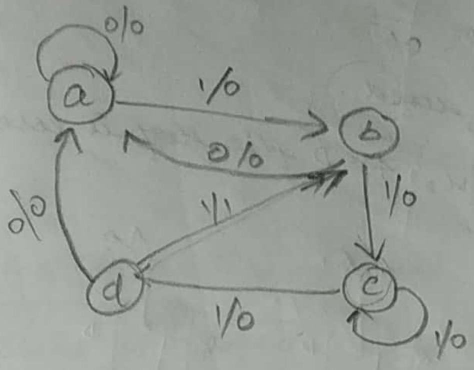
soln:-

3. Det
we
If
seq
F=1
fro
and
goes
00
sep

soln:-

Q) Design a sequential logic ckt to detect the sequence of 1101. Use T flip flop.

soln:-



110 1101

000

1101101

110|1101

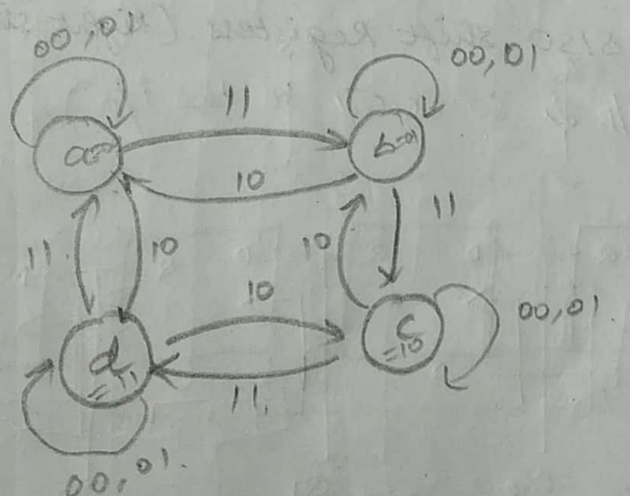
1101101

0001001

3. ~~Detect~~ Design a sequential logic ckt ~~that~~ with 2 JK flipflops A and B and 2 i/p E and F. If E = 0, the circuit remains in the same state regardless of the value of F. When E = 1 and F = 1, the ckt goes through the state transitions from 00 to 01, to 10, to 11, back to 00 and repeats. When E = 1 and F = 0, the ckt goes through the state transitions from 00 to 11, to 10, to 01, back to 00 and repeats.

E F
0 0
0 1
1 0
1 1

soln:-



4 V. k map.

05/10/18

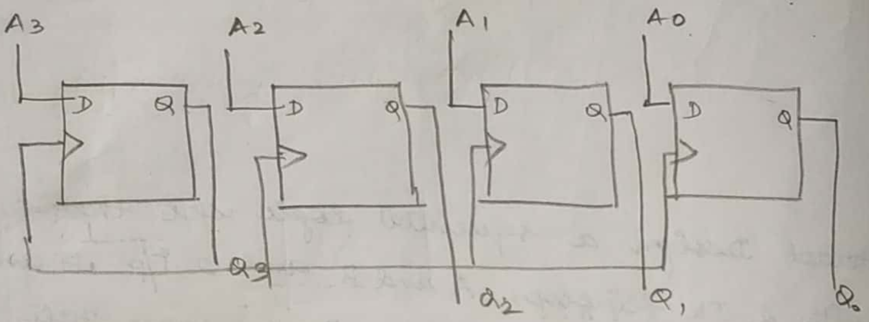
Registers.

flip flop → Store 1 bit info

If many flipflops → registers.

D flip flop is used.

For 4-bit registers, 4-D flip flop is used.



Shift registers:-

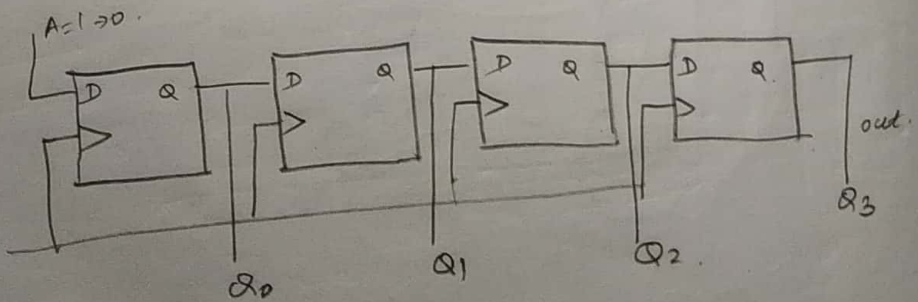
1. serial in serial out – SISO
2. " " parallel " – SIPO
3. parallel in serial out – PISO
4. parallel in parallel out – PIPO.

