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Digital logic

- Properties of different gates

	Gates		Idempotance	Commutative	Associative
1	NOT	−	✗	✗	✗
2	AND	·	✓	✓	✓
3	OR	+	✓	✓	✓
4	NAND	↑	✗	✓	✗
5	NOR	↓	✗	✓	✗
6	XOR	⊕	✗	✓	✓
7	XNOR	⊙	✗	✓	✓

Idempotance : $A \cdot A = A$

Commutative : $A \cdot B = B \cdot A$

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

Imp: K map
MUX
Latches
Number system: Fixed , Floating
Binary Single Precision
Conversion Double Precision
Code
Hexa
Decimal
Octa

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① Properties

1) Property of 0 : $p + 0 = p$
$p * 0 = 0$

2) Property of 1 : $p + 1 = 1$
$p * 1 = p$

3) Complementary : $p + \bar{p} = 1$
$p * \bar{p} = 0$

4) Commutative : $p + q = q + p$
$p \cdot q = q \cdot p$

5) Idempotence : $p + p = p$
$p * p = p$

6) Involution : $\bar{\bar{p}} = p$

7) Demorgan : $\overline{p+q} = \bar{p} \cdot \bar{q}$
$\overline{pq} = \bar{p} + \bar{q}$

8) Associative : $p + (q + r) = (p + q) + r$
$p(qr) = (pq)r$

9) Absorption : $p + qp = p$
$p \cdot (pq) = p$

10) Conditional : $p \Rightarrow q = \bar{p} + q$

11) Biconditional :
$(p \Leftrightarrow q) = (p \Rightarrow q)(q \Rightarrow p)$
$= (\bar{p} + q)(p + \bar{q})$

12) Distribution
$X + \bar{X}\bar{Y} = X + \bar{Y}$
$X + YZ = (X + Y)(X + Z)$
$X(Y + Z) = XY + XZ$

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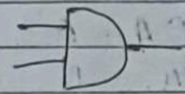
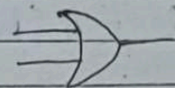
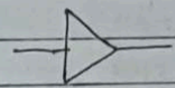
Logic Gates

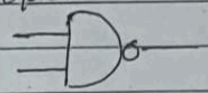
② Base Gates

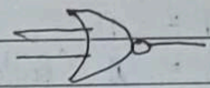
AND  all 1 = 1 $A \cdot B$

OR  any 1 = 1 $A + B$

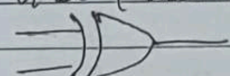
NOT  $1 \rightarrow 0$; $0 \rightarrow 1$ $\bar{A} = A$

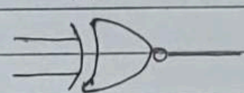
③ Universal Gate

NAND  all 1 = 0 $\overline{AB} =$

NOR  opposite of OR $\overline{A+B} =$

④ Arithmetic Gate (used in half, full adder, substractor)

XOR  odd 1 = 1 = diff [$A \oplus B = A\bar{B} + \bar{B}\bar{A}$]

XNOR  same input = 1 = same $AB + \bar{A}\bar{B}$

☆ Making different gates using NOR and NAND

	NAND	NOR
NOT	1	1
AND	2	3
OR	3	2
XOR	4	5
XNOR	5	4

NAND $\xleftrightarrow[4]{}$ NOR

★ Buffer: agar zero pass to zero, agar 1 pass to 1

Eg: Using XOR as buffer $(A\bar{B}+\bar{A}B)$

Inverter i) $A \oplus \bar{A} = 1 \Rightarrow A \oplus 1 = \bar{A}$

Buffer ii) $A \oplus 0 = A \Rightarrow A \oplus A = 0$

iii) $A \oplus A \oplus A \oplus \ldots\ldots = \left[\begin{array}{l} \text{even} = 0 \\ \text{odd} = A \text{ (Buffer)} \end{array}\right.$

Eg: Using XNOR $(AB+\bar{A}\bar{B})$

i) $A \odot A = 1$

ii) $A \odot \bar{A} = 0$

Inverter iii) $A \odot 0 = \bar{A}$

Buffer iv) $A \odot 1 = A$

v) $A \odot A \odot A \odot \ldots\ldots = \left[\begin{array}{l} \text{even} = 1 \\ \text{odd} = A \text{ (Buffer)} \end{array}\right.$

(5) Cannonical Sum of Product

SOP (Sum of Product) can have all the literals but Cannonical form of SOP must have all product terms containing all literals either in complementary or uncomplementary form

$f(x,y,z) = xyz + yz$ → SOP

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

$xyz + x\bar{y}$ SOP

$x\bar{y}z + xy\bar{z}$ CSOP

Eg:

x	y	z	f	SOP
0	0	0	0	
0	0	1	1	✓
0	1	0	0	
0	1	1	1	✓
1	0	0	0	
1	0	1	1	✓
1	1	0	0	
1	1	1	1	✓

$f(x,y,z) = \bar{x}\bar{y}z + \bar{x}yz + x\bar{y}z + xyz$

Sum of all minterms of 'f' which 'f' assumes 1 is the cannonical SOP or disjunctive normal form

$f(x,y,z) = \Sigma\, m1 + m3 + m5 + m7$

$\Sigma m(1,3,5,7)$

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⑥ Duality Theorem : Variables are not changed but

$$\cdot \longleftrightarrow +$$
$$OR \longleftrightarrow AND$$
$$NOT \longleftrightarrow NOT$$
$$XOR \longleftrightarrow XNOR$$
$$NAND \longleftrightarrow NOR$$
$$0 \longleftrightarrow 1$$

Eg: $\bar{A}B + A\cdot\bar{B}$ apply duality theorem
$(\bar{A}+B)\cdot(A+\bar{B})$

$AB\bar{C} + \bar{A}BC + ABC$
$(A+B+\bar{C})\cdot(\bar{A}+B+C)\cdot(A+B+C)$

→ Self dual fng: A fng is said to be self dual if and only if its dual is equivalent to given fng

Eg: $f(x,y,z) = (XY + YZ + ZX) = (x+y)(y+z)(z+x)$
$= (xy + xz + y + yz)(zx)$
$= yz + xy + xz + xz$
$= yz + xy + xz$

· How many self dual fung possible with 1 variable
→ Find total no. of combinations $= \bar{A}, A$ ② $= 2^n$
→ Find total no. of Boolean fng (logical exp) $= 0, 1, \bar{A}, A$ ④ 2^{2^n}
→ Total no. of self dual fng : ② $= 2^{2^{(n-1)}}$
→ n = no. of variables

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· How many self dual fng with 2 variables
→ Total no. of combinations $= 4 = 2^n$
→ Total no. of boolean fng $= 2^{2^n} = 16$
→ Total no. of self dual fng $= 4$

A	B	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	---- f_{16}
0	0	0	0	0	0	0	0	0	1	
0	1	0	0	0	1	1	0	1	0	
1	0	0	0	1	0	1	1	1	0	
1	1	0	1	0	0	0	1	1	0	

$(f_1 - f_{16}) = \cancel{0}, \cancel{1}, A, \bar{A}, B, \bar{B}, \cancel{\bar{A}\bar{B}}, \cancel{\bar{A}B}, \cancel{A\bar{B}}, \cancel{AB},$
$\cancel{A+B}, \cancel{A+\bar{B}}, \cancel{\bar{A}+B}, \cancel{\bar{A}+\bar{B}}, \cancel{AB+\bar{A}\bar{B}}, \cancel{A\bar{B}+\bar{A}B}$
$= A, \bar{A}, B, \bar{B}$

	1 variable	2 variable
→ Total combinations	2^n	2^n
→ Total boolean fng	2^{2^n}	2^{2^n}
→ Total self dual	$2^{2^{n-1}}$	2^n

7) K Map: Minimization using K map: graphical way to reduce a boolean expression

Given fn: $f(A, B) = \Sigma m(2, 3)$

	A	B	f
0	0	0	0
1	0	1	0
2	1	0	1
3	1	1	1

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

$= A\bar{B} + AB$

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

→ Karnaugh Map:
→ Boolean expression having n variables, no. of cells required in K Map: 2^n cells
→ It is based on Grey code (Unit distance code)
→ Based on 3 types of input values (0, 1, dont care)

Eg: K map of 3 variables:

$f(A, B, C)$:

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

Eg: K map of 4 variables
$f(A, B, C, D)$

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	5	7	6
AB 11	12	13	15	14
$A\bar{B}$ 10	8	9	11	10

if $f(A, B, C, D)$

AB \ CD

if (C, D, A, B)

CD \ AB

Eg: K map of 2 variables
$f(A, B)$

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

Eg: use of dont care (d)

$F(A,B,C,D) = \sum m(0,2,5,7,7,11) + d(3,8,10,12,14)$

dont care are drawn on the K map but only used when needed to have bigger groups, can be ignored

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:	3: ×	2: 1
$\bar{A}B$ 01	4:	5: 1	7: 1	6:
AB 11	12: ×	13:	15:	14: ×
$A\bar{B}$ 10	8: ×	9: 1	11: 1	10: ×

as its SOP (minterms) i.e value of 1's

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

① $A\bar{B}$
② $\bar{A}BC$
③ $\bar{B}\bar{D}$

(8) Redundant Group/Essential prime: atleast one '1' should be uncommon in intersecting group same for '0' for POS and SOP

(9) Half adder: (addition of 2 bits) $2I \rightarrow 2O$

Eg:

X	Y	Carry (MSB)	Sum (LSB)
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

$S(\text{minterm}) = \bar{x}y + x\bar{y} = x \oplus y$
$C(\text{minterm}) = xy$

(10) Full adder: (addition of 3 bits) $3I \rightarrow 2O$

x	y	z	Carry (MSB)	Sum (LSB)
0	0=0	0=0	0	0
0	0=0	1=1	0	1
0	1=1	0=1	0	1
0	1=1	1=0	1	0
1	0=1	0=1	0	1
1	0=1	1=0	1	0
1	1=0	0=0	1	0
1	1=0	1=1	1	1

$S(\text{minterm}) = x \oplus y \oplus z$
$C(\text{minterm}) = xy + yz + zx$
$= (x \oplus y)z + xy$

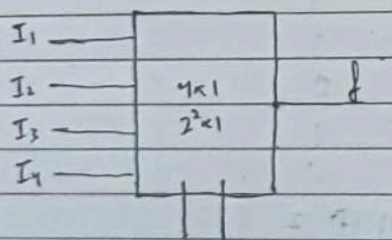
(11) Half Substractor: (substraction of 2 bits) $2I \rightarrow 2O$

x	y	borrow	sum
0	0	0	0
0	1	1	1
1	0	0	1
1	1	0	0

S (minterm) = $x \oplus y$
B (minterm) = $\bar{x}y$

(12) Multiplexer:
→ It is a combination of circuit that has 2^n input lines and a single output lines
→ A multiplexer is an electronic switch that connects 1 out of 'n' input to output
→ It is functionally complete i.e all boolean function can be realized using one multiplexer without any other gates

→ 4 × 1 Multiplexer:

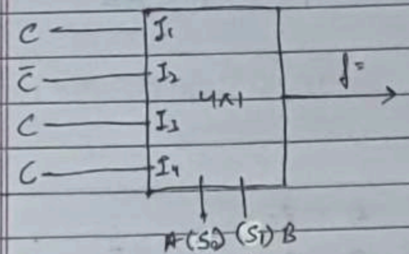


$4 = 2^2$ jitni power utni select lines

S_0	S_1
0	0
0	1
1	0
1	1

$$f = (\bar{S_0}\bar{S_1}) I_1 + (\bar{S_0} S_1) I_2 + (S_0 \bar{S_1}) I_3 + (S_0 S_1) I_4$$

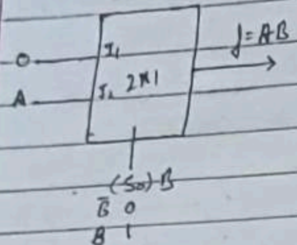
Eg: $F(A, B, C) = \Sigma(1, 2, 5, 7)$



$A(S_0)$	$(S_1)B$
0	0
0	1
1	0
1	1

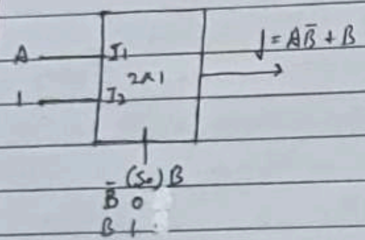
$1 = 001 \quad \bar{A}\bar{B}C = I_1 C$
$2 = 010 \quad \bar{A}B\bar{C} = I_2 \bar{C}$
$5 = 101 \quad A\bar{B}C = I_3 C$
$7 = 111 \quad ABC = I_4 C$

→ AND



A	B	f
0	0	0
0	1	0
1	0	0
1	1	1 = AB

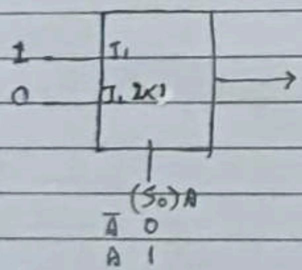
→ OR



A	B	f	
0	0	0	$\bar{A}\bar{B}$
0	1	1	$\bar{A}B$
1	0	1	$A\bar{B}$
1	1	1	AB

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

→ NOT



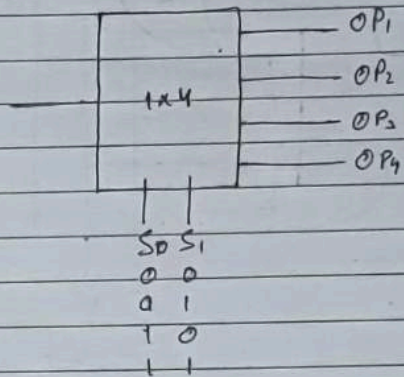
A
0
1

(13) Demultiplexer :

→ It is a combination of circuits that has 2^n output lines and a single input line

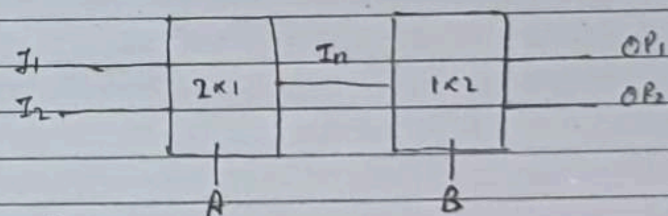
→ Input bus ek current hai jisko direct karna hai 4 mai se koi ek output ko at a single time

→ 1x4 Demultiplexer



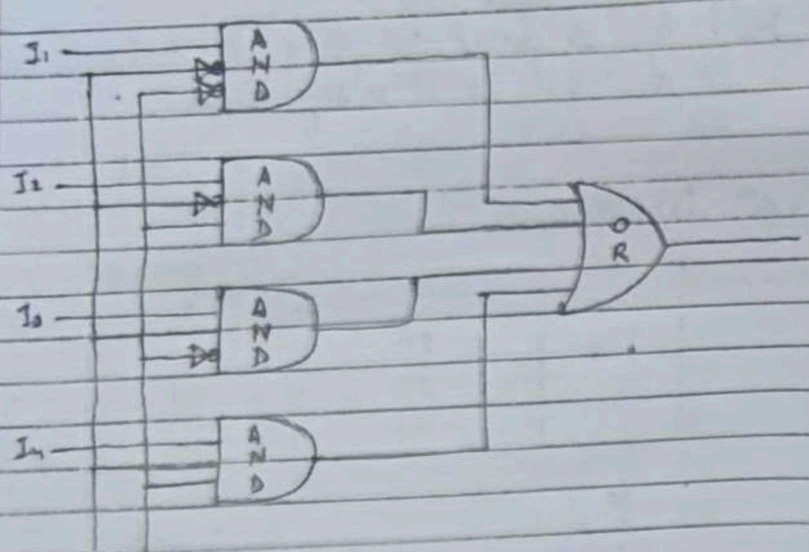
S_1	S_0	OP_1	OP_2	OP_3	OP_4
0	0	I	0	0	0
0	1	0	I	0	0
1	0	0	0	I	0
1	1	0	0	0	I

→ Converter (Multiplexer + Demultiplexer)



A	B		
0	0	I_1	OP_1
0	1	I_1	OP_2
1	0	I_2	OP_1
1	1	I_2	OP_2

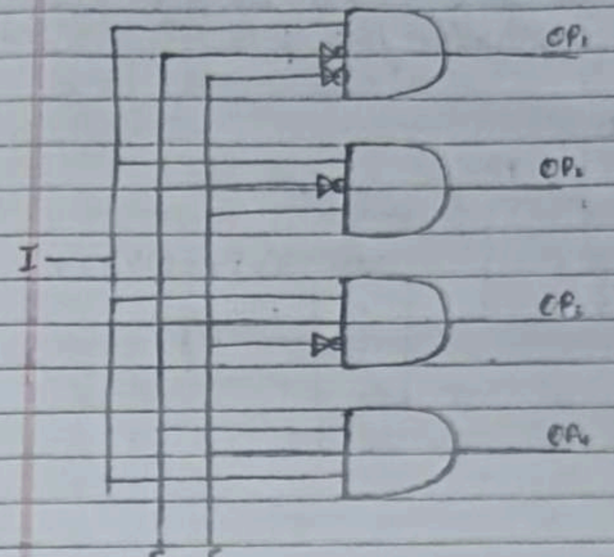
→ Working of Multiplexer (4×1)



S_0	S_1	
0	0	I_1
0	1	I_2
1	0	I_3
1	1	I_4

$$Z = \bar{S}_0 \bar{S}_1 I_0 + \bar{S}_0 S_1 I_1 + S_0 \bar{S}_1 I_2 + S_0 S_1 I_3$$

→ Working of Demultiplexer (1×4)



S_0	S_1
0	0
0	1
1	0
1	1

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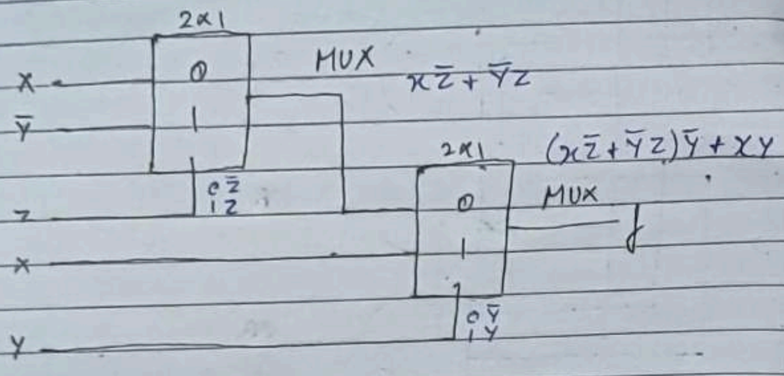
(14) Cascading multiplexer

Eg: Consider the circuit below. Which one of the following option correctly represents $f(x, y, z)$?



cascading i.e passing

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

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

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

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

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

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

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(15) Decoders

→ It is multiple input and multiple output devices

→ Decoder is a combinational circuit that converts n lines input into 2^n lines output ($n : 2^n$)

→ Application : converting binary code to

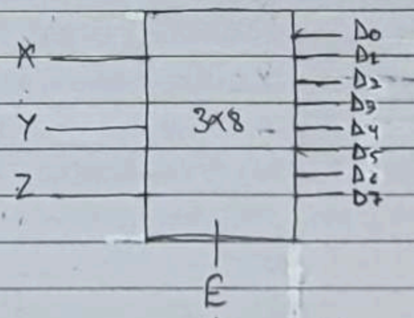
i) Octal (3×8)
ii) Hexadecimal (4×16)
iii) Decimal (4×10)

$8 = 2^3$ $\quad n \times 2^n$

$16 = 2^4$

2^n is max less than it is allowed

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



↳ enable pin always 1

D_0 $\bar{X}\bar{Y}\bar{Z}$
D_1 $\bar{X}\bar{Y}Z$
D_2 $\bar{X}Y\bar{Z}$
D_3 $\bar{X}YZ$
D_4 $X\bar{Y}\bar{Z}$
D_5 $X\bar{Y}Z$
D_6 $XY\bar{Z}$
D_7 XYZ

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(16) Encoder

→ It is also a multiple input and multiple output device

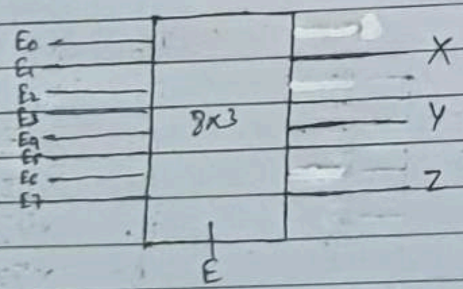
→ Encoder is a combinational circuit that converts 2^n inputlines into n output lines. $(2^n : n)$

→ Application i) Octal to binary (8 : 3)

ii) Hexadecimal to binary (16 : 4)

iii) Decimal to binary (10 : 4)

E_7	E_6	E_5	E_4	E_3	E_2	E_1	E_0	X	Y	Z	E
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	0	1	0	0	0	1	1
0	0	0	0	0	1	0	0	0	1	0	1
0	0	0	0	1	0	0	0	0	1	1	1
0	0	0	1	0	0	0	0	1	0	0	1
0	0	1	0	0	0	0	0	1	0	1	1
0	1	0	0	0	0	0	0	1	1	0	1
1	0	0	0	0	0	0	0	1	1	1	1



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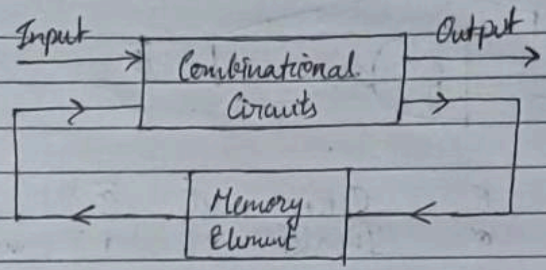
(17) Sequencial Circuit

→ The output (final) not only depend on input but also on the previous output.