Shift registers (2 operations)

Left shift — Right shift.

1. SISO shift Registers. (right shift)

(o/p is connected to the i/p)



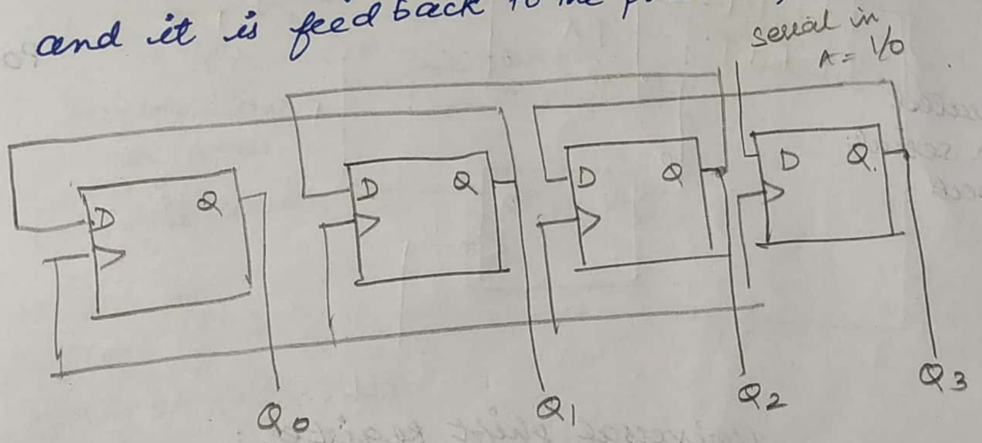
clk	Q_0	Q_1	Q_2	Q_3
1	1	0	0	0
2	1	1	0	0
3	1	1	1	0
4	0	1	1	1
5.	0	0	1	1

o/p → Q_3 → SISO

o/p → $Q_0\ Q_1\ Q_2\ Q_3$ → SIPO

2. serial in parallel out (left shift)

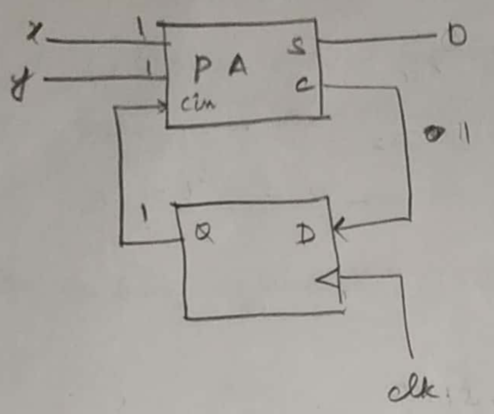
i/p is given to the last flipflop.
and it is feed back to the previous feed back.



clk	Q_0	Q_1	Q_2	Q_3
1	0	0	0	1
2	0	0	1	1
3	0	1	1	1
4	1	1	1	1
5	1	1	1	0

when i/p is A 1→0
A=0.

without using shift register.



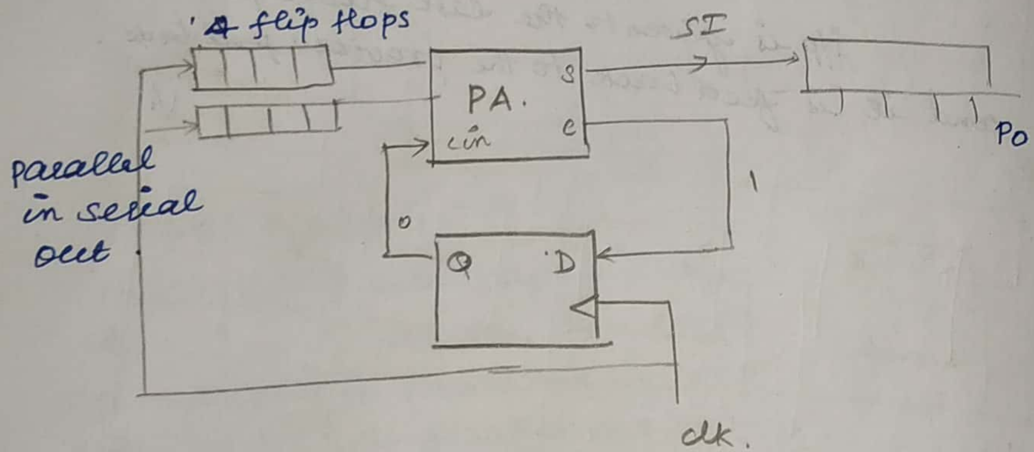
$x_3\ x_2\ x_1\ x_0$

$y_3\ y_2\ y_1\ y_0$

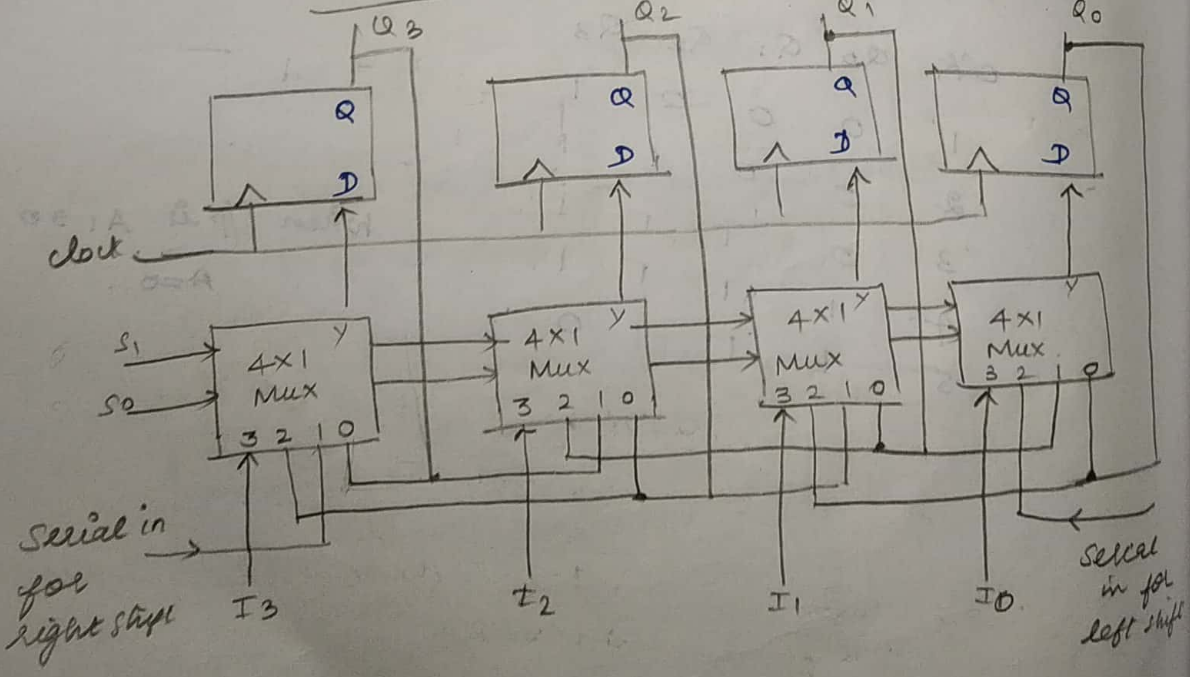
1101
1110

c 1 1011

After using shift registers:-



universal shift register:



$I_1\ I_2\ I_3\ I_4$ → parallel inputs.

S_1	S_0	
0	0	No change.
0	1	Right shift (serial in)
1	0	Left shift (serial in)
1	1	(parallel in) serial out