Input + Q_n ⟶ Final Output (Q_{n+1})

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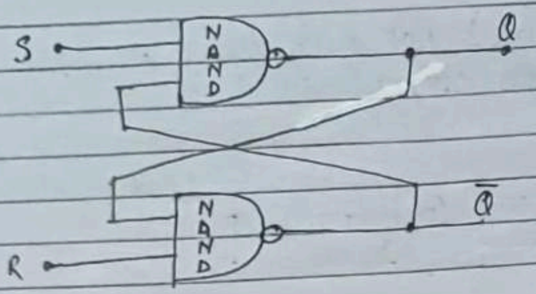
(13) SR latch (NAND)



		NAND
0	0	1
0	1	1
1	0	1
1	1	0

S	R	Q_{n+1}	Q	$\bar{Q}$	
0	0	Invalid	1	1	not possible
0	1	1	1	0	
1	0	0	0	1	
1	1	Hold	Q	$\bar{Q}$	

$$\overline{1\cdot\bar{Q}} = \bar{1} + \bar{\bar{Q}} = 0 + Q = Q$$
$$\overline{1\cdot Q} = \bar{1} + \bar{Q} = 0 + \bar{Q} = \bar{Q}$$

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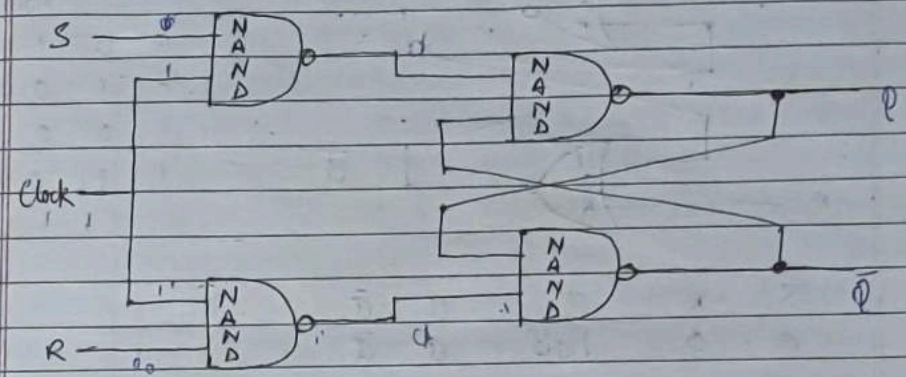
(19) SR flip flop (NAND)



clock	S	R	Q_{n+1}	Q	$\bar{Q}$
x	x	x	x (Q_n)	x	x
1	0	0	Hold	Q	$\bar{Q}$
1	0	1	0	0	1
1	1	0	1	1	0
1	1	1	Invalid	1	1

* when using NOR Q is abo[illegible]
when using NAND Q is above infront of S

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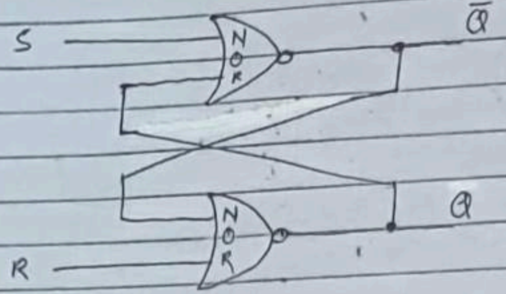
(20) SR latch (NOR)



		NOR
0	0	1
0	1	0
1	0	0
1	1	0

S	R	Q_{n+1}	Q	$\bar{Q}$
0	0	Hold	Q	$\bar{Q}$
0	1	0	0	1
1	0	1	1	0
1	1	Invalid	0	0

$\overline{0+Q} = 1 \cdot \bar{Q} = \bar{Q}$

$\overline{0+\bar{Q}} = 1 \cdot \bar{\bar{Q}} = Q$

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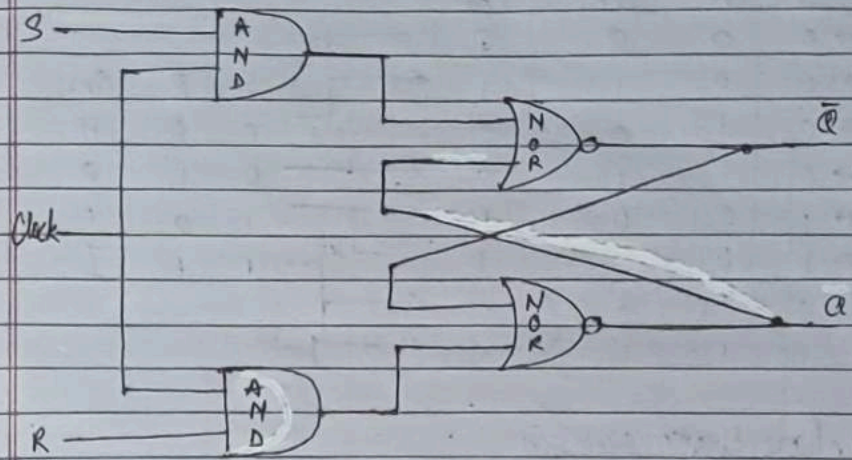
(21) SR flip flop (NOR)



clock	S	R	Q_{n+1}	Q	$\bar{Q}$
X	X	X	X	X	X
1	0	0	Hold	Q	$\bar{Q}$
1	0	1	0	0	1
1	1	0	1	1	0
1	1	1	Invalid	1	1

Eg: 3 inputs SR latch (flip flop) → characteristic Table

S	R	Q_n	Q_{n+1}	
0	0	0	0	Hold
0	0	1	1	
0	1	0	0	Reset
0	1	1	0	
1	0	0	1	Set
1	0	1	1	
1	1	0	X	Invalid
1	1	1	X	

S	R	Q_{n+1}
0	0	H
0	1	0
1	0	1
1	1	I

→ characteristic equation:

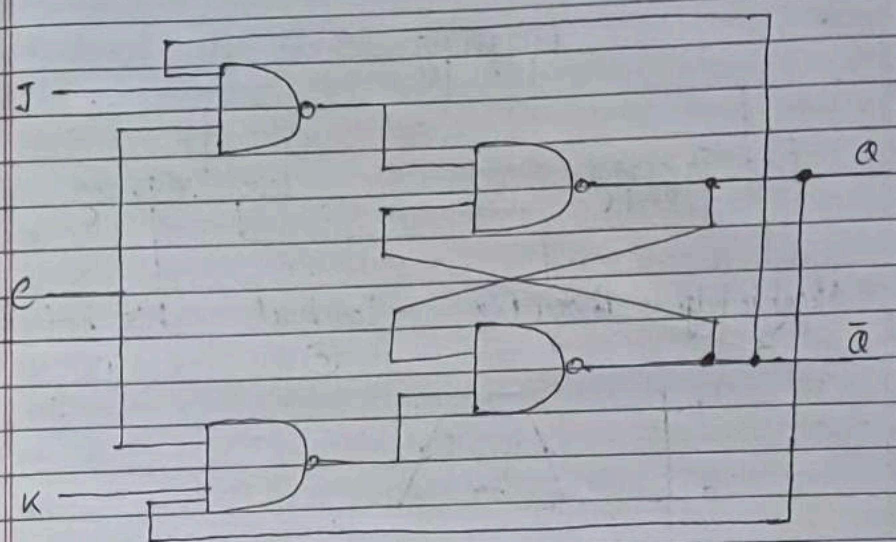
S \ RQ	$\bar{R}\bar{Q}$	$\bar{R}Q$	RQ	$R\bar{Q}$
$\bar{S}$	(0)	1 (1)	(3)	(2)
S	1 (4)	1 (5)	X (7)	X (6)

$Q_{n+1} = S + \bar{R}Q_n$

→ excitation table

Q_n	Q_{n+1}	S	R
0	0	0	X (unpredictable)
0	1	1	0
1	0	0	1
1	1	X	0

(22) JK flip flop



clock	J (~~S~~)	K (~~R~~)	Q_{n+1}
1	0	0	Hold
1	0	1	0
1	1	0	1
1	1	1	~~Invalid~~ Toggle (i.e $1 \rightarrow 0$, $0 \rightarrow 1$)

case 1 : $Q_n = 1 \rightarrow Q_{n+1} = 0$

case 2 : $Q_n = 0 \rightarrow Q_{n+1} = 1$

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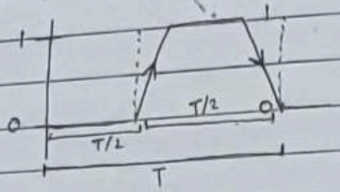
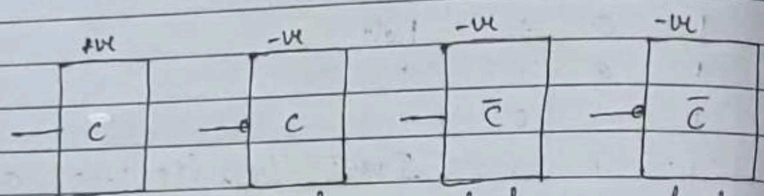
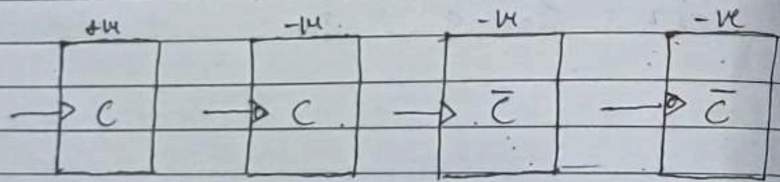
(23) Types of triggering:

Triggering
- Edge Triggering
  - Negative Edge ↘
  - Positive Edge ↗
- Level Triggering
  - Low Level (0)
  - High level (1)





level level level level



edge edge edge edge

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Eg 3 input JK latch (flip flop)

→ characteristic table

	J	K	Q_n	Q_{n+1}	
→	0	0	0	0	Hold
⇸	0	0	1	1	
→	0	1	0	0	reset
⇸	0	1	1	0	
⇸	1	0	0	1	set
⇸	1	0	1	1	
⇸	1	1	0	1	Toggle
⇸	1	1	1	0	

J	K	Q_{n+1}
0	0	Hold
0	1	0
1	0	1
1	1	Toggel

→ characteristic equation

J \ KQ_n	$\bar{K}\bar{Q}_n$	$\bar{K}Q_n$	KQ_n	$K\bar{Q}_n$
$\bar{J}$	(0)	1 (1)	(3)	(2)
J	1 (4)	1 (5)	(7)	1 (6)

$Q_{n+1} = \bar{K}Q_n + J\bar{Q}_n$

→ Excitation table

	Q_n	Q_{n+1}		J	K
	0	0	→	0	X
	0	1	⇸	1	X
	1	0	⇸	X	1
	1	1	⇸	X	0

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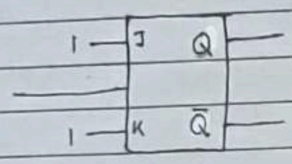
(24) Race around condition

Condition 1: level triggered JK flip flop

Condition 2: When $J = K = 1$ (Toggel mode)

Condition 3: $T_w >> T_d$

★ all 3 conditions must be fullfilld
★ only level triger clock



T_w = clock time
T_d = processing time

jab processing time kam hai or clock time zyada tab ek clock time mai do bar value (output) toggel hogayi i.e $1 \to 0 \to 1$ toh humko patahi nahi chala ki kuch change hua bhi hai kinahi
ek he clock pulse mai do bar toggle hogayi toh hum decide he nahi kar pa rahe ki actual output kya hai

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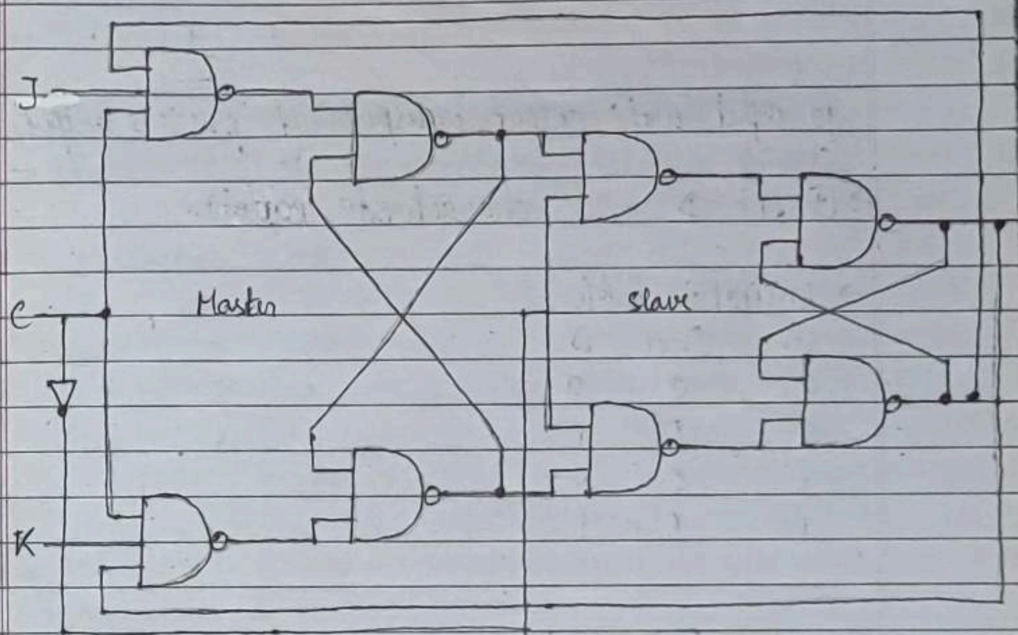
(25) Master slave JK flip flop

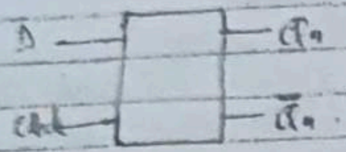
This has been devloped to tackle the JK flip flops race around condition problem.

★ edge trigger can solve this problem but what can be solution using level trigger is solved by master slave



26 D flip flop (Transparent flip flop)

Block diagram: (storage device)



characteristic table

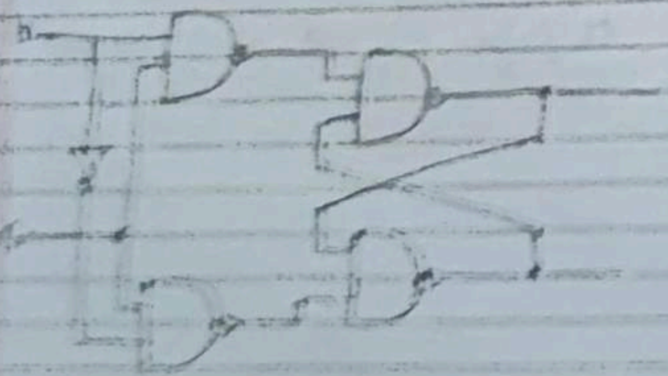
D	Q_n	Q_{n+1}
0	0	0
0	1	0
1	0	1
1	1	1

jo input wahi output irrespective of previous output

→ $Q_{n+1} = D$ characteristic equation

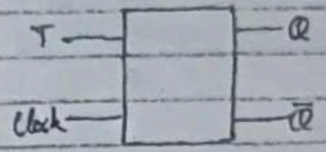
→ excitation table

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1



27 T flip flop (Toggle flip flop)

Block diagram:



characteristic table

T	Q_n	Q_{n+1}
0	0	0
0	1	1
1	0	1
1	1	0

T	Q_{n+1}
0	Q
1	$\bar{Q}$

0 pe same, 1 pe toggle

→ $Q_{n+1} = T \oplus Q_n$ XOR : characteristic equation

→ excitation table

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

Eg: Convert $\underbrace{\text{SR flip flop}}_{\text{given}}$ to $\underbrace{\text{D flip flop}}_{\text{required}}$

D	Q_n	Q_{n+1}	S	R
0	0	0	0	X
0	1	0	0	1
1	0	1	1	0
1	1	1	X	0

Q_n	Q_{n+1}	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

D \ Q_n	$\bar{Q}_n$	Q_n
$\bar{D}$	(0)	(1)
D	1 (2)	X (3)

$S = D$

D \ Q_n	$\bar{Q}_n$	Q_n
$\bar{D}$	X (0)	1 (1)
D	(2)	(3)

$R = \bar{D}$

Eg: Convert $\underbrace{\text{T flip flop}}_{\text{given}}$ to $\underbrace{\text{JK flip flop}}_{\text{required}}$

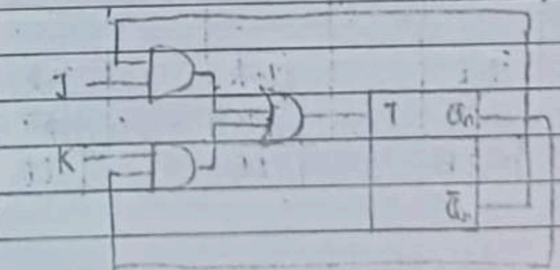
J	K	Q_n	Q_{n+1}	T
0	0	0	0	0
0	0	1	1	0
0	1	0	0	0
0	1	1	0	1
1	0	0	1	1
1	0	1	1	0
1	1	0	1	1
1	1	1	0	1

T excitation

0	0	0
0	1	1
1	0	1
1	1	0

J \ KQ_n	$\bar{K}\bar{Q}_n$	$\bar{K}Q_n$	KQ_n	$K\bar{Q}_n$
$\bar{J}$	(0)	(1)	1 (3)	(2)
J	1 (4)	(5)	1 (7)	1 (6)

$T = KQ_n + J\bar{Q}_n$: characteristic equation



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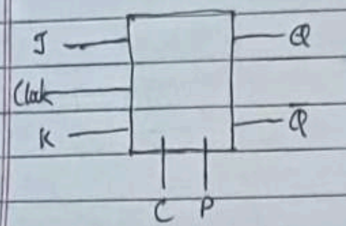
(28) Preset and clear input in flip flop

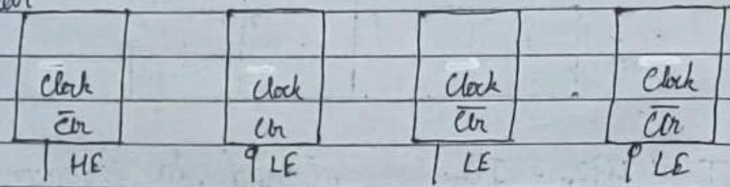
pins used when making counters



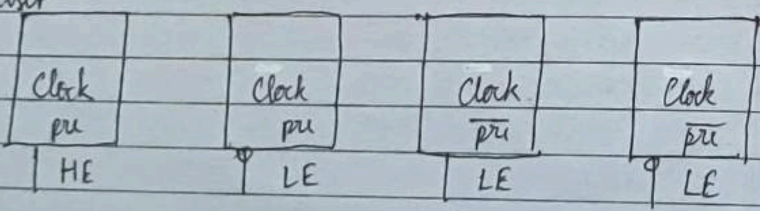
clear ko active : value = 0
preset ko active : value = 1

High enable to active clear or preset i.e giving 1
Low enable to deactive clear or preset i.e giving 0

→ clear



→ preset



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(29) Counters :

→ It is a device that is used to store the number of times a particular event or process has occured, often in relationship to a clock

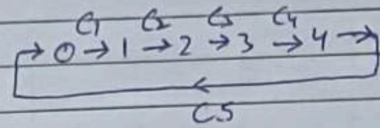
→ A counter circuit is usually constructed of a number of flip flops connected in cascade.

→ provide clock pulse to trigger

→ random, ascending, descending order of counting

→ now using edge trigger

Eg: How to find the mod value of a counter?

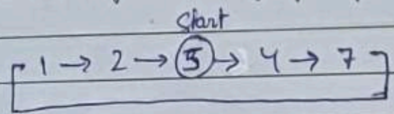


C_n : clock

★ mod = no. of different states + largest value in sequence ★
mod = 5 (0,1,2,3,4)

ii) after 21 clocks what will be output = 1

Eg: How to find no. of flip flops required to design mod-n counter



after 17 clocks
C_5 repeats

after 17 = 7 ; to Mod 5 clocks required

$$2^n \geq M$$ n = no. of ff required

$$2^n \geq 5$$ n = 3 i.e 3 ff required

or $\text{ceil}(\log_2 M)$

for M = 272 : $\text{ceil}(\log_2 272)$ = 8. ..... ≈ 9 i.e 9 ff required

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ii) $\boxed{0 \to 4 \to 8 \to 1 \to 5}$

Mod 5 ⇒ $\log_2 5 = 3$ X

bcoz of 8 is 1000

3 ff i.e $2^3 = 8$ as 1 ff stores 1 bit.

max combination is 7 i.e 111

for 8 : 4 ff required = 4 ✓

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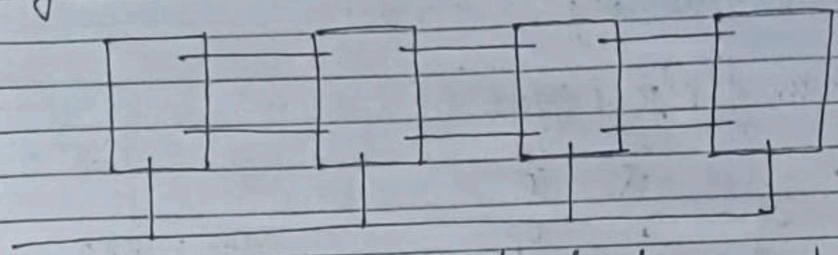
(30) Synchronous and Asynchronous

0 - 4 - 2 - 6 - 3

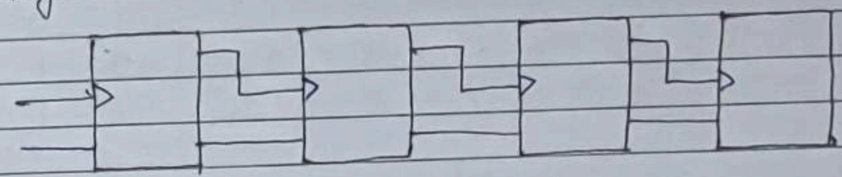
→ Synchronous



- sabko individually clock signal mil raha magar eksath
- ring, T-R (johnson counter)

→ Asynchronous

- Jumping sequence



- ek ka signal pichle wale pe dependent hai
- little slower than synchronous counter
- low cost
- easy design
- ripple counters

(follows only the sequential order)

- Only up or only down

0 - 1 - 2 - 3 - 4

4 - 3 - 2 - 1 - 0

31 Up / Down counter

up: ascending 1 2 3 4 5
down: descending 5 4 3 2 1

· use of edge trigger

	+ve	-ve
	Q	$\bar{Q}$
+ve →	Down	Up
-ve →	Up	Down

same : down
diff : up

Design of synchronous counter

$\boxed{0 \rightarrow 1 \rightarrow 3 \rightarrow 2}$

		D
0	0	0
0	1	1
1	0	0
1	1	1

2 flip flops (D type) required
2 states : i) present
ii) next

Present		Next		D flip flops	
Q_1	Q_0	Q_1^+	Q_0^+	D_1	D_0
0	0	0	1	0	1
0	1	1	1	1	1
1	0	0	0	0	0
1	1	1	0	1	0

D_1

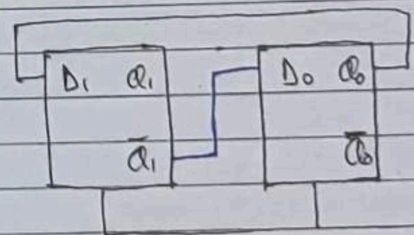
$Q_1 \backslash Q_0$	$\bar{Q}_0$	Q_0
$\bar{Q}_1$	(0)	1 (1)
Q_1	(2)	1 (3)

D_0

$Q_1 \backslash Q_0$	$\bar{Q}_0$	Q_0
$\bar{Q}_1$	1 (0)	1 (1)
Q_1	(2)	(3)

$D_1 = Q_0$

$D_0 = \bar{Q}_1$



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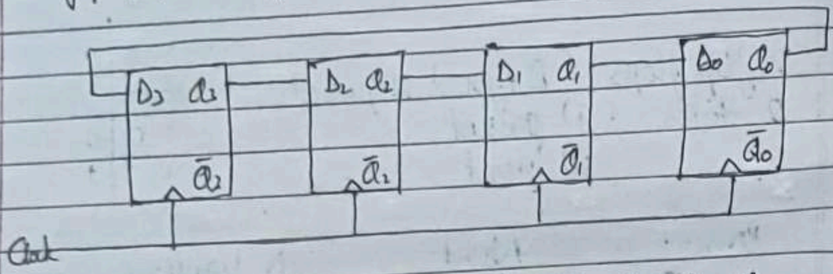
(32) Ring counter

4 flip flop (D types)



$Q_3^+(n+1) = D_3 = Q_0(n)$

$Q_2^+(n+1) = D_2 = Q_3(n)$

$Q_1^+(n+1) = D_1 = Q_2(n)$

$Q_0^+(n+1) = D_0 = Q_1(n)$

$2^n \longrightarrow n$

$16 \longrightarrow 4$

	Q_3	Q_2	Q_1	Q_0
	0	0	0	0
	0	0	0	0
	1	0	0	0
C_1	0	1	0	0
C_2	0	0	1	0
C_3	0	0	0	1
C_4	1	0	0	0

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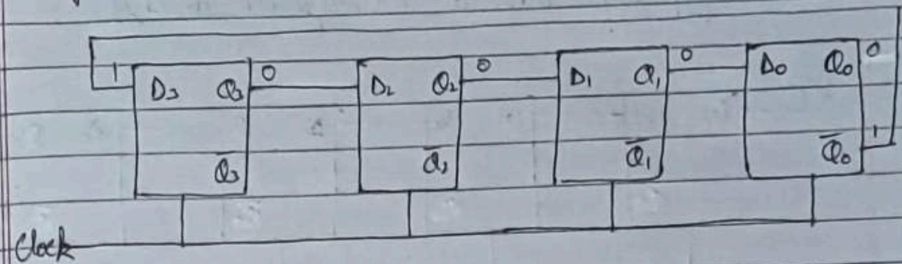
(33) Johnson counter (Twisted ring counter)

4 flip flops (D types)



$Q_3^+(n+1) = D_3 = \bar{Q}_0(n)$

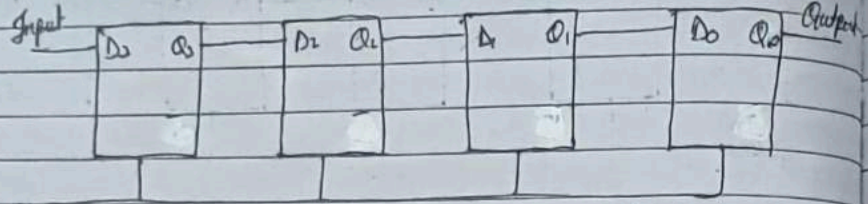
$Q_2^+(n+1) = D_2 = Q_3(n)$

$2^n = 16 - 8 = 8$

	Q_3	Q_2	Q_1	Q_0
	0	0	0	0
	1	0	0	0
C_1	1	1	0	0
C_2	1	1	1	0
C_3	1	1	1	1
C_4	0	1	1	1
C_5	0	0	1	1
C_6	0	0	0	1
C_7	0	0	0	0

(34) Shift Registers

→ They are used to implement arithematic operations
→ eg. left shift, right shift
→ Base flip flop used in the register is D ff



Mode	Clocks needed for n-bit shift register		
	Loading	Reading	Total
SISO	n	n-1	2n-1
SIPO	n	0	n
PISO	1	n-1	n
PIPO	1	0	1

S: serial I: input
P: parallel O: output

choti se badi = multiply
badi se choti = divide

(35) Binary Number System

1) Conversions
→ Binary to decimal

a) 101_2
$= 1\times2^2+0\times2^1+1\times2^0 = 4+0+1$
$= 5_{10}$

b) 1101.11_2
$1\times2^3+1\times2^2+0\times2^1+1\times2^0+1\times2^{-1}+1\times2^{-2}$
$= 8+4+0+1+0.5+0.25$
$= 13.75_{10}$

c) 101101.101_2
$1\times2^5+0\times2^4+1\times2^3+1\times2^2+0\times2^1 * 1\times2^0+1\times2^{-1}+0+1\times2^{-3}$
$= 32+0+8+4+0+1+0.5+0.125$
$= 45.625$

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→ Decimal to Binary

a) $25_{10} \longrightarrow \_\_\_\__2$

2	25	1
2	12	0
2	6	0
2	3	1
	1	

11001_2

b) 25.025_{10}

$0.025 \times 2 = 0.05$ 0
$0.050 \times 2 = 0.1$ 0
$0.10 \times 2 = 0.2$ 0
$0.20 \times 2 = 0.4$ 0
$0.40 \times 2 = 0.8$ 0
$0.80 \times 2 = 1.6$ 1
$0.60 \times 2 = 1.2$ 1

now 0.2 will repeat so we stop

$25.025_{10} = 11001.0000011_2$

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c) 45.125_{10}

2	45	1
2	22	0
2	11	1
2	5	1
2	2	0
	1	

$0.125 \times 2 = 0.25 = 0$
$0.25 \times 2 = 0.50 = 0$
$0.50 \times 2 = 1.0 = 1$

101101.001_2

d) 67.125

67	67	1
2	33	1
2	16	0
2	8	0
2	4	0
2	2	0
	1	

$0.0125 \times 2 = 0.025$ 0
$0.025 \times 2 = 0.050$ 0
$0.050 \times 2 = 0.10$ 0
$0.10 \times 2 = 0.20$ 0
$0.20 \times 2 = 0.40$ 0
$0.40 \times 2 = 0.80$ 0
$0.80 \times 2 = 1.60$ 1
$1.60 \times 2 = 3.2$ 1
$0.2 \times 2 =$ stoped
0.2 repeats

$67.125_{10} = 1000011.00000011$

→ Decimal to Octal

a) $356_{10} \longrightarrow \_\_\__{8}$

8	356	
8	44	4
8	5	4
	0	5

544_8

b) 412.375_{10}

8	412	
8	51	4
8	6	3
	0	6

$0.375 \times 8 = 3$

634.3_8

c) 513.5625_{10}

8	513	
8	64	1
8	8	0
8	1	0
	0	1

0.5625×8
$= 44$

1001.44_8

→ Octal to decimal

a) 142_8

$= 1\times8^2 + 4\times8^1 + 2\times8^0$

$= 64 + 32 + 2$

$= 98_{10}$

b) 512.125_8

$= 5\times8^2 + 1\times8^1 + 2\times8^0 + 1\times8^{-1} + 2\times8^{-2} + 5\times2^{-3}$

$= 320 + 8 + 2 + 1/8 + 2/64 + 5/512$

$= 330.15805_{10}$

c) 173.062_8

$1\times8^2 + 7\times8^1 + 3\times8^0 + 0 + 6/64 + 2/512$

123.09765_{10}

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→ Octal to Binary

a) $4513_8 \longrightarrow \_\_\__2$

4 5 1 3
100 101 001 011

100101001011_2

b) 1004.241_8

1 0 0 4 . 2 4 1
001 000 000 100 010 100 001

1000000100.010100001_2

c) 516.23_8

5 1 6 . 2 3
101 001 110 010 011

101001110.010011_2

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→ Binary to Octal

a) $101101111_2 \longrightarrow \_\_\__8$

101 101 111
5 5 7

557_8

b) 10110111

010 110 111
2 6 7

267_8

c) 1110101.11_2

001 110 101 . 110
1 6 5 6

165.6_8

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→ Decimal to Hexadecimal

a)

$$\begin{array}{r|ll} 16 & 422 & \\ \hline 16 & 26 & 6 \\ \hline 16 & 1 & A \\ & & 1 \end{array} \uparrow$$

$1A6_{16}$

b) 422.03125_{10}

$0.03125 \times 16 = 0.5$
$0.5 \times 16 = 8.0$

$1A6.08_{16}$

c)

$$\begin{array}{r|ll} 16 & 216 & \\ \hline 16 & 13 & 8 \\ \hline & & D \end{array} \uparrow$$

$D8_{16}$

d) 512.0125_{10}

$$\begin{array}{r|ll} 16 & 512 & \\ \hline 16 & 32 & 0 \\ \hline 16 & 2 & 0 \\ & & 2 \end{array}$$

$0.125 \times 16 =$

200.05_{16}

0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F
16	10
17	11
18	12
19	13
20	14
21	15
22	16
23	17
24	18
25	19
26	1A
27	1B
28	1C
29	1D
30	1E
31	1F
32	20
33	21
34	22
35	23

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→ Hexadecimal to Decimal

a) 216_{16}

$2 \times 16^2 + 1 \times 16^1 + 6 \times 16^0$
$512 + 16 + 6$
534_{10}

b) $13A.2B_{16}$

$1\ 3\ 10 \cdot 2\ 11$
$= 1 \times 16^2 + 3 \times 16^1 + 10 \times 16^0 + 2/16^1 + 11/16^2$
$= 256 + 48 + 160 + 0.125 + 0.6$
$= \cancel{1.464.423}$
$= 464.812_{10}$

→ Hexadecimal to Binary

a) $2A1_{16}$

2 A 1

0010 1010 0001

1010100001_2

b) $B2F7 \cdot CD_{16}$

B 2 F 7 . C D

1100 0010 1111 0111 . 1101 1101

$1100001011110111 \cdot 11011110_2$

c) $BEE2 \cdot FACE_{16}$

B E E 2 . F A C E

1100 1110 1110 0010 . 1111 1010 1101 1110

$1100111011100010 \cdot 1111101011011110_2$

→ Binary to Hexadecimal

a) 101101011_2

0001 | 0110 | 1011

1 6 B

$16B_{16}$

b) $110101011 \cdot 11$

0001 | 1010 | 1011 . | 1100 |

1 A B . C

$1AB \cdot C_{10}$

c) $1010110000 \cdot 01_2$

| 0010 | 1011 | 0000 . | 0100 |

2 C 0 . 4

$2C0 \cdot 4_{16}$

d) $1100010101 \cdot 001_2$

| 0011 | 0001 | 0101 . | 0010 |

3 1 5 . 2

$315 \cdot 2_{16}$

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→ Octal to Hexadecimal

a) 6704.053_8

6 7 0 4 . 0 5 3
110 111 000 100 . 000 101 011

1101|1100|0100 . 0001|0101|1000
D C 4 . 1 5 1

$DC4.151_{16}$

b) 513.25_8

5 1 3 . 2 5
101 001 011 . 010 101

~~0101|0001|0011|.0010|~~

0001|0100|1011 . 0101|0100
1 4 B . 5 4

$14B.54_{16}$

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→ Hexadecimal to Octal

a) $A.2C3_{16} \rightarrow$ ______$_8$

A . 2 C 3
1010 0010 1100 0011

001|010 . 001|011|000|011
1 2 . 1 3 0 3

12.1303_8

b) $F1D0.E7_{16}$

F 1 D 0 . E 7
1111 0001 1101 0000 . 1110 0111

001|111|000|111|010|000 . 111|001|110
1 7 0 7 2 0 . 7 1 6

170720.716_8

c) $ED1A.ABE_{16}$

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(36) Unsigned binary integers:

a)

+7	00111
+3	00011
+10	01010

b)

+4	00100
+6	00110
+10	01010

c)

+7	00111
+8	01000
+15	01111

mean is 15 after that more decimal are needed

d)

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- True form = positive form without any -ve sign
- 1's complement : -ve form having inverted binary i.e 0 → 1 and 1 → 0
- 2's complement : by adding 1 to LSB of the 1's form of the number

a)

+7	00111	True form
-3	11100	1's
+4	00011	
	+1	
	00100	True form

★ in 1's form when there's a carry 1 then its get added to the LSB

b)

-7	11000	1's
+3	00011	True form
-4	11011	1's

c)

-7	11000	1's
-3	11100	1's
-10	10100	
	1	
	10101	

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Eg: Addition using 1's complement

a)

+4	100	
+2	010	
+6	110	

b)

-4	011	1's
+2	010	True
-2	101	1's

c)

+4	100	True
-2	101	1's
+2	001	
	1	
	010	True

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(37) Rules for substraction

add M to r's complement of N
r = base
$M + (r^n - N)$

For substraction we need to covert 3 bit into 4 bits

Case 1: positive $(M > N)$
$M - N$ $(M + r\text{'s comp of } N)$

Eg $(5-3)$

+5	0101	True
-3	1100	1's
+2	0001	
	1	
	0010	

Case 2: negative

Here the sum doesnt produce any carry
To obtain the result take there r's complement to the sum and place the negative singn infront of the result

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ii) M<N

Eg 3-5

+3 0011
-5 1010
-2 1101

Eg 65-63 using 1's compliment

2	65	1
2	32	0
2	16	0
2	8	0
2	4	0
2	2	0
	1	

2	63	1
2	31	1
2	15	1
2	7	1
2	3	1
	1	

65 : 1000001 True
63 : 0111111 True

SB
+65 01000001 True
-63 11000000 1's
00000001
1
+2 $\boxed{0}$0000010 True

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Eg: 65-63 using 2's compliment

+65 01000001 True
-63 11000000 1's
+1
11000001 2's

01000001
11000001
1 00000010

drop

* in 2's compliment the extra 1 after addition (carry) is dropped as 2's compliment is created by adding 1 to 1's compliment