No of clock = No of shift

00 → 0
01 → 1
10 → 2
11 → 3

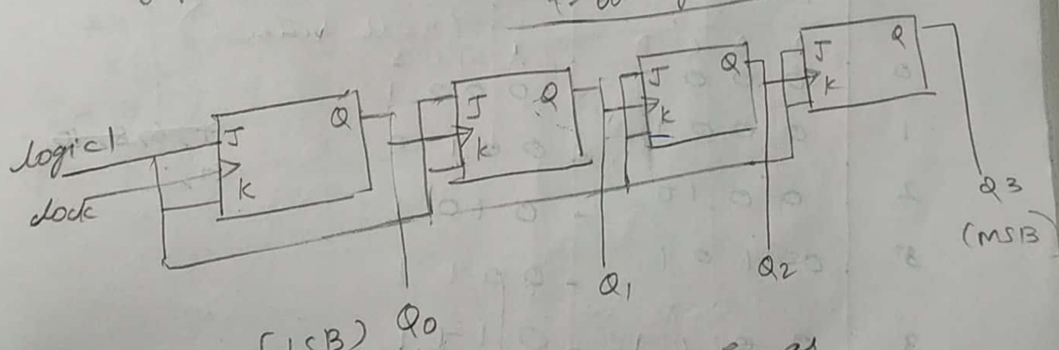
counters

Asynchronous counter — Binary [Ripple counter]

Synchronous counter.

We can use JK, D, T flipflop.
Mostly we won't use D flip flop.

4-bit asynchronous



- O/p of the flip flop is given as clock for Next flip flop → counter
- When there is 1 → 0 transition (it works as clock) 2nd flipflop complements the previous o/p. i.e. → 1.

⇒ Follows negative edge transition signal

serial in for left shift.

Q_3	Q_2	Q_1	Q_0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0
0	1	0	0

compliment for a clock)

previous value retained

0 to 1 transition, there is no 1 to 0 transition

To obtain +ve edge trigger get output from $\bar{Q}$ instead of Q.

SYNCHRONOUS COUNTER

4-bit synchronous counter

count sequence: 0, 1, 2, 5, 3, 7, 9, 15 — irregular

4, 6, 8, 10, 11, 12, 13, 14 → Dont cares.

	P.S				N.S (next values)			
	A	B	C	D	A	B	C	D
0	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	1	0
2	0	0	1	0	0	1	0	1
5	0	1	0	1	0	0	1	1
3	0	0	1	1	0	1	1	1
7	0	1	1	1	1	0	0	1
9	1	0	0	1	1	1	1	1
15	1	1	1	1	0	0	0	0 (start from beginning)

~~4, 6, 8, 10~~, 11,

atleast 4 bits are required for representy.

	JA	KA	JB	KB	JC	KC	JD	KD.
0	0	X	0	X	0	X	1	X
1	0	X	0	X	1	X	X	1
2	0	X	1	X	X	1	1	X
5	0	X	X	1	1	X	X	0
3	0	X	1	X	X	0	X	0
7	1	X	X	1	X	1	X	0
9	X	0	1	X	1	X	X	0
15	X	1	X	1	X	1	X	1

0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

13, 14

JA

AB\CD	00	01	11	10
00	0	0	0	0
01	X	0	1	X
11	X	X	X	X
10	X	X	X	X

$\boxed{JA = BC}$

KB

KA

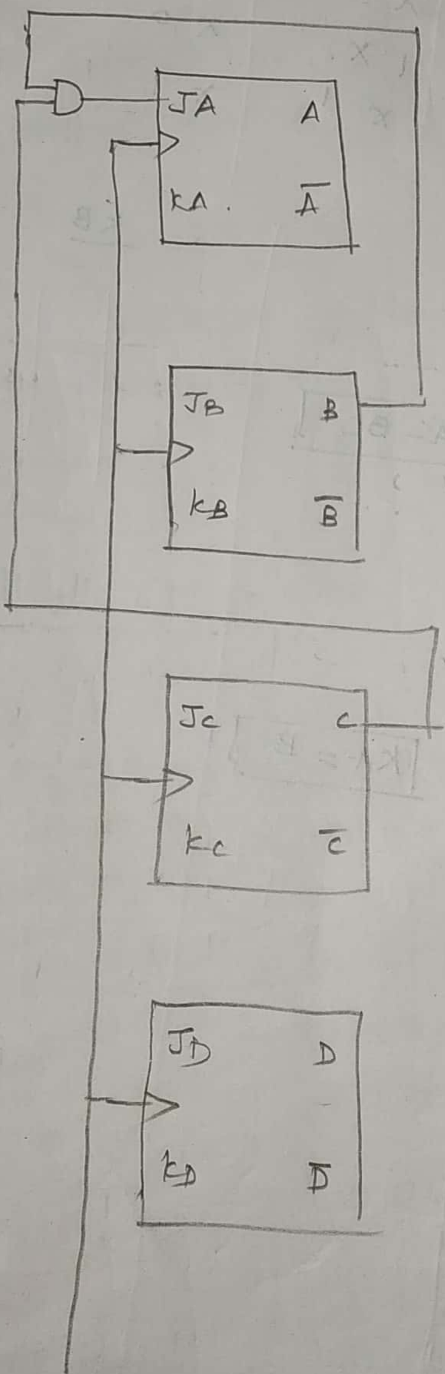
	AB\CD	00	01	11 (CD)	10 ($C\bar{D}$)
	00	X_0	X_1	X_3	X_2
$\bar{A}B$	01	X_4	X_5	X_7	X_6
AB	11	X_{12}	X_{13}	1_{15}	X_{14}
	10	X_8	0_9	X_{11}	X_{10}