Eg: X = 1010100 , Y = 1000011 (X - Y) using 1's

0111100 1's
+1 2's
0111101

1's
1010100
0111100
0010000
1
0010001 $(17)_{10}$

2's
1010100
0111101
1 0010001 $(17)_{10}$

drop

+9 : 00001001 True
-9 : 10001001 mag
11110110 1's
11110111 2's

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(38) Signed and Unsigned bit

→ Signed bit

+9 : $\boxed{0}$0001001

-9 : $\boxed{1}$0001001

→ Unsigned bit

unsigned numbers $(0 \rightarrow (2^n - 1))$

n = 8   0 − (256 − 1)
0 − 255   Binary
00 − FF   Hexadecimal

Eg
-6   11111010   2's
+13   00001101   True
+7   00000111

+6   00000110   True
-6   11111001   1's
-6   +1   2's
11111010

-6   11111010   2's
+13   00001101   True
+7   00000111

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Eg: -6   11111001   1's
+13   00001101   True
+7   00000110
+1
00000111   True

Eg: Sign Magnitude representation:

-3 : 1011
-7 : 1111

Eg: 1's Complement Representation

-3 : 1100
-7 : 1000

Eg: 2's Complement representation

-3 : 1101
-7 : 1001

Eg: -6   -6
+13   0110 (6)   1's comp   2's comp
1110 (-6)   1001   1001
+1
1010

10000110   11111001   11111001
+1
11111010

Eg: -6 10000110
-13 10001101

M > N

10000110
1s: 11111001

2s: 11111001
+1
11111010

10001101
11110010

11110010
+1
11110011

-6	11111010	2s
-13	11110011	2s
	1 11101101	2s

drop

11101101 1s
00010010
+1 2s
00010011 = (+19)

19 : 00010011 True
-19 : 10010011 Sign
11101100 1s
+1
11101101 2s

Eg Addition using 1s complement

a)

	True	1s
+4	0100	1011
+2	0010	1101
+6		1000
		1
		1001 1s of 6

b)

-4	1100 (T of 4)	1011 1s of 4
+2	0010	0010
-2		1101

c)

+4	0100	0100
-2	1010	1101
+2		0001
		1
		0010

d)

	-4	-2
-4	1100	1010
-2	1011	1101
-6		

~~1000~~
~~1101~~
~~1001~~
~~1~~
~~1010~~

1011
1101
1000
1
1001 1s of (-6)

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Eg) -4 using 2's complement
-2

	-4	-2
True (Sign)	1100	1010
1's	1011	1101
2's	1100	1110

```
 -4      1100
+ -2     1110
 -6     (1)1010
         drop
```

Eg: +4
-2
+2

	+4	-2
True (Sign)	0100	1010
1's		1101
2's		1110

```
 +4     0100
 -2     1110
 +2    (1)0010
        drop
```

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Eg -4
+2
-2

	-4	+2
True(sign)	1100	0010
1's	1011	
2's	1100	

```
 -4     1100
 +2     0010
        1110     2's of (-2)
```

Eg: +4
+2
+6

+4	+2
0100	0010

```
 +4    0100
 +2    0010
 +6    0110
```

Eg: Substraction using 2's complement

a)
$$\begin{array}{r} +4 \\ -2 \\ \hline +2 \end{array}$$

	+4	-2
True	0100	1010
1's		1101
2's		1110

$$\begin{array}{rr} +4 & 0100 \\ -2 & 1110 \\ \hline +2 & ①0010 \end{array}$$

drop

b)
$$\begin{array}{r} +4 \\ -+2 \\ \hline +2 \end{array}$$

+4	-2	
0100	1010	True
	1101	1's
	1110	2's

$$\begin{array}{rr} +4 & 0100 \\ -2 & 1110 \\ \hline & 0010 \end{array}$$

★ The reason BCD is till 9 as after 9 i.e 10, 11, 12 ... get to two digits binary

(39) BCD (Binary Coded Decimal)

Decimal	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Highest 4bit : $(1111)_2 = (15)_{10}$

a) $4 + 5 = 9$
$$\begin{array}{r} 0100 \\ 0101 \\ \hline 1001 \end{array}$$

b) $4 + 8 = 12$
$$\begin{array}{r} 0100 \\ 1000 \\ \hline 1100 \end{array}$$

i.e 12 > 9 ✓
(12) this no. is outside BCD limit so we need to add the binary equivalent of 6 to the resultant

$$\begin{array}{r} 1100 \\ +0110 \\ \hline 10010 \end{array}$$

10010 → 0001|0010 BCD representation of 12
1 2
0001 0010

c) $8+9 = $

$$\begin{array}{r} 1000 \\ 1001 \\ \hline 10001 \end{array}$$

$$\begin{array}{r} 10001 \\ +00110 \\ \hline 10111 \end{array}$$

adding 6

$10111 \rightarrow$ 0001|0111 BCD representation for 17

0001 0111 = 1 7 = 17

d) BCD coded addition:

$$\begin{array}{r} 184 \\ +576 \\ \hline \end{array}$$

1	0001	8	1000	4	0100
5	0101	7	0111	6	0110
	0110		1111		1010
			0110		+0110
	0111		10110		10000

(0111|0110|0000)BCD

$1+5 = 6 : <9$ so no need to add (+6) to it

$8+7 = 15 : >9$

$4+6 : 10 : >9$

* Hexadecimal : $2^4 = 16$ so 4 bits (A:10) 1010
  Binary : $2^1 = 2$ so 1 bit (0,1) 0,1
  Octal : $2^3 = 8$ so 3 bits (7:) 111

(40) Gray Code

Gray	Decimal	Binary
0000	0	
0001	1	
0011	2	
0010	3	
0110	4	

→ Gray to Binary: $G_3 \quad G_2 \quad G_1 \quad G_0$

$\oplus \quad \oplus \quad \oplus$

$B_3 \quad B_2 \quad B_1 \quad B_0$

→ Binary to Gray: $B_3 \oplus B_2 \oplus B_1 \oplus B_0$

$G_3 \quad G_2 \quad G_1 \quad G_0$

$B_3 \quad B_3 \oplus B_2 \quad B_2 \oplus B_1 \quad B_0 \oplus B_1$

Eg: Convert GC: 1010 to BC

$B_3 = 1$

$B_2 = 1 \oplus 0 = 1$

$B_1 = 1 \oplus 1 = 0$

$B_0 = 0 \oplus 0 = 0$ $(1100)_2$

(41) Boolean algebra

$x + 0 = x$

$x + \bar{x} = 1$

$x + x = x$

$x + 1 = 1$

$\bar{\bar{x}} = x$

$x \cdot 1 = x$

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

$x \cdot x = x$

$x \cdot 0 = 0$

$x(y+z) = xy + xz$

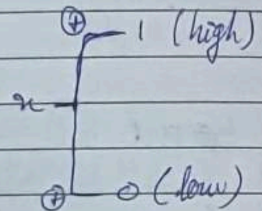
$\overline{(x+y)} = \bar{x} \cdot \bar{y}$

$x + xy = x$

$x + yz = (x+y)\cdot(x+z)$

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

$x(x+y) = x$



★ add gives higher result

★ multiply gives lower result

(42) Canonical & Standard form

Canonical form: when the terms of the expression has each term of the given function.

$F(ABC) = \underline{3} + \underline{3} + \underline{3}$ ie ABC

$F(ABCD) = \underline{4} + \underline{4} + \underline{4}$ ie $ABCD$

a) $F = (\bar{A}+B)\cdot(A+\bar{B})$

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

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

Eg Express the boolean fun as SOP (sum of minterms)

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

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

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

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

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

7 4 6 5 4 1

$m_7 \; m_6 \; m_5 \; m_4 \; m_1$

$F(ABC) = \Sigma(1, 4, 5, 6, 7)$: SOP

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Eg. $F(XYZ) = XY + \bar{X}Z$

$X = xy,\ Y = \bar{x},\ Z = Z$

$x + yz = (x+y)(x+z)$ distribution property

POS

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

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

$= M_0\ M_2\ M_4\ M_5$

Eg. $F(xyz) = (xy+z)(y+xz)$ SOP
$= xy + xz + zy + xz$
$= xy + zx + zy$
$= (xyz + xy\bar{z} + xyz + x\bar{y}z + xyz + \bar{x}yz$
$= xyz + xy\bar{z} + x\bar{y}z + \bar{x}yz$
$\quad 7 \quad 6 \quad 5 \quad 3$

$= m_7\ m_6\ m_5\ m_3$

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$(xy+z)(y+zx)$ POS

Eg $F(xyz) = (z+x)(y+z)(y+x)(y+z)$
$= y\bar{y} + (z+x)(y+z)(y+x)$
$= (z+x+y)(z+xy\bar{y})(y+z+\bar{x})(y+z+x)$
$(y+x+z)(y+x+\bar{z})$

$= (x+y+z)(x+\bar{y}+z)(\bar{x}+y+z)(x+y+\bar{z})$
$= (0\ 0\ 0)(0\ 1\ 0)(1\ 0\ 0)(0\ 0\ 1)$
$=\ \ 0 \quad 2 \quad 4 \quad 1$
$M_0 \quad M_2 \quad M_4 \quad M_1$

Eg: $F = \bar{A}B(\bar{D} + \bar{C}D) + B(A + \bar{A}CD)$
$= \bar{A}B(\bar{D} + \bar{C}D) + B(A + \bar{A}CD)$
$= B(\bar{A}\bar{D} + \bar{A}\bar{C}D + A + \bar{A}CD)$
$= B(\bar{A}(\bar{D} + \bar{C}D + CD) + A)$
$= B(\bar{A}(\bar{D} + D(\bar{C}+C) + A)$
$= B(\bar{A}(\bar{D}+D) + A)$
$= B(\bar{A}+A)$
$= B$

or
$= \bar{A}B\bar{D} + \bar{A}B\bar{C}D + AB + \bar{A}BCD$
$= \bar{A}BD(1) + AB + \bar{A}B\bar{D}$
$= \bar{A}B + AB$
$= B(\bar{A}+A)$
$= B$

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

Eg: $F = xy + \overline{(xy)} * wz$

$= A + \bar{A}B$

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

$= (xy + wz)(1)$

$= xy + wz$

Eg: $F(A,B) = \Sigma(0,2,3)$

$= 00, 10, 11$

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

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

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

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

Eg: $F = (A+B)(A+\bar{B})\cdot(\bar{A}+B)(\bar{A}+\bar{B})$

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

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

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

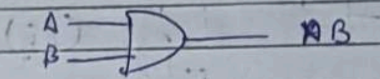
$= 0$

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

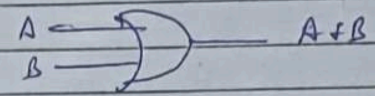
(43) Logic gates

1. AND
2. OR
3. NOT
4. XOR
5. NOR] universal gates
6. NAND]
7. ~~XNOR~~

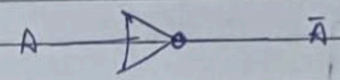
1) AND



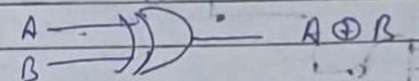
2) OR



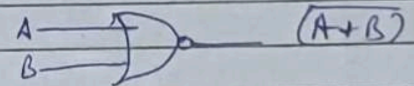
3) NOT



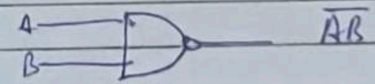
4) XOR



5) NOR



6) NAND



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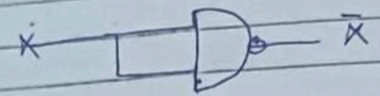
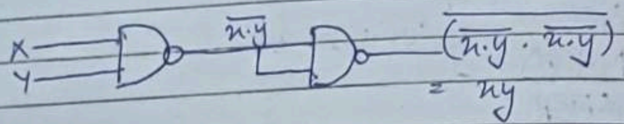
(44) NAND as universal gate

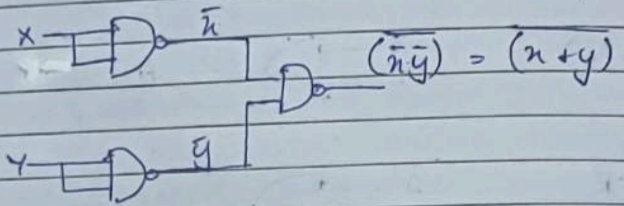
a) NOT



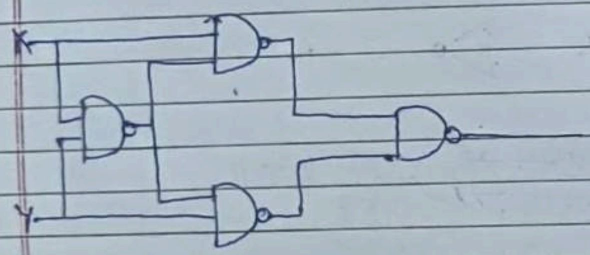
b) AND



c) OR



d) XOR



★ jo jo change hota hai vo hatke rest all should be taken.

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(45) K map

a) $F(x\,y\,z) = \Sigma(2,3,4,5)$

$x \backslash yz$	$\bar{y}\bar{z}$ 00	$\bar{y}z$ 01	yz 11	$y\bar{z}$ 10
0 $\bar{x}$			1	1
1 x	1	1		

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

b) $F(x,y,z) = \Sigma(3,4,6,7)$

$x \backslash yz$	00	01	11	10
0 $\bar{x}$			1	
1 x	1		1	1

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

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

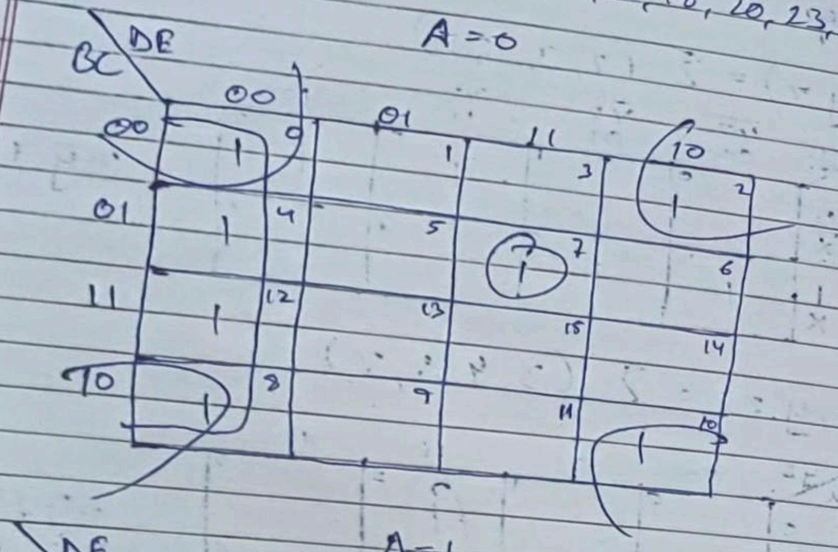
c) $F(xyzw) = \Sigma(0,1,2,4,5,6,8,9,12,13,14)$

$WX \backslash YZ$	$\bar{Y}\bar{Z}$ 00	$\bar{Y}Z$ 01	YZ 11	$Y\bar{Z}$ 10
00 $\bar{W}\bar{X}$	1	1		1
01 $\bar{W}X$	1	1		1
11 WX	1	1		
10 $W\bar{X}$	1	1		1

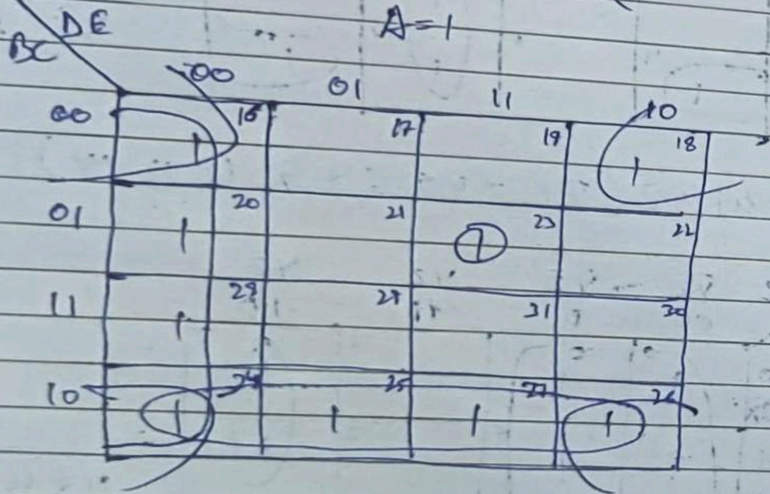
$\bar{y} + \bar{w}y\bar{z} + w\bar{x}\bar{z}$

$F(ABCDE) = (0,2,4,7,8,10,12,16,18,20,23,24,28,26,27,28)$

A = 0



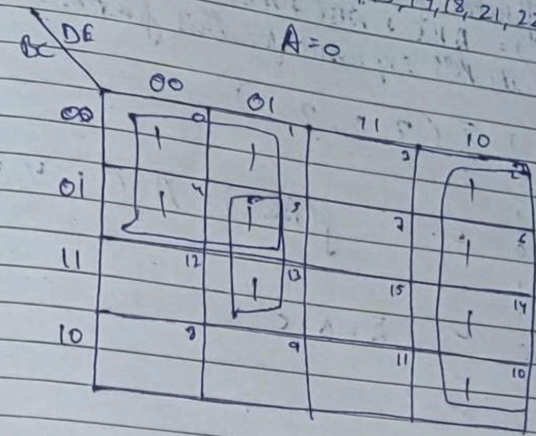
A = 1



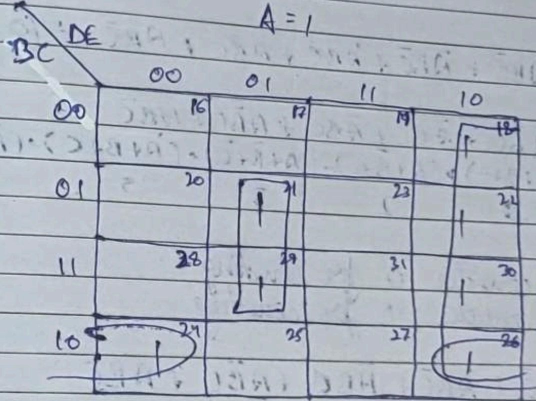
$\bar{D}\bar{E} + \bar{C}\bar{E} + AB\bar{C} + \bar{B}CDE$

e) $F(ABCDE) = (0,1,2,4,5,6,10,13,14,18,21,22,24,26,28,29,30)$

A = 0



A = 1



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

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★ $F(AB) = \bar{A}\bar{B} + \bar{A}B + A\bar{B} + AB \quad (0,1,2,3)$
$= \bar{A} + A$
$= 0$

★ Eg: Consider function for SOP
$f(ABC) = ABC + \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC$
What is the POS expression for this function.