$\boxed{KA = B}$

JB

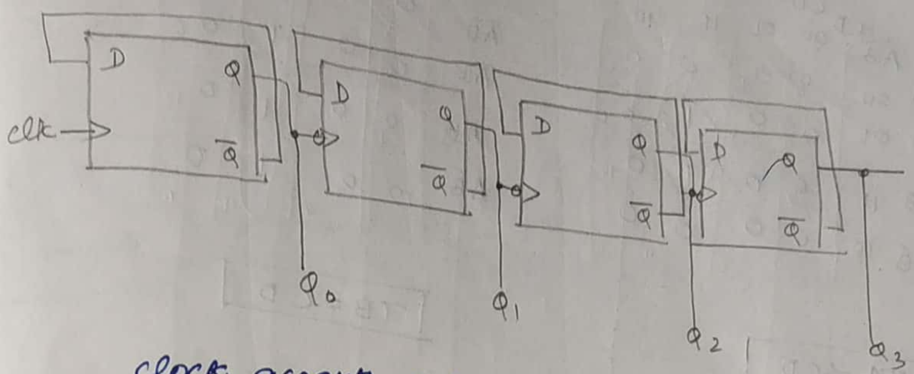
AB\CD	00	01	11	10
00	0_0	0_1	1_3	1_2
01	X_4	X_5	X_7	X_6
11	X_{12}	X_{13}	X_{15}	X_{14}
10	X_8	1_9	X_{11}	X_{10}

$\boxed{JB = A+C}$


JA
A
KA
$\bar{A}$
JB
B
KB
$\bar{B}$
Jc
C
Kc
$\bar{C}$
JD
D
KD
$\bar{D}$

.10.18

Asynchronous binary ripple counter using Dff

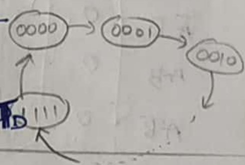


clock accepts only -ve edge 1-0
if +ve have to be accepted (D-Q̄) is connected.

Synchronous binary ripple counter.

(no input, no output, only clock change)

using T flip flop — upcount



P.S (A B C D)	N.S (A B C D)	T_A	T_B	T_C	T_D	
0000	0001	0	0	0	1	0
0001	0010	0	0	1	1	1
0010	0011	0	0	0	1	2
0011	0100	0	1	1	1	3
0100	0101	0	0	0	1	4
0101	0110	0	0	1	1	5
0110	0111	0	0	0	1	6
0111	1000	1	1	1	1	7
1000	1001	0	0	0	1	8
1001	1010	0	0	1	1	9
1010	1011	0	0	0	1	10
1011	1100	0	1	1	1	11
1100	1101	0	0	0	1	12
1101	1110	0	0	1	1	13
1110	1111	0	0	0	1	14
1111	0000	1	1	1	1	15

TA

AB \ CD	$\bar{C}\bar{D}$ 00	$\bar{C}D$ 01	CD 11	$C\bar{D}$ 10
$\bar{A}\bar{B}$ 00	0_0	0_1	0_3	0_2
$\bar{A}B$ 01	0_4	0_5	1_7	0_6
AB 11	0_{12}	0_{13}	1_{15}	0_{14}
$A\bar{B}$ 10	0_8	0_9	0_{11}	0_{10}

$\boxed{TA = BCD}$

TB

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	0_0	0_1	1_3	0_2
$\bar{A}B$	0_4	0_5	1_7	0_6
AB	0_{12}	0_{13}	1_{15}	0_{14}
$A\bar{B}$	0_8	0_9	1_{11}	0_{10}