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

0	1	
1	0	✓
2	1	
3	1	
4	0	✓
5	0	✓
6	0	✓
7	1	

$f(ABC) = \Pi(1, 4, 5, 6)$

$\bar{A} + B + C$

★ Eg $F_1 = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}C + AB\bar{C} = (0, 2, 3, 5, 6)$

$\bar{F_1} = \overline{\bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}C + AB\bar{C}}$
$= (A+B+C)\cdot(A+\bar{B}+C)\cdot(A+\bar{B}+\bar{C})\cdot(\bar{A}+B+C)\cdot(\bar{A}+\bar{B}+C)$
$= \quad 0 \quad 2 \quad 3 \quad 5 \quad 6$

POS we consider 0 for counting
SOP we consider 1 for counting

$F = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}C + AB\bar{C}$
$(000) + (010) + (011) + (101) + (110)$

$\bar{F} = (A+B+C)\cdot(A+\bar{B}+C)\cdot(A+\bar{B}+\bar{C})\cdot(A+\bar{B}+C)\cdot(\bar{A}+\bar{B}+\bar{C})$
$(1\,1\,1)\cdot(1\,0\,1)\cdot(1\,0\,0)\cdot(1\,0\,1)\cdot(0\,0\,1)$

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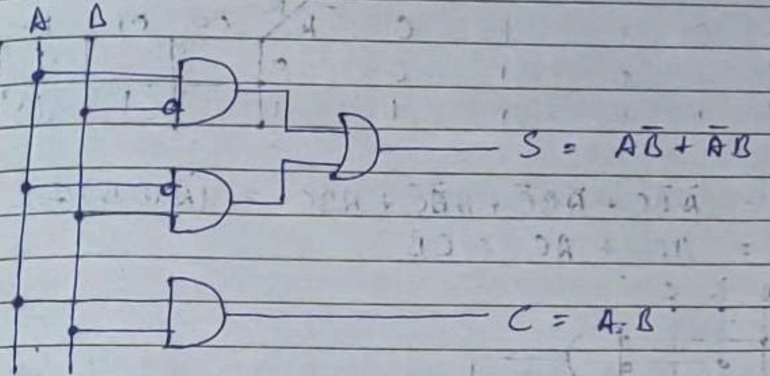
(46) Half adder:

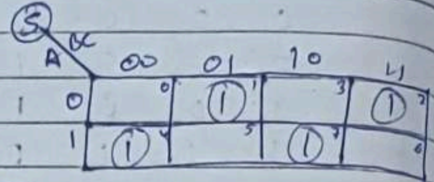
A	B	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

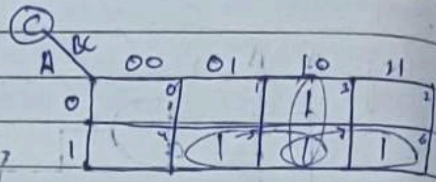
$S = A \oplus B$
$C = A \cdot B$



(47) Full Adder:

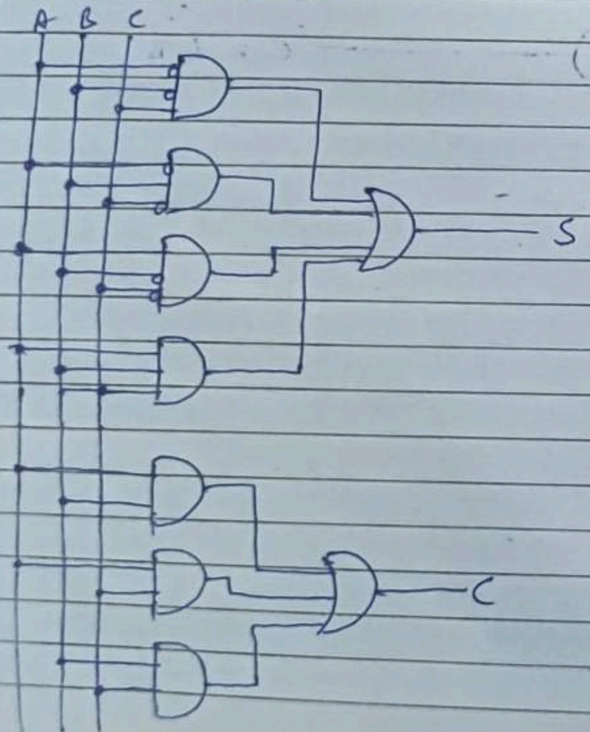
	A	B	C	C	S
0	0	0	0	0	0
1	0	0	1	0	1
2	0	1	0	0	1
3	0	1	1	1	0
4	1	0	0	0	1
5	1	0	1	1	0
6	1	1	0	1	0
7	1	1	1	1	1



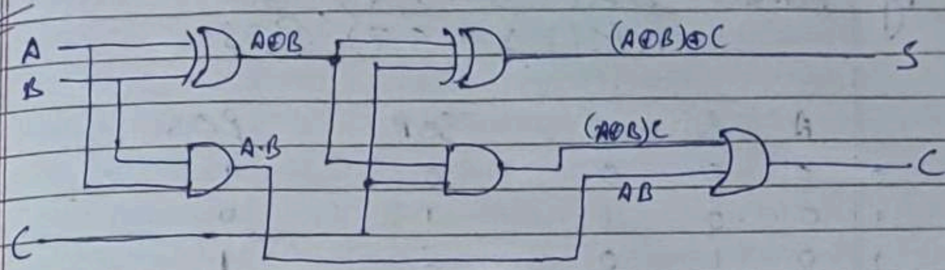


$S = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC = (A \oplus B) \oplus C$

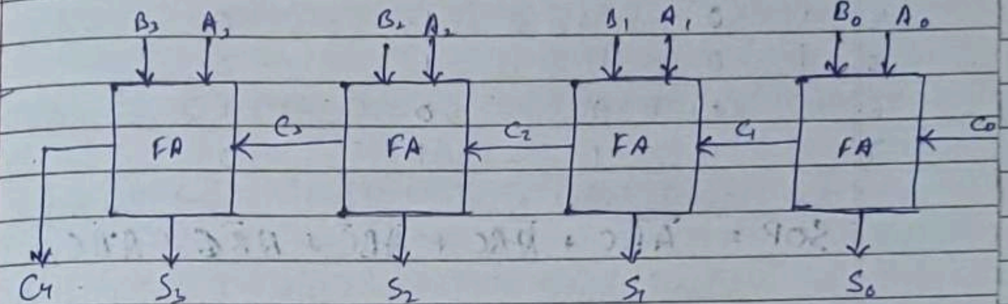
$C = AB + AC + CB$



3 bit



4 bit



for 1st FA : $A_0 B_0 C_0$ are 3 bits to be added then the output of 1st FA is used as the 3 bit input of 2nd FA as C

Eg: $F(ABC) = \Sigma m(1,3,4,5,7)$, SOP
$\Pi M(1,3,4,5,7)$: POS

	A	B	C	SOP	POS
0	0	0	0	0	1
1	0	0	1	1	0
2	0	1	0	0	1
3	0	1	1	1	0
4	1	0	0	1	0
5	1	0	1	1	0
6	1	1	0	0	1
7	1	1	1	1	0

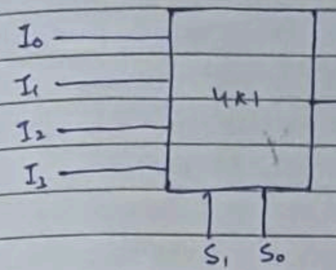
$SOP = \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}\bar{C} + A\bar{B}C + ABC$

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

4

Eg: i) F(0, 2, 3, 5, 6)
ii) F(0, 1, 2, 4)
iii) F(1, 3, 4, 6)
] SOP & POS

(40) MUX



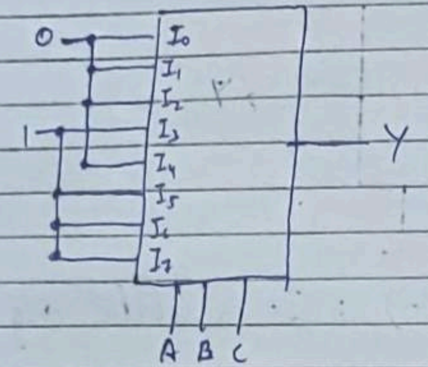
when $(S_1\ S_0) = (0,0)$: I_0 is selected only

when $(S_1\ S_0) : (0,1)$: I_1 is selected only

when $(S_1\ S_0) : (1,0)$: I_2 is selected only

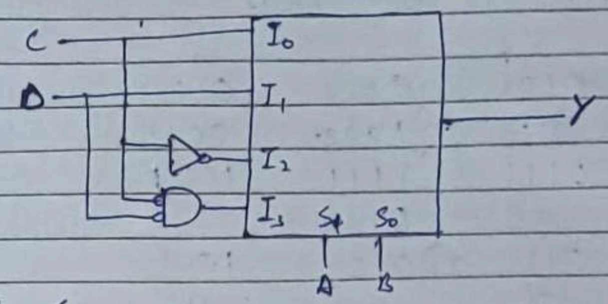
when $(S_1\ S_0) : (1,1)$: I_3 is selected only

Eg: $F(ABC) = \Sigma(3,5,6,7)$ using 8×1



	A	B	C			
0	0	0	0		0	
1	0	0	1		0	
2	0	1	0		0	
3	0	1	1	✓	1	$\bar{A}BC$
4	1	0	0		0	
5	1	0	1	✓	1	$A\bar{B}C$
6	1	1	0	✓	1	$AB\bar{C}$
7	1	1	1	✓	1	ABC

Eg:



	S_1 A	S_0 B		C	D		
0	0	0		0	0	0	
1	0	0	I_0	0	1	0	
2	0	0		1	0	1	2
3	0	0		1	1	1	3
4	0	1		0	0	0	
5	0	1	I_1	0	1	1	5
6	0	1		1	0	0	
7	0	1		1	1	1	7
8	1	0		0	0	1	8
9	1	0	I_2	0	1	1	9
10	1	0		1	0	0	
11	1	0		1	1	0	
12	1	1		0	0	1	12
13	1	1	I_2	0	1	0	
14	1	1		1	0	0	
15	1	1		1	1	0	

$F(ABCD) = \Sigma m(2,3,5,7,8,9,12)$

★ ek digit ko 4 bits se represent karna hota hai

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Eg: add 183 to 576 using BCD

576	0101	0111	0110
183	0001	1000	0011
759	0111	1111	1001
		0110	
	0111	1 0101	1001
	7	5	9

Eg: Binary to Gray code

Record MSB as it is
add MSB to next bit record sum neglect carry
repeat process

Eg

1 0 1 1 binary

1 1 1 0 gray

$g_3 = b_3$
$g_2 = b_2 \oplus b_3$
$g_1 = b_1 \oplus b_2$
$g_0 = b_0 \oplus b_1$

Eg: 1 1 1 0
1 0 0 1

Eg: 1 0 0 1
1 1 0 1

Eg: 1 0 1 0
1 1 1 1

★ from G to B & B to G MSB doesn't change

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Gray code =

Minimum error code, two successive value differ in only 1 bit, binary is converted to gray to reduce switching

Decimal	Binary	Gray
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000
16	10000	0000

ek koi aise bit flip karo jisse next term he obtain ho na ki pichla wala.

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Eg: Grey to binary

Record MSB as it is
Add MSB to the next bit of Grey record sum right
Repeat process

1 1 1 0 Grey
1 0 1 1 binary

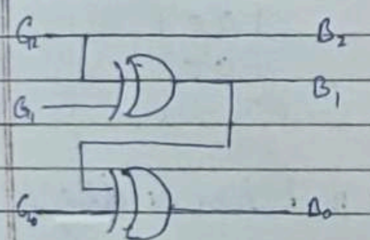
Eg:
1 0 0 1 → 1 1 1 0

0 1 1 0 → 0 1 0 0

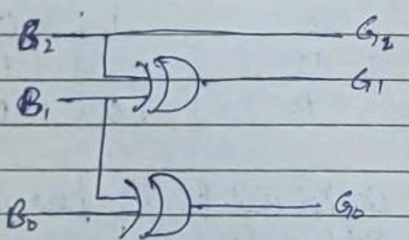
$b_3 = g_3$
$b_2 = b_3 \oplus g_2$
$b_1 = b_2 \oplus g_1$
$b_0 = b_1 \oplus g_0$

3 bits

G to B



B to G



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(49) Full substracter

A	B	Bin	D	Bout
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

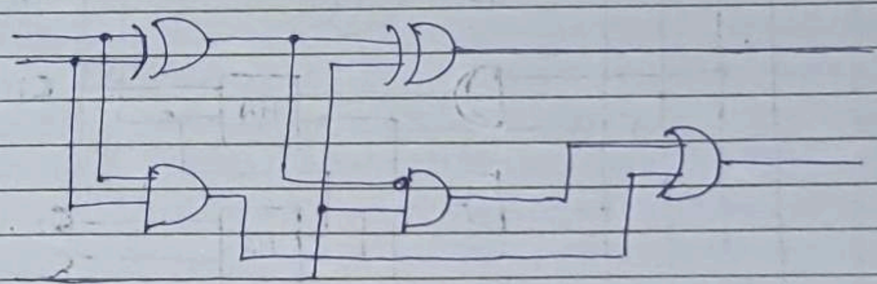
Difference

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

Bout

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

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



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Eg: $C = K + Z_8Z_4 + Z_8Z_2$

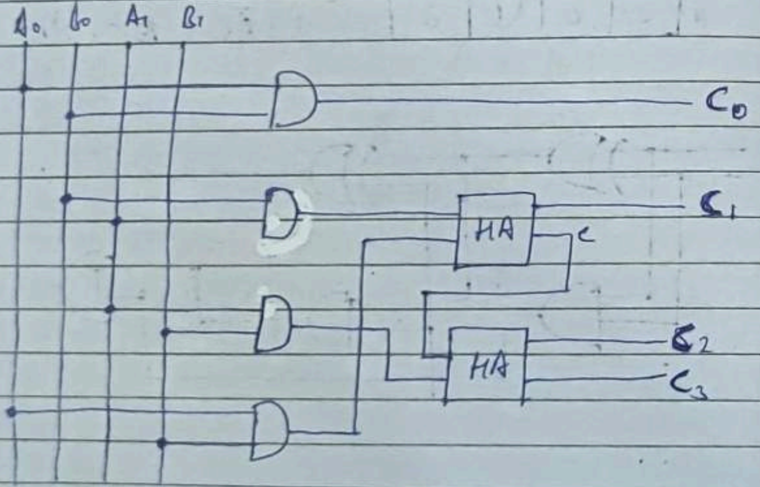
$= Z_8Z_2 + Z_8Z_2Z_1 + Z_8Z_4 + Z_8Z_4Z_1 + Z_8Z_4Z_2 + Z_8Z_4Z_2Z_1$
$+ K + KZ_1 + KZ_2Z_1 + KZ_1$

$= Z_8Z_2 + Z_8Z_4 + Z_8Z_4Z_2 + \quad + KZ_2$

$= Z_8Z_2 + Z_8Z_4 + K$

(50) Binary Multiplier

	B_1	B_0
	A_1	A_0
	A_0B_1	A_0B_0
A_1B_1	A_1B_0	$\times$
A_1B_1	$A_0B_1 + A_1B_0$	A_0B_0
C_2	C_1	C_0



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(51) Comparators : >, <, =

a) 1 Bit comparator

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

A > B

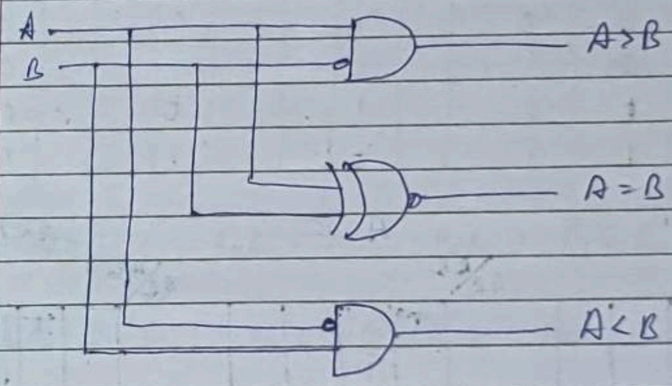
A \ B	0	1
0	0	0
1	1	0

A = B

A \ B	0	1
0	1	0
1	0	1

A < B

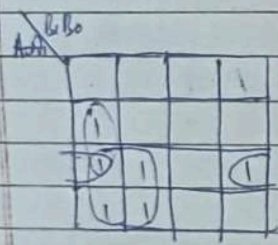
A \ B	0	1
0	0	1
1	0	0



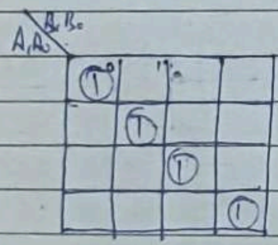
b) 2 bit comparator

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	1	0	0	1
0	0	1	0	0	0	1
0	0	1	1	0	0	1
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	1
1	0	0	0	1	0	0
1	0	0	1	1	0	0
1	0	1	0	0	1	0
1	0	1	1	0	0	1
1	1	0	0	1	0	0
1	1	0	1	1	0	0
1	1	1	0	1	0	0
1	1	1	1	0	1	0

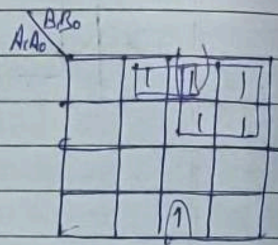
A > B

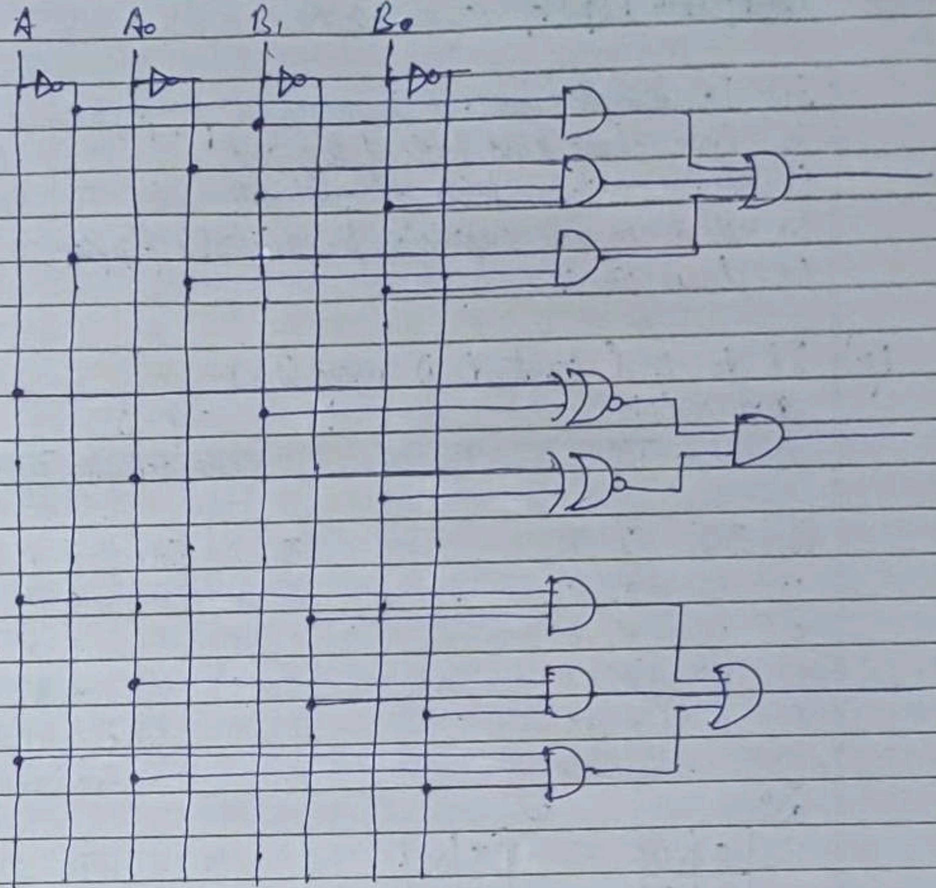


A = B



A < B





$A > B$: $A_0B_0 + A_0A_1 + B_0B_1 = \bar{A}_1\bar{A}_0B_0 + \bar{A}_1B_1 + \bar{A}_0B_1B_0$

$A = B$: $(\bar{A}_0\bar{B}_0 + A_0B_0)(\bar{A}_1\bar{B}_1 + A_1B_1)$

$A < B$: $A_0\bar{B}_1\bar{B}_0 + A_1\bar{B}_1 + A_1A_0\bar{B}_0$

(51) Multiplexer Flip Flop conversions :

S1 : Identify the available & required flip flops.
S2 : Make characteristic table of required
S3 : Make excitation table of available
S4 : Write boolean expression for available flip flop
S5 : Draw circuit

Eg1) JK to D (construct D using JK)

ava = JK
excitation TT

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

req = D
characteristic TT

Q_n	D	Q_{n+1}	J	K
0	0	0	0	X
0	1	1	1	X
1	0	0	X	1
1	1	1	X	0

J:

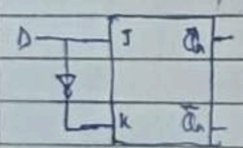
Q_n \ D	0	1
0	0	1
1	X	X

$J = D$

K:

Q_n \ D	0	1
0	X	X
1	1	0

$K = \bar{D}$



Eg2) T to D (construct D using T)

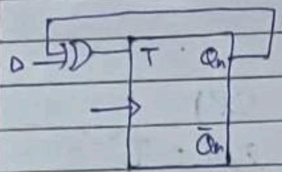
ava = T
excitation TT

Q_n	T	Q_{n+1}
0	0	0
0	1	1
1	0	1
1	1	0

req = D
characteristic TT

Q_n	D	Q_{n+1}	T
0	0	0	0
0	1	1	1
1	0	0	1
1	1	1	0

$T = D \oplus Q_n$



Eg3) SR to JK (construct JK using SR)

ava = SR
excitation TT

Q_n	Q_{n+1}	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

J	K	Q_{n+1}
0	0	Hold
0	1	0
1	0	1
1	1	Invalid

req = JK
characteristic TT

Q_n	J	K	Q_{n+1}	S	R
0	0	0	0	0	X
0	0	1	0	0	X
0	1	0	1	1	0
0	1	1	1	1	0
1	0	0	1	X	0
1	0	1	0	0	1
1	1	0	1	X	0
1	1	1	0	0	1

S

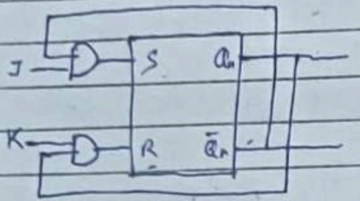
Q_n \ JK	00	01	11	10
0	0	0	1	1
1	X	0	0	X

R

Q_n \ JK	00	01	11	10
0	X	X	0	0
1	0	1	1	0

$S = \bar{Q}_n J$

$R = Q_n K$



(Eg4) SR to T (construct T using SR)

ava = SR

req = T

excitation

Q_n	Q_{n+1}	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

characteristic

Q_n	T	Q_{n+1}	S	R
0	0	0	0	X
0	1	1	1	0
1	0	1	X	0
1	1	0	0	1

S

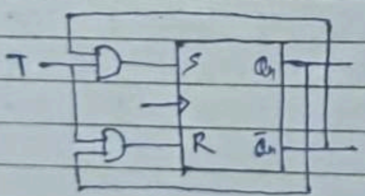
Q_n \ T	0	1
0	0	1
1	X	0

R

Q_n \ T	0	1
0	X	0
1	0	1

$S = \bar{Q}_n T$

$R = Q_n T$



(Eg5) D to JK (construct JK using D)

ava = D

req = JK

excitation

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

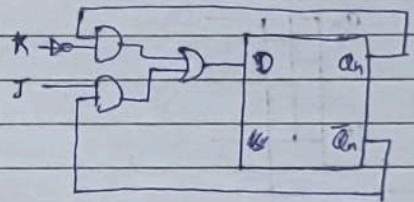
character

J	K	Q_n	Q_{n+1}	D
0	0	0	0	0
0	0	1	1	1
0	1	0	0	0
0	1	1	0	0
1	0	0	1	1
1	0	1	1	1
1	1	0	1	1
1	1	1	0	0

D

J \ KQ_n	00	01	11	10
0		1		
1	1	1		1

$D = J\bar{Q}_n + \bar{K}Q_n$



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(Pg6) T to JK (construct JK using T)

ava = T excitation

req = JK characteristic

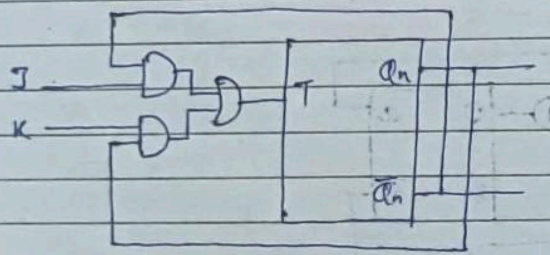
Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

J	K	Q_n	Q_{n+1}	T
0	0	0	0	0
0	0	1	1	0
0	1	0	0	0
0	1	1	0	1
1	0	0	1	1
1	0	1	1	0
1	1	0	1	1
1	1	1	0	1

T: J \ KQ_n

		1	
1		1	1

$T = KQ_n + J\bar{Q}_n$



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PYQ

Pg1) 2's complement of 43

64	32	16	8	4	2	1
0	1	0	1	0	1	1

00101011 ★ 2's complement of +ve no. is the no. itself

range of 2's complement $= -2^{n-1}-1$ to $+2^{n-1}-1$

Pg2) 2's complement of -539_{10} in hexadecimal

0010|0001|1011 True

110111100100 1's

+1

1101|1110|0101 2's

D E 5

2 | 539 1
2 | 268 1
2 | 134 0
2 | 67 1
2 | 33 1
2 | 16 0
2 | 8 0
2 | 4 0
2 | 2 0
1

Pg3) Decimal expression: $16^3\times 9 + 16^2\times 7 + 16^1\times 5 + 16^0\times 3$ no. of 1's in the unsigned binary are

badi se choti bana to decimal $9753_{16} \rightarrow$

9 7 5 3

1001011101010011 = 9 times 1

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Q94) $A = a_3\ a_2\ a_1\ a_0$
$B = b_3\ b_2\ b_1\ b_0$

multiply digits C_1 of the product C

c) $C_1\ a_0 b_1 + a_1 b_0$

Q95) The value of r if $(224)_r = (13)_r$

$224_r = (13)_r^2$
$2 \times r^2 + 2 \times r^1 + 4 \times r^0 = (1 \times r^1 + 3 \times r^0)^2$
$2r^2 + 2r + 4 = r^2 + 9 + 6r$
$r^2 - 4r - 5 = 0$
$(r-5)(r+1) = 0$
$r = 5, -1$
$r = 5$

Q96) In 2's complement addition overflow

b) cannot occur when a +ve value is added to -ve value

Q97) decimal value of 0.25

$0.25 \times 2 = 0.0$ 0
$0.50 \times 2 = 0.01$ 1

0.01

2003
Q98) both in 2's form division of 11111011 by

a) 11100111 00011001 (-25) 2's
b) 11100100
c) 11010111
d) 11011011

11111011 ~~Bina~~ (-5)
00000100 1s
+1
00000101 2s

2002
Q99) 2's represent of -15

00001111
11110000
+1
d) 11110001

2004
Q910) 73_x is equal to 54_y the possible values of x & y
x based no. system, y based number system

$73_x = 54_y$
$7x^1 + 3x^0 = 5y^1 + 4y^0$
$7x + 3 = 5y + 4$
$7x - 5y = +1$

d) 8, 11

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2004 Eg 11) A = 11111010] in 2's form find the product of A & B
B = 00001010] product also in 2's complement

A 00000101 ⇒ -6 (11111010)
+1
00000110 = 6

B 00001010 = 10

A x B = 60 = 2's form = True form for +ve

64 32 16 8 4 2 1
60 = 00111100
11000011
+1
11000100

a) 11000100 = -60

Eg 12) 1234568 equals to

22130232

00|1010|0111|0010|1110
a) A 7 2 E₁₆

A72E

Eg 13) 16 bits 2's compliment of decimal (-28)

28 = 00011100
11100011
+1

c) 11111111 11100100

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Eg 14) 1217_8 equivalent to

a) 1217_{16}
b) $028F_{16}$
c) 2297_{10}
d) $0B17_{16}$

1 2 1 7
001|010|001|111
2 8 F

Eg 15) $(123)_5 = (x8)_y$

$1\times5^2 + 2\times5^1 + 3\times5^0 = x\times y^1 + 8$
$25 + 10 + 3 = xy + 8$
$38 - 8 = xy$
$30 = xy$

jab base 5 tha toh digit zyada the jab y base hua to digits do hogaye i.e base bada hogo he and x chota hoga y se, x unknown hai to ek hi guess hai biggest ka 8 and y > 8 hoga hi tabhi y ki mai represent ho sakta hai

$x < y$; $y > 8$

$x = 1$, $y = 30$
$x = 2$ $y = 15$
$x = 3$ $y = 10$
$x = 4$ $y = 7.5$ decimal not allowed
$x = 5$ $y = 6$ $y > 8$: 6 not allowed

3 possible solutions.

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Eg 16) $(43)_x = (y3)_8$

$4x + 3 = 8y + 3$
$4x - 8y = 0$
$x = 2y$

$y < 8$ $\quad$ $x \le 8$
$x \ge 4$

$x = 6,\ y = 3$
$x = 8;\ y = 4$
$x = 10;\ y = 5$ $\quad$ 5 possible solutions
$x = 12;\ y = 6$
$x = 14;\ y = 7$

2016 Eg 17) 1111 1111 1111 0101 : 16 bits 2's
find decimal representation :

11110101
00001010
+1
00001011

-11

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Eg 18) $\frac{312}{20} = 13.1$ the base of the number system so that the above equation hold is :

$\frac{(312)_r}{(20)_r} = (13.1)_r$

$\frac{3r^2 + r + 2}{2r + 0} = r^1 + 3 + 1/r$

$3r^2 + r + \cancel{2} = 2r^2 + (6r) + \cancel{2}$
$0 = 2r^2 - 3r^2 + 5r$
$r^2 - 5r = 0$
$r = 0,\ r = 5$

Eg 19) P is a 16 bit signed integer P is $(F87B)_{16}$ of 2's complement $8 \times P = ?$ (in 2's complement) in hexadecimal

F 8 7 B
1111 1000 0111 1011 $= 3979_{10}$
$\times 8$
31832_{10}

16	31832

2	31832	0
2	15916	0
2	7958	0
2	3979	1
2	1989	1
2	994	0
2	497	1
2	248	0
2	124	0
2	62	0
2	31	1
2	15	1
2	7	1
2	3	1

~~0111 1100 0101 1000~~
~~7 C 5 8~~

0111110001011000
1000001110100111
+1

1000|0011|1010|1000
8 3 A 8

FFFF
83A8

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* n = no. of shifts = 2^n
$8 = 2^3 = 3$ no. of shifts
$4 = 2^2 = 2$ no of shifts
$2 = 2^1 = 1$ no. of shifts

(Q19) P is a 16 bit signed integer P is $(F87B)_{16}$ of 2's complement and hexadecimal
$8 \times P = ?$ (2's complement)

a) C3D8
b) 187B
c) F878
d) 987B

M1 F87B
1111 1000 0111 1011 = 63611
×8
508888

0111|1100|0011|1101|1000 = +ve no. = 2's complement
7 C 3 D 8

M2 agar 4 hai 0100 → 0010 i.e divided by 2

left shift multiply by 2 if only once shift
no. of shifts = 2^n

1111100001111011+000 ×8

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(Q20) Consider = Z = X − Y where X, Y, Z are all signed. X & Y each represent n bits. To avoid overflow the representation of Z would require a min of

to avoid overflow 1(+ve)/1(−ve)

4 bits
X = +6
Y = −5
4 bits × not possible due to signed bit 11 requires 5 bits
X − Y = 11 ① (111)
sign max 3 bit

a) n
b) n−1
c) n+1
d) n+2

2017 (Q21) For W X Y Z boolean variables which is incorrect

a) $WX + (X+Y)W + X(X+Y) = X + WY$
$WX + WX + WY + X$
$WY + WX + X$
$X + WY$

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

c) $(W\bar{X}(Y + X\bar{Z}) + \bar{W}\bar{X})Y = X\bar{Y}$
$(W\bar{X}Y + \cancel{WX\bar{X}\bar{Z}} + \bar{W}\bar{X})Y$
$W\bar{X}Y + \bar{W}\bar{X}Y$
$\bar{X}Y$

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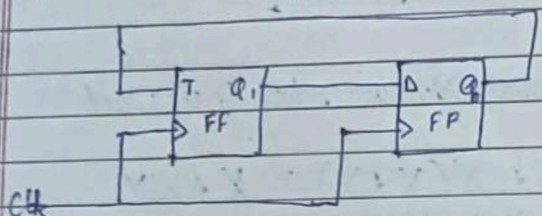
2017 Eg22. $f(WXYZ) = \Sigma m(0,1,2,3,7,8,10) + \Sigma d(5,6,11,15)$
which of following is a min POS form $f(WXYZ)$

WX \ YZ				
	1	1	1	1
	0	X	1	X
	0	0	X	0
	1	0	X	1

$\bar{F} = X\bar{Z} + WZ$

$F = (\bar{W} + \bar{Z})(\bar{X} + Z)$

2017 Eg23 combination of T & D ff, initially Q_0 & $Q_1 = 1$ before 1st clock... for 3rd & 4th cycle



Q_{n+1}
D → D
T·1 → toggle
T=0 → same

$D = Q_1$; $T = Q_0$

	D	T		output T Q_1	D Q_0
0	= 1	= 1		1	1
1	0	1	1st	0	1
2	1	0	2nd	1	0
3	1	1	3rd	1	1
4	0	1	4th	0	1

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1998 Eg24 An equivalent 2's complement representation of 2's complement number 1101 is:

1101 i.e no is -ve
MSB

1101
a) 110100
b) 001101
c) 110111
d) 111101 as many signed bits added of same mag

1993 Eg25 2' complement of 16 bit number (1 sign bit & 15 mag bits) is FFFF. Its magnitude in decimal representation is

1111 1111 1111 1111 i.e -ve no.
0000 0000 0000 0000
+1
0000 0000 0000 0001
= 1

1998 Eg26 Two 2's complement no. having sign bits x and y are added and the sign bit of the result is z. Then the occurance of overflow is indicated by boolean function

let MSB (sign bit MSB)

A $x \ldots b_1 b_0$
+ B $y \ldots c_1 c_0$
S $z \ldots s_1 s_0$

range
(-2^{n-1}) to $(2^{n-1}-1)$
$n = 4$
-8 to $+7$

MSB = 0
Case of overflow: Sum of 2 (+ve) gives (-ve)
Sum of 2 (-ve) gives (+ve)
MSB = 1

Sum of 2 +ve give a (-ve) number

$A = +ve \quad x = 0$
$B = +ve \quad y = 0 \quad \bar{x}\cdot\bar{y}z$
$S = -ve \quad z = 1$

Sum of 2 -ve give a (+ve) number

$A = -ve \quad x = 1$
$B = -ve \quad y = 1 \quad xy\bar{z}$
$S = +ve \quad z = 0$

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

2002 Pg27) 4 bit 2s complement representation of a decimal no. is 1000. The no.

1000 give a negative no.
0111
+1
1000 = 8

(-8) = -ve decimal

$A \xrightarrow{2's} -A \xrightarrow{2's} A$

2004 Pg28) The range of signed decimal number can be represented by 6 bit is complement form is:

range = $(-2^{n-1}-1)$ to $(2^{n-1}-1)$.
$-2^{6-1}-1$ to $2^{6-1}-1$
-31 to $+31$

d)

2004 Pg29) 11001, 1001, 111001 corresponds to 2's complement representation of which one of the following sets of numbers

a) 25, 9, 57
b) -6, -6, -6
c) -7, -7, -7
d) -25, -9, -57

MSB repeated

111001
11001
1001

MSB = -ve as its 1

(-7)

1001
0110
+1
0111 = (7)

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2005 Eg30) 43_{10} into hexadecimal & BCD

0010|1011
2 B

4 3
43 = 0100 0011

~~0010 1011~~
~~0110~~
~~0011 0001~~

2006 Eg31) A new binary coded pentary (BCP) is proposed in which every digit of base 5 number is represented by its corresponding 3 bit binary code. Eg: 5 base number 24 will be represented by its BCP code 010100. In this number system, the BCP code 100010011001 corresponds to the following number in base 5 system.

r = 5 : 0 to 4

0	000
1	001
2	010
3	011
4	100

24 = 2 4
010 100

given: 100|010|011|001
4 2 3 1

4231_5

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2007 Eg32) X = 01110, Y = 11001 are two 5 bit binary numbers represented by 2's compliment format. The sum of X & Y represents 2's compliment format using 6 bits is.

Ans) (+ve) X = 01110

not needed for +ve [~~10001~~ ~~+1~~ ~~10010~~]

X = +14

(-ve) Y = 11001
00110
+1
00111
Y = -7

Ans) X + Y = 14 − 7
= +7

01110
11001
(1) 00111
drop

2004 Eg33) The no. of bytes required to represent decimal no. 1856357 in BCD

nibble or 4 bits for 1 no.

1byte 1byte 1byte 1byte
0 1 8 5 6 3 5 7

00000001 1000 0101 0110 0011 0101 0111

i.e total of 4 bytes required

2007 Eg 34) $P = 11101101$, $Q = 11100110$ (both 2's form)
Q is subtracted from P the value obtained in signed 2's

MSB of P & Q = 1 i.e both -ve

$P = 11101101$

$$\begin{array}{r} 00010010 \\ +1 \\ \hline 10011 \end{array} \quad (19)$$

$P = (-ve) = -19$

$Q = 11100110$

$$\begin{array}{r} 00011001 \\ +1 \\ \hline 00011010 \end{array}$$

$Q = (-ve) = -26$

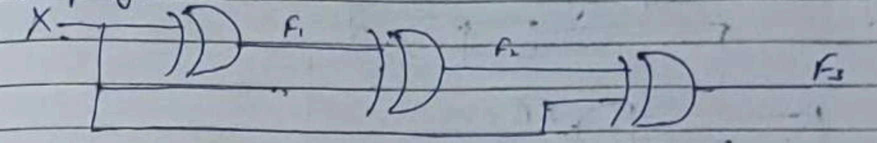
$P - Q \Rightarrow -19 - (-26)$
$= 26 - 19$

$$\begin{array}{lr} +26 & 00011010 \\ -19 & 11101101 \\ \hline & \text{①}00000111 \quad +7 \end{array}$$

b)

drop

2008 Eg 35) Output of XORs



for similar inputs

$Y = A \oplus B$ $\qquad F_1 = 0$

$= A\bar{B} + \bar{A}B$ $\qquad F_2 = 0\cdot\bar{A} + \bar{0}A$

$\qquad = A$

$Y = A \oplus A$ $\qquad F_3 = 0$

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

a) $= 0$

1988 Eg 36) Min no. of 2 inputs NAND gate required to implement the fn
$F = (\bar{X}+\bar{Y})(Z+W)$

$F = (W+Z)(\overline{XY})$
$= \overline{XY}.W + \overline{XY}.Z$

b) 4

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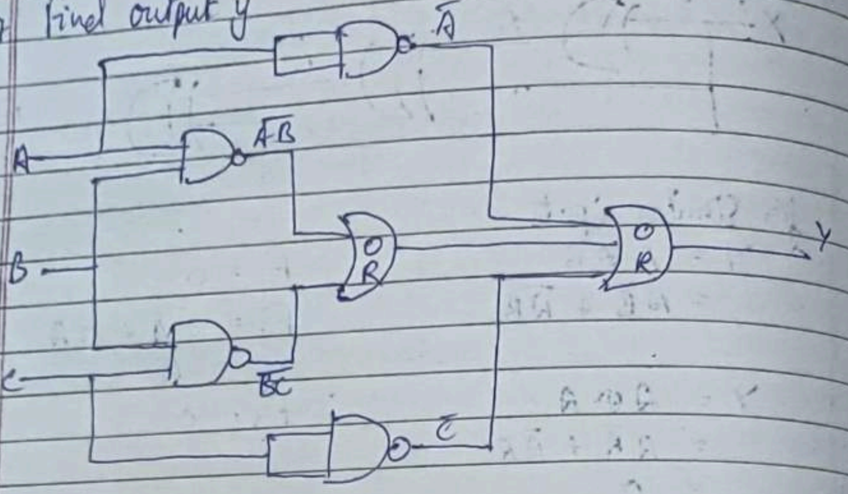
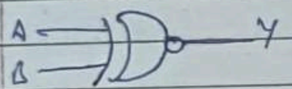
1993
Pg37 Find output y