$\boxed{TB = CD}$

TC

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	0_0	1_1	1_3	0_2
$\bar{A}B$	0_4	1_5	1	0_6
AB	0_8	1_9	1_{11}	0_{10}
$A\bar{B}$	0_{12}	1_{13}	1_{14}	0_{15}

$\boxed{TC = D}$

TD

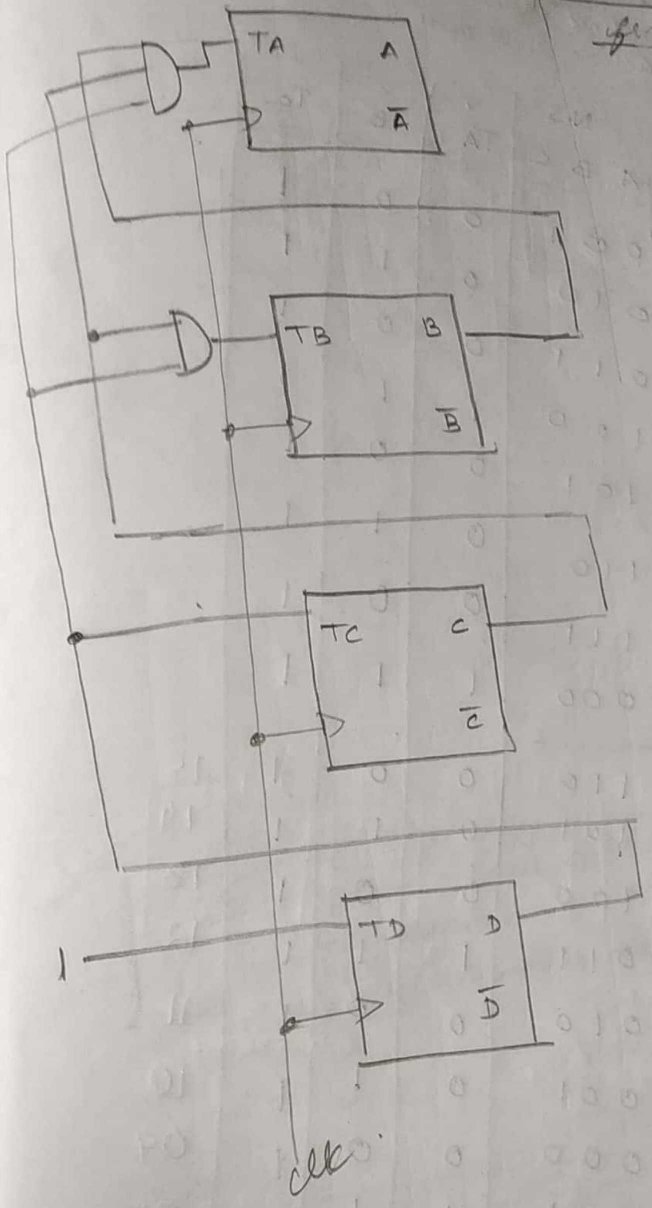
AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1	1	1	1
$\bar{A}B$	1	1	1	1
AB	1	1	1	1
$A\bar{B}$	1	1	1	1

$\boxed{TD = 1}$

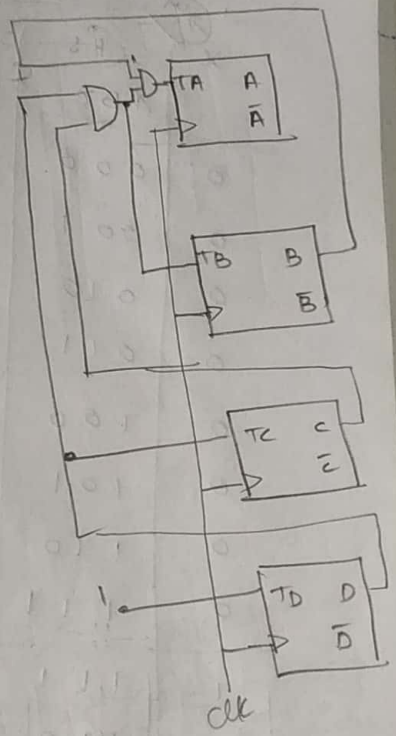
For n bit counters.

	V	W	X	Y	Z
....	T_V	T_W	T_X	T_Y	T_Z
....	$WXYZ$	XYZ	YZ	Z	1

LOGIC DIAGRAM.



from the k map



3bit synchronous up/down counter using T-ff.

x → up/down. 0 → assume up count.
1 → assume down count.

x	P.S A B C	N.S A B C	TA	TB	Tc	
0	0 0 0	0 0 1	0	0	1	0
0	0 0 1	0 1 0	0	1	1	1
0	0 1 0	0 1 1	0	0	1	2
0	0 1 1	1 0 0	1	1	1	3
0	1 0 0	1 0 1	0	0	1	4
0	1 0 1	1 1 0	0	1	1	5
0	1 1 0	1 1 1	0	0	1	6
0	1 1 1	0 0 0	1	1	1	7
1	1 1 1	1 1 0	0	0	1	15
1	1 1 0	1 0 1	0	1	1	14
1	1 0 1	1 0 0	0	0	1	13
1	1 0 0	0 1 1	1	1	1	12
1	0 1 1	0 1 0	0	0	1	11
1	0 1 0	0 0 1	0	1	1	10
1	0 0 1	0 0 0	0	0	1	09
1	0 0 0	1 1 1	1	1	1	08

TA

xA \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{x}\bar{A}$	0_0	0_1	1_3	0_2
$\bar{x}A$	0_4	0_5	1_7	0_6
xA	1_{12}	0_{13}	0_{15}	0_{14}
$x\bar{A}$	1_8	0_9	0_{11}	0_{10}

$TA = \bar{x}BC + \bar{x}\bar{B}\bar{C}$

$= \cancel{B \odot C}$

$\bar{x}BC + x\bar{B}C$

TB

xA \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{x}\bar{A}$	0_0	1_1	1_3	0_2
$\bar{x}A$	0_4	1_5	1_7	0_6
xA	1_{12}	0_{13}	0_{15}	1_{14}
$x\bar{A}$	1_8	0_9	0_{11}	1_{10}

$\cancel{B\bar{x} + x\bar{c}}$

$TB = C\bar{x} + x\bar{C}$

$= x \oplus C$

Tc

xA \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{x}\bar{A}$	1	1	1	1
$\bar{x}A$	1	1	1	1
xA	1	1	1	1
$x\bar{A}$	1	1	1	1

$Tc = 1$

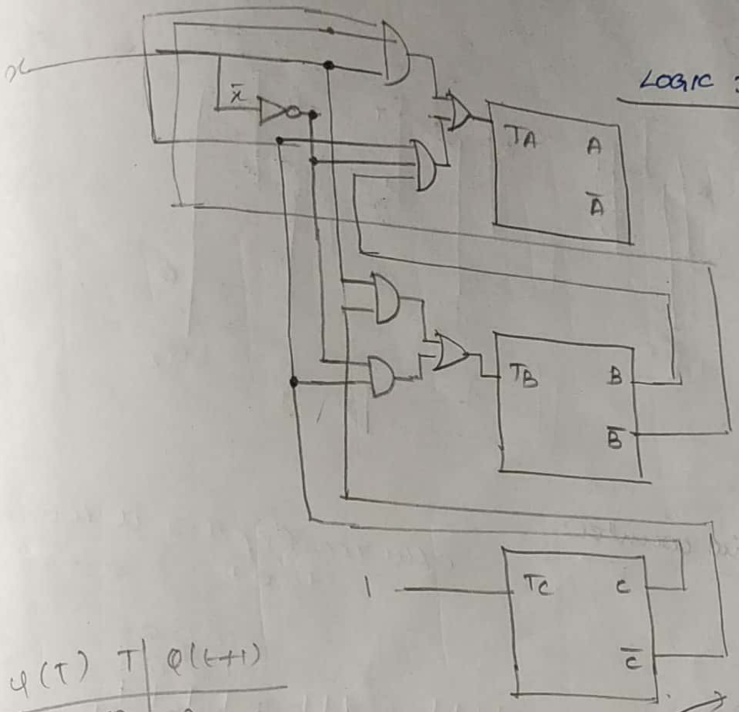
T-ff.