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

c) $= \overline{AB} + \overline{BC} + \bar{A} + \bar{C}$

1993
Pg38) output from XNOR input A & B



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

$\bar{Y} = \overline{A \oplus B} = XNOR$

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

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

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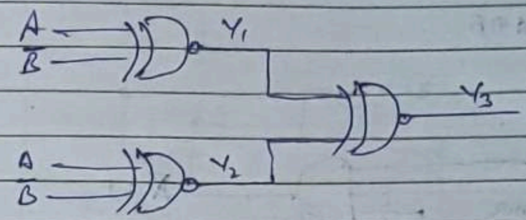
1993
Pg39) The output:



$Y_1 = A \cdot \bar{B} = Y_2$

$Y_3 = Y \odot Y$

$= \bar{Y}\bar{Y} + YY$

$= \bar{Y} + Y$

b) $= 1$

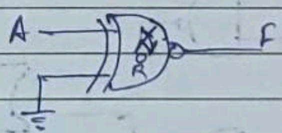
1995
Pg40 min NAND for $A + A\bar{B} + A\bar{B}C$

$A + A\bar{B}$

A

a) 0

1997
Pg41 Output of logic gate



$F = A \odot 0$

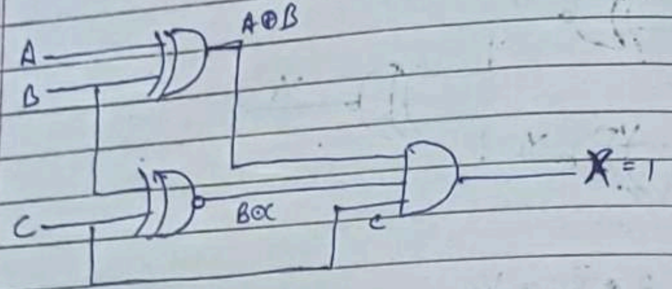
$= \bar{A}\bar{0} + A0$

$= \bar{A}1$

$= \bar{A}$

d) $\bar{A}$

2000 Eg 41) What input to get $X = 1$ (as output)



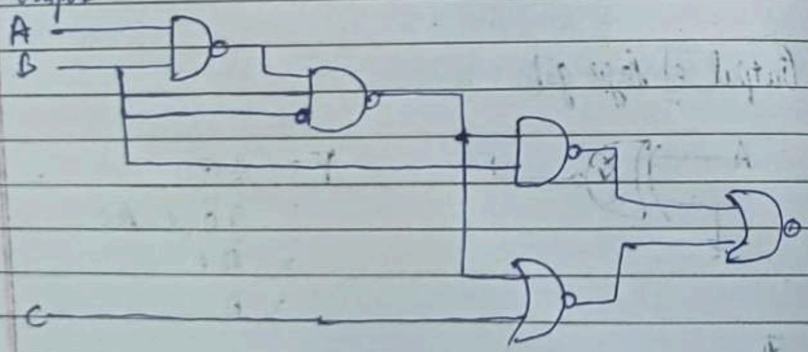
$(A\oplus B)\cdot(B\odot C)\cdot C$

A	B	A⊕B	B	C	B⊙C
0	0	0	0	0	1
0	1	1	0	1	0
1	0	1	1	0	0
1	1	0	1	1	1

C = 1
A = 0 ✗
B = 1 ✗

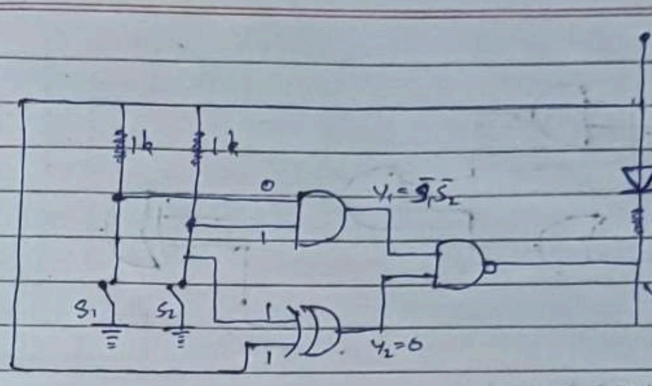
d) ABC = 101

2000 Eg 42) Output



c) B

2001 Eg 43)



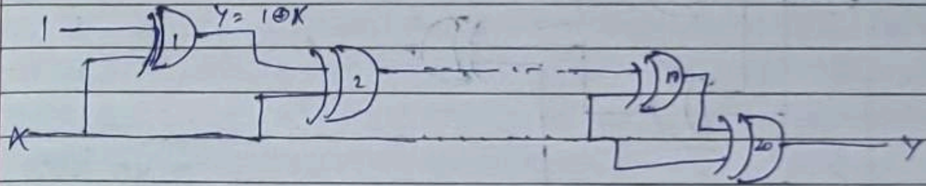
$Y = (\overline{Y_1 \cdot Y_2})$

$= (\overline{\bar S_1 \bar S_2 \cdot 0})$

$Y = 1$

d) doesnot depend on S_1 & S_2

2002 Eg 44) Cascading 20 XOR find output



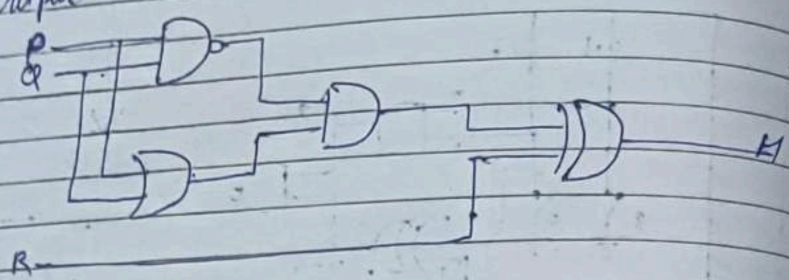
$Y_1 = \bar 1 X + 1 \bar X = \bar X$

$Y_2 = \bar{\bar X} X + \bar X \bar X = 1$

b) 1

2008

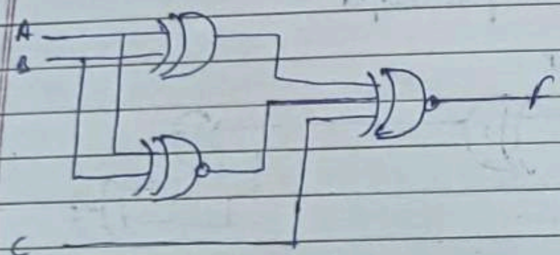
Eg45) Output



$M = P \oplus Q \oplus R$

2010

Eg46) $F = 1$



$F = (A \oplus B) \odot (A \oplus B) \odot C$

$1 \odot 1 \odot 1 = 1$

$0 \odot 0 \odot 0 = 1$

a) $A = 1 \quad B = 1 \quad C = 0$

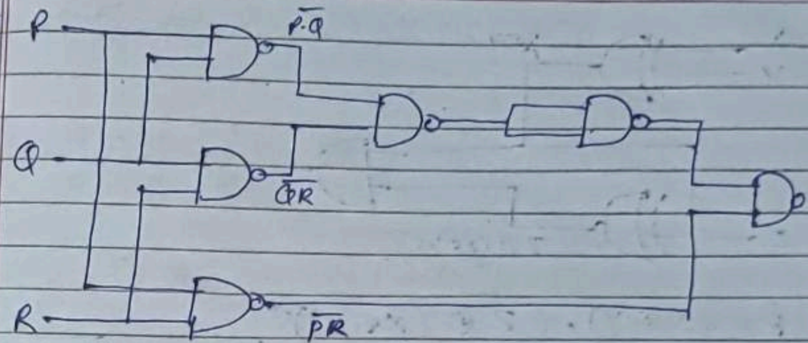
b) $A = 1 \quad B = 0 \quad C = 0$

c) $A = 0 \quad B = 1 \quad C = 0$

d) $A = 0 \quad B = 0 \quad C = 1$

2011

Eg47



$Y = PQ + QR + PR$

b) 2 or more are 1 $\Rightarrow Y = 1$

$P = 1$

$Q = 1 \qquad 1 + 1 + 1 = 1$

$R = 1$

~~a)~~ odd are 0

$P = 0 \qquad\qquad\qquad P = 0$

$Q = 1 \quad = 0 + 1 + 0 \qquad Q = 0 \quad 0 + 0 + 0$

$R = 1 \quad = 1 \qquad R = 0 \quad = 0$

~~a)~~ $P = 0$

$Q = 0 \quad 0 + 0 + 0$

$R = 0 \quad = 0$

~~d)~~ odd are 1

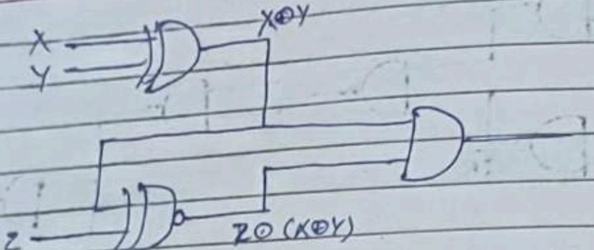
$P = 1 \qquad\qquad\qquad P = 1$

$Q = 0 \quad 1 + 0 + 0 \qquad Q = 1 \quad 1 + 1 + 1$

$R = 0 \quad = 1 \qquad R = 1 \quad 1$

2014

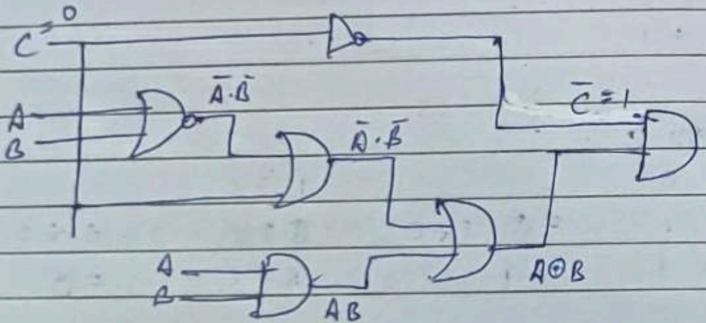
Eg48)



$$F = (X\oplus Y)\cdot(Z\odot(X\oplus Y))$$
$$= (X\oplus Y)\cdot(X\oplus Y)\cdot Z + (X\oplus Y)\cdot\overline{(X\oplus Y)}\cdot\bar{Z}$$
$$= X\oplus Y\cdot Z + 0$$
$$= (X\bar{Y} + \bar{X}Y)Z$$
$$= X\bar{Y}Z + \bar{X}YZ$$

2014

Eg49)

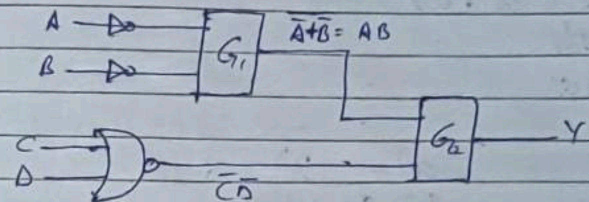


$Y = A\bar{B} + \bar{A}B$

a) $Y = A\oplus B$

2015

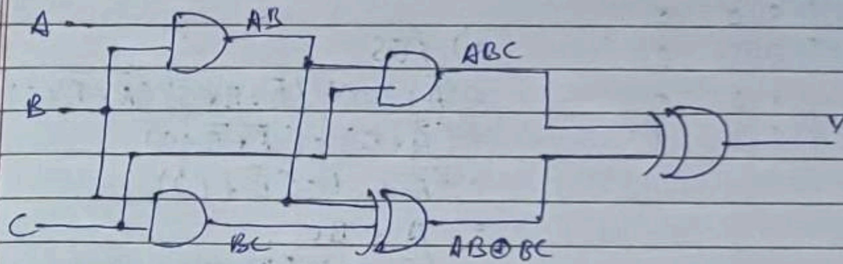
Eg50 identify gate G_1 & G_2 $Y = AB + \bar{C}\bar{D}$



a) G_1 = NOR, G_2 = OR

2016

Eg51



$Y = AB\oplus BC\oplus ABC$

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

$$= \bar{A}BC + AB\bar{C} + ABC$$
$$= \bar{A}BC + AB$$
$$= B(\bar{A}C + A)$$
$$= B(\underbrace{\cancel{(\bar{A}+A)}}_{1}\cdot(C+A))$$
$$= B(C+A)$$

1992
Eg52) for A,B,C : F = true when
i) A is false & B is true
ii) A is false & C is true
iii) A,B,C are false
iv) A,B,C are true

A	B	C	F
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

a) = $2^3 = 8$

b) SOP

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

$= \bar{A} + ABC$

$= \bar{A} + BC$

c) POS

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

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

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

$= \bar{A} + BC$

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

1993
Eg53) logic circuit using NOR for ABC and output y

LSB A	0	1	0	1	0	1	0	1
B	0	0	1	1	0	0	1	1
MSB C	0	0	0	0	1	1	1	1
Y	1	1	1	0	1	0	0	0

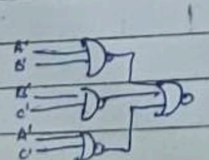
C \ BA				
	1	1	0	1
	1	0	0	0

$F = (A+B+C)\cdot(A+B+C)(A+B+C)(A+B+C)$

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

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

by NOR



1998
Eg54) dual form $AB + \bar{A}C + BC = \bar{A}B + AC$

$- \leftrightarrow +$

$\cdot \leftrightarrow +$

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

$+ \leftrightarrow \cdot$

$0 \leftrightarrow 1$

variable remain same

1999
Eg55) reduced form of $\bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + AB\bar{C}$

M1 Boolean laws

M2 K map

A \ BC	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	1		1	1
A				1

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

2003
Eg56) no of distinct boolean expression for 4 variables

$2^{2^n} = 2^{2^4} = 2^{16} = 65536$

2004
Eg57) boolean function f of 2 variables x & y is defined as follows.

$f(x,y) =$

$f(0,0) = f(0,1) = f(1,1) = 1, \quad f(1,0) = 0$

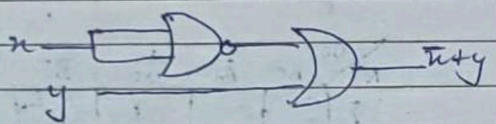
Assuming complements of x & y are not available, a min cost solution for realizing f using only 2 inputs NOR gates and 2 input OR gates (each having unit cost) would have total cost of

x	y	f
0	0	1
0	1	1
1	0	0
1	1	1

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

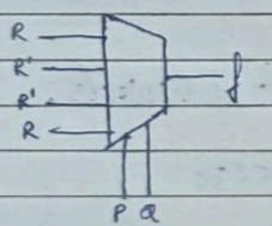
$= \bar{x} + xy$

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



d) 1 units

2010
Eg58) boolean expression f



$f = \bar{P}\bar{Q}R + \bar{P}Q\bar{R} + P\bar{Q}\bar{R} + PQR$

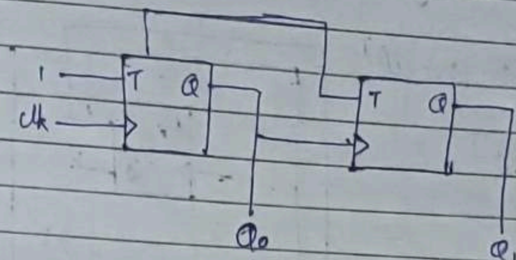
$= \bar{P}(Q \oplus R) + P(Q \odot R)$

$001 + 010 + 100 + 111$

$= P \oplus Q \oplus R$

Asynchronous : ek ka output dusare ki clock
Synchronous : ek ~~ke~~ clock pure mai

2010
Eg59) For sequential circuit below if initial value of Q_1Q_0 is 00 what are the next 4 values



Q_0	Q_1	
0	0	Q_1 change due to $Q_0=1$
1	1	no change due to $Q_0=0$
0	1	Q_1 change due to $Q_0=1$
1	0	Q_1 no change due to $Q_0=0$
0	0	

→ +ve edge trigger T(FF)
→ Asynchronous
→ flip flop only change on rising edge

2011
Eg60) no. of D(FF) to design mod 258 counter (min no.)

$256 = 2^8$ 8 bits

$258 = 2^8 + 2$ 9 bits

a) 9 bits

Eg61) Simplified SOP for expression $(P+\bar{Q}+\bar{R})\cdot(P+\bar{Q}+R)\cdot(P+Q+\bar{R})$

$(0\ 1\ 1)\cdot(0\ 1\ 0)\ (0\ 0\ 1)$

given $= \Pi M(1,2,3) \Rightarrow$ remaining are SOP $= \Sigma m(0,4,5,6,7)$

b)

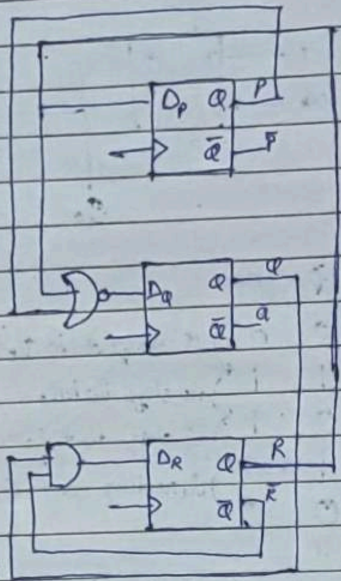
P \ QR	00	01	11	10
0	1	0	0	0
1	1	1	1	1

$P + \bar{Q}\bar{R}$

2011

Eg61 If all FF were reset at 0 at power on what is the total no. of distinct output (states) represented by PQR generated by the counter is

→ Syncronus (as all have same clk).