$TA = \bar{x}BC + x\bar{B}\bar{C}$

$TB = x \oplus C \Rightarrow x\bar{C} + \bar{x}C.$

$TC = 1.$

LOGIC DIAGRAM



Q(T)	T	Q(t+1)
0	0	0
1	1	1
1	0	1
1	1	0

comp

comp

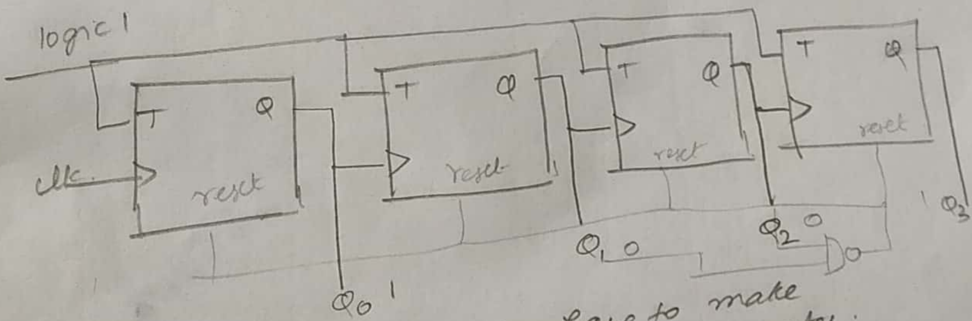
BCD Ripple counter (Decade counter) → Asynchronous

(use either JK or T) or Mod 10 counter

Asynchronous → direct ckt digram.

Synchronous → design

→ 0 to 9 (4 bits) → 4 flipflops.



From the above we have to make BCD ripple counter.

For

0 0 0 0

1 0 0 1

0 0 0 0.

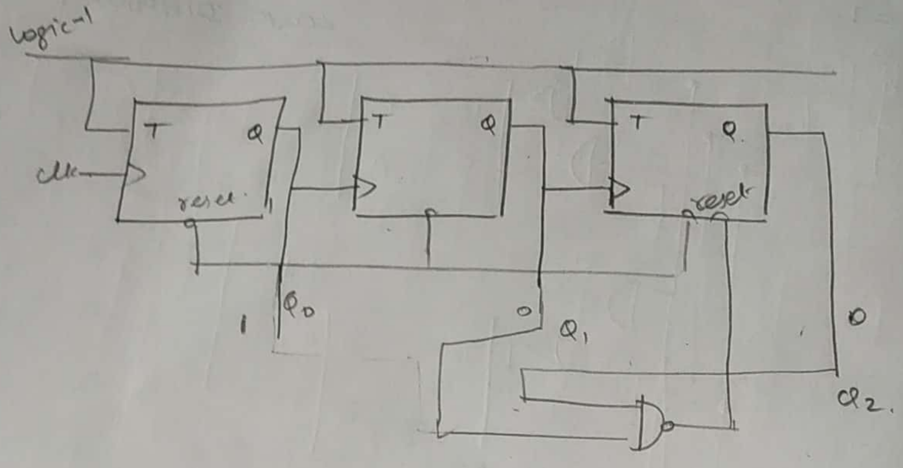
(Reset → accepts active low)

Preset → active low)

C	$B\bar{C}$
	1
	1
1	
1	

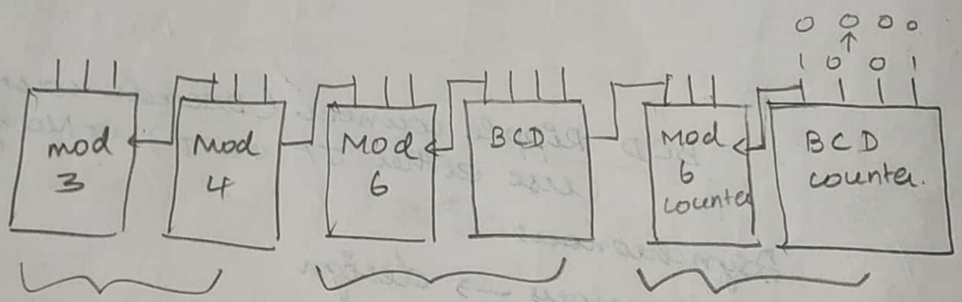
Mod - 5 counter

(3 bits enough) For Mod 10 (4 bits)



Real time counter:

after reaching 9 → it becomes
1001 0000



after reaching 23 → reset

after reaching 59 → reset

after reaching 59 → reset