→ $D_P = R$ (1st)

$P_{t+1} = D_P$

$D_Q = \overline{(P+R)}$ (2nd)

$Q_{t+1} = D_Q$

$D_R = \bar{R}Q$

$R_{t+1} = D_R$

→ PQR

	P Q R	R	$\overline{(P+R)}$	$\bar{R}\cdot Q$
	0 0 0			
1	0 1 0	(0	$\overline{(0+0)}$	$\bar{0}\cdot 0$)
2	0 1 1	(0	$\overline{(0+0)}$	$\bar{0}\cdot 1$)
3	1 0 0	(1	$\overline{(1+0)}$	$\bar{1}\cdot 0$)
4	0 0 0	(0	$\overline{(1+0)}$	$\bar{0}\cdot 0$)

b) 4

2014

Eg62 No of self dual for n variables

$2^{2^{n-1}}$

2012

Eg62 Reduced expression for SOP

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

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

Eg For TT, V = 1 if & only if the input is valid

Input				Outputs		
D_0	D_1	D_2	D_3	X_0	X_1	V
0	0	0	0	x	x	0
1	0	0	0	0	0	1
x	1	0	0	0	1	1
x	x	x	0	1	0	1
x	x	x	1	1	1	1

a) Priority encoder (3 : 8). valid output only in encoder

b) Decoder (8 : 3) input zyada output kam

d) Multiplexer (4 : 1)

c) Demultiplexer (1 : 4

2014

Eg63 minimal SOP of $F = PQ + \bar{P}QR + \bar{P}Q\bar{R}S$

M1

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

$= Q((P+R)\underbrace{(P+\bar{P})}_{1} + \bar{P}\bar{R}S)$

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

$= Q((P+\bar{R}S)\underbrace{(P+\bar{P})}_{1} + R)$

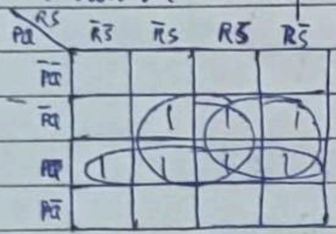
$= Q((P+\bar{R}S) + R)$

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

$= QP + RQ + QS$

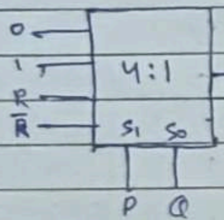
M2

4 Variable K.map



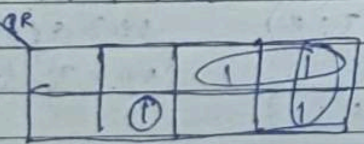
2014

Eg64 for 4:1 multiplexer with S_0 S_1 selection lines. SOP for F



I_{00} I_{01} I_{10} I_{11}

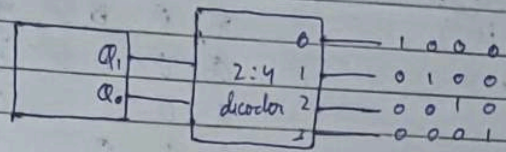
$0 + \bar{P}Q + RP\bar{Q} + \bar{R}PQ$



$\bar{P}Q + Q\bar{R} + P\bar{Q}R$

2014

Eg65 Let $k = 2^n$. A circuit is built by giving the output of an n bit binary counter as input to an n to 2^n bit decoder. This circuit is equivalent to a



Q_1	Q_0		
0 = 0	0	1 0 0 0	0 ki line lit
1 = 0	1	0 1 0 0	1 ki line lit
2 = 1	0	0 0 1 0	2 ki line lit
3 = 1	1	0 0 0 1	3 ki line lit

a) k bit binary up counter

b) k bit binary down counter

c) k bit ring counter

d) k bit johnson counter

ring	johnson
1000	0000
0100	1000
0010	1100
0001	1110

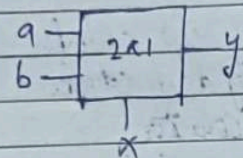
2014

Eg66 Function of block having 4 variables x, y, a, b,
~~x, y, a, b~~ x, a, b are inputs y as output
which digital logic block is implemented (combinational)

```
f(x, y, a, b){
    if (x is 1)
        y = a;
    else
        y = b;
}
```

x	a	b	y_a	y_b	y_x
0	0	0	0	0	0
0	0	1	0	1	1
0	1	0	1	0	0
0	1	1	1	1	1
1	0	0	0	0	0
1	0	1	0	1	0
1	1	0	1	0	1
1	1	1	1	1	1

a) Full adder × multiple outputs
b) Priority encoder ×
c) Multiplexer
d) Flip Flop (sequential)



2014 Eg67

$F(P,Q) = ((1\oplus P)\oplus(P\oplus Q))\oplus((P\oplus Q)\oplus(Q\oplus 0))$

$= (\overline{P}\oplus P\oplus Q)\oplus(P\oplus Q\oplus Q)$

$(1\oplus Q)\oplus(P\oplus 0)$

$\overline{Q}\oplus P$

$= P\odot Q$

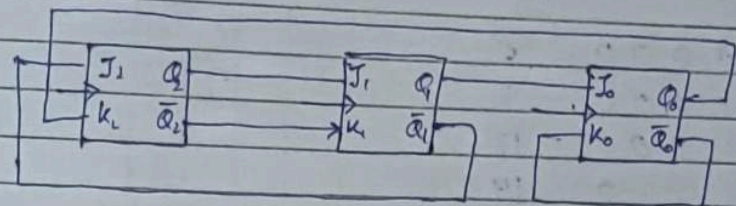
$= \overline{P\oplus Q}$] XNOR

$= P\oplus\overline{Q}$

$1\oplus P = \overline{P}$
$0\oplus P = P$
$P\oplus\overline{P} = 1$
$P\oplus P = 0$

2014

Eg68 The sequential circuit is built using JK flip flop which is initialized by $Q_2Q_1Q_0 = 000$. The output for next 3 cycles



$J_2 = \overline{Q}_1$ $\quad J_1 = Q_2$ $\quad J_0 = Q_1$
$K_2 = Q_0$ $\quad K_1 = \overline{Q}_2$ $\quad K_0 = \overline{Q}_0$

$Q_2(t+1) = J_2\overline{Q}_2 + \overline{K}_2 Q_2$
$Q_1(t+1) = J_1\overline{Q}_1 + \overline{K}_1 Q_1$
$Q_0(t+1) = J_0\overline{Q}_0 + \overline{K}_0 Q_0$

Q_2	Q_1	Q_0
0	0	0
1	0	0
1	1	0
1	1	1

J K: 1 0; J K: 0 1; J K: 0 1

$(1\cdot1+1\cdot0)\ (0\cdot1+0\cdot0)\ (0\cdot1+0\cdot1)$

(1 0 1) (1 0 1) (0 0 1)

c) 100, 110, 111

* functionally complete if its satisfy NOT and any of AND or OR

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2015

Eg 69 Consider a 4 bit Johnson counter with initial value 0000
The counting sequence of this counter is

d)

0 0 0 0	0
1 0 0 0	8
1 1 0 0	12
1 1 1 0	14
~~1 1 1 0~~	
1 1 1 1	15
0 1 1 1	7
0 0 1 1	3
0 0 0 1	1
0 0 0 0	0

2015

Eg 70 Which is functionally complete

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

$g(\bar{x},y,z) = \bar{x}yz + \bar{x}y\bar{z} + xy$

for not

$\Rightarrow f(x,1,1) = \bar{x}\,1\,1 + x\cdot 0 + 0\cdot 0$

$= \bar{x}$

for OR

$f(x, 0, f(z,1,1)) = x + z$

for not

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

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

$= (x+1)y$

$= y$

only f is functionally complete

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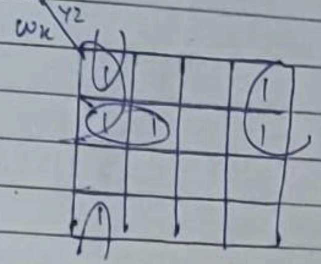
2015

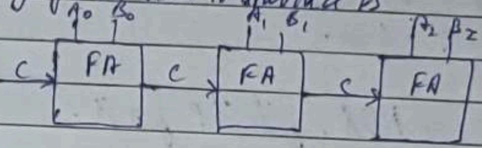
Eg 71 Total no. of prime implicants of $f(w,x,y,z) = \sum(0,2,4,5,6,10)$ is



3

2016

Eg 72 Consider a 8 bit ripple carry adder for computing the sum A & B where A & B are integers represented in 2's complement form. If the decimal value of A is one, the decimal value of B that leads to longest latency for the sum to stabilize is



longest latency is the waiting period for a FA to get the carry which is to be added highest when 1111 is added lowest when no carry is generated

0 0 0	0 0 1	1 1 1	0 0 0
0 0 1	1 1 1	1 1 1	0 0 0
0 0 1	1 0 0 0	1 1 1 0	0 0 0
		highest	Lowest

-ve

in 8 bit 2's is ①1111111 → 00000000

+1 +1

100000000 00000001

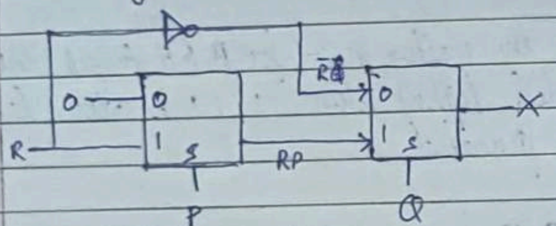
(-1)

2016
Eg73 Min no. of JK (FF) used to create a synchronous counter to count
0-1-0-2-0-3

00	0000	1st
01	0001	
00	0100	2nd
10	0010	
00	1100	3rd
11	0011	

1 for sequence
2 for zero
3 for 1st & 2nd zeros
4 for 2nd & 3rd zeros

2016
Eg74 2 cascading 2:1 MUX, find SOP for X

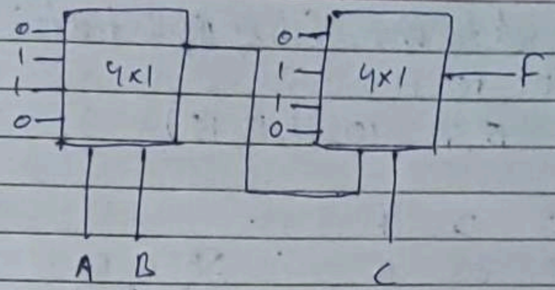


$PQR + \bar{R}\bar{Q}$

2018
Eg75 (f_1 AND f_2) $\oplus$ f_3
$f_1 = \Sigma(0, 2, 5, 8, 14)$
$f_2 = \Sigma(2, 3, 6, 8, 14, 15)$
$f_3 = \Sigma(2, 7, 11, 14)$

a) $(f_1 \cdot f_2) \oplus f_3 = (2, 8, 14) \oplus (2, 7, 11, 14)$
$= (7, 14, 8)$

Eg76



Case O_1 is 1st then C

A	B	C	O_1	F	
0	0	0	0	0	
0	0	1	0	1	$\bar{A}\bar{B}C$
0	1	0	1	1	$\bar{A}B\bar{C}$
0	1	1	1	0	
1	0	0	1	1	$A\bar{B}\bar{C}$
1	0	1	1	0	
1	1	0	0	0	
1	1	1	0	1	ABC

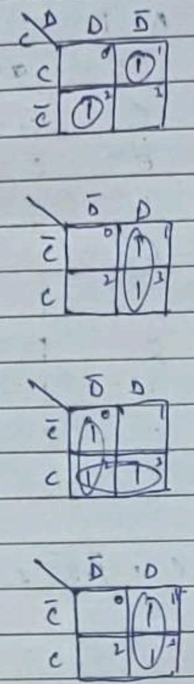
$F = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$

Eg77 let A,B be selection lines. ∵ C,D be input to obtain F

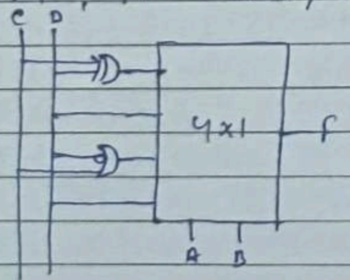
AB = 00, 01, 10, 11

$F = \Sigma(1, 2, 5, 7, 8, 10, 11, 13, 15)$

	A	B	C	D	F
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	1
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	1
6	0	1	1	0	0
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	0
10	1	0	1	0	1
11	1	0	1	1	1
12	1	1	0	0	0
13	1	1	0	1	1
14	1	1	1	0	0
15	1	1	1	1	1



$D = F_2 = F_4$, $F_1 = C \oplus D$, $F_3 = \bar{D} + C$, ε



Eg78 Input A_3, A_2, A_0, A_1, output $B_3\ B_2\ B_0\ B_1$

where $B = A$ for $A < 10$

$B = A - 4$ for $A > 10$

	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
10	1	0	1	0	0	1	1	0
11	1	0	1	1	0	1	1	1
12	1	1	0	0	1	0	0	0
13	1	1	0	1	1	0	0	1
14	1	1	1	0	1	0	1	0
15	1	1	1	1	1	0	1	1

$B_0 = A_0$

$B_1 = A_1$

$B_2 = \Sigma(4, 5, 6, 7, 10, 11)$

$B_3 = \Sigma(8, 9, 12, 13, 14, 15)$

B_2

$A_3A_2 \backslash A_1A_0$				
	1	1	1	1
			1	1

B_3

$A_3A_2 \backslash A_1A_0$				
	1	1	1	1
	1	1		

$B_2 = \bar{A}_3 A_2 + A_1 A_3 \bar{A}_2$

$B_3 = A_3 A_2 + A_3 \bar{A}_1$

Eg 7) when $< 3 : 1$, $> 3 : 0$ for 3 variables

A	B	C	F
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

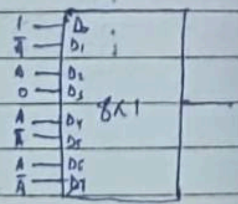
$A \backslash BC$				
	1	1		1
	1			

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

Eg: Design a mux for $\Sigma m(0,1,5,6,8,10,12,15)$

	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
$\bar{A}$	0	1	2	3	4	5	6	7
A	8	9	10	11	12	13	14	15
	1	$\bar{A}$	A	0	A	$\bar{A}$	A	$\bar{A}$

implementation table



(5) Counters :

- 2 bit synchronous counter by JK FF

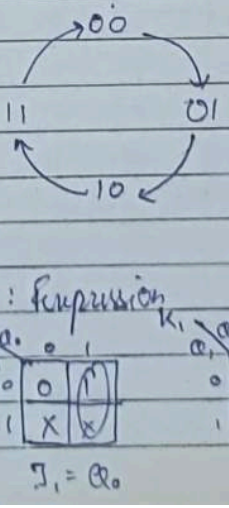
S_1 : Identify no. of bits and flip flops
S_2 : Write Excitation table of JK FF
S_3 : draw State table & diagram
S_4 : Solve from K map by getting boolean expression
S_5 : Make the circuit from equation obtained.

S_1 : 2 bits + JK FF

S_2 :

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

S_3 : State diagram + table



Q_1	Q_0	Q_1^+	Q_0^+	J_1 ($Q_1 \to Q_1^+$)	K_1	J_0 ($Q_0 \to Q_0^+$)	K_0
0	0	0	1	0	X	1	X
0	1	1	0	1	X	X	1
1	0	1	1	X	0	1	X
1	1	0	0	X	1	X	1

S_4 : Expression

J_1:

$Q_1 \backslash Q_0$	0	1
0	0	1
1	X	X

$J_1 = Q_0$

K_1:

$Q_1 \backslash Q_0$	0	1
0	X	X
1	0	1

$K_1 = Q_0$

J_0:

$Q_1 \backslash Q_0$	0	1
0	1	X
1	1	X

$J_0 = 1$

K_0:

$Q_1 \backslash Q_0$	0	1
0	X	1
1	X	1

$K_0 = 1$

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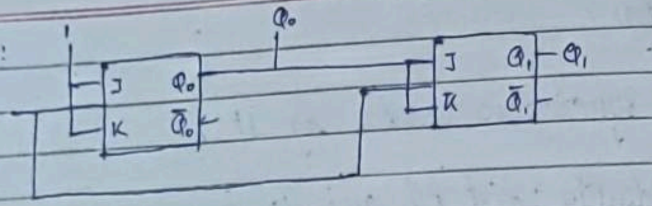
Date

S_5:



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- 3 bit synchronous counter by T FF

S_1: 3 bits + T FF

S_2: excitation table of T FF

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

S_3: State diagram + table

$$\begin{array}{ccccccc} 000 & \longrightarrow & 001 & \longrightarrow & 010 & \longrightarrow & 011 \\ \uparrow & & & & & & \downarrow \\ 111 & \longleftarrow & 110 & \longleftarrow & 101 & \longleftarrow & 100 \end{array}$$

						$Q_2 Q_2^+$	$Q_1 Q_1^+$	$Q_0 Q_0^+$
Q_2	Q_1	Q_0	Q_2^+	Q_1^+	Q_0^+	T_2	T_1	T_0
0	0	0	0	0	1	0	0	1
0	0	1	0	1	0	0	1	1
0	1	0	0	1	1	0	0	1
0	1	1	1	0	0	1	1	1
1	0	0	1	0	1	0	0	1
1	0	1	1	1	0	0	1	1
1	1	0	1	1	1	0	0	1
1	1	1	0	0	0	1	1	1

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S_4: Boolean expression

T_2

$Q_1 \backslash Q_1Q_0$	00	01	11	10
0	0	0	1	0
1	0	0	1	0

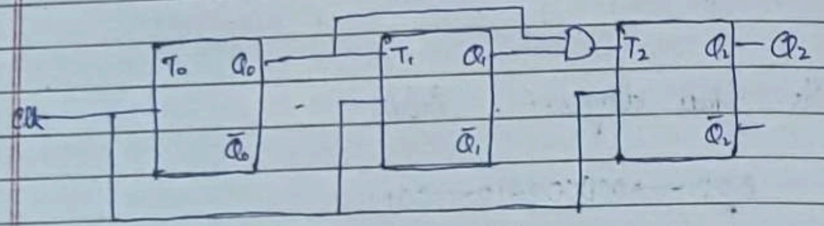
T_1

$Q_2 \backslash Q_1Q_0$	00	01	11	10
0	0	1	1	0
1	0	1	1	0

$T_0 = 1$

$T_1 = Q_0$

$T_2 = Q_0 Q_1$



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- 3 bit synchronous up / down counter

S_1: 3 bit; T FF

S_2: excitation table

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

$M = 0$ up

$M = 1$ down

S_3: state diagram & table

$000 \underset{1}{\overset{0}{\rightleftarrows}} 001 \underset{1}{\overset{0}{\rightleftarrows}} 010 \underset{1}{\overset{0}{\rightleftarrows}} 011$

$0 \Uparrow \Downarrow 1 \qquad\qquad\qquad 1 \Uparrow \Downarrow 0$

$111 \underset{0}{\overset{1}{\rightleftarrows}} 110 \underset{0}{\overset{1}{\rightleftarrows}} 101 \underset{0}{\overset{1}{\rightleftarrows}} 100$

S_5: Circuit diagram

Sq:

	m	Q_2	Q_1	Q_0	Q_2^+	Q_1^+	Q_0^+	T_2	T_1	T_0
up	0	0	0	0	0	0	1	0	0	1
	0	0	0	1	0	1	0	0	1	1
	0	0	1	0	0	1	1	0	0	1
	0	0	1	1	1	0	0	1	1	1
	0	1	0	0	1	0	1	0	0	1
	0	1	0	1	1	1	0	0	1	1
	0	1	1	0	1	1	1	0	0	1
	0	1	1	1	0	0	0	1	1	1
down	1	0	0	0	1	1	1	1	1	1
	1	0	0	1	0	0	0	0	0	1
	1	0	1	0	0	0	1	0	1	1
	1	0	1	1	0	1	0	0	0	1
	1	1	0	0	0	1	1	1	1	1
	1	1	0	1	1	0	0	0	0	1
	1	1	1	0	1	0	1	0	1	1
	1	1	1	1	1	1	0	0	0	1

$T_0 = 1$

T_1 (mQ_2 / Q_1Q_0)

		1	1
1	1		
1	1		
		1	1

T_2 (mQ_2 / Q_1Q_0)

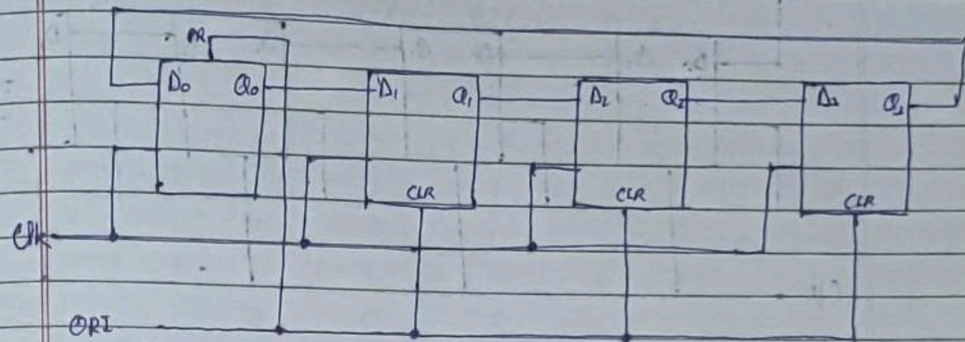
		1	1
1	1		

$T_1 = Q_0\bar{m} + \bar{Q}_0 m$

$T_2 = Q_1Q_0\bar{m} + \bar{Q}_1\bar{Q}_0 m$

- Ring counter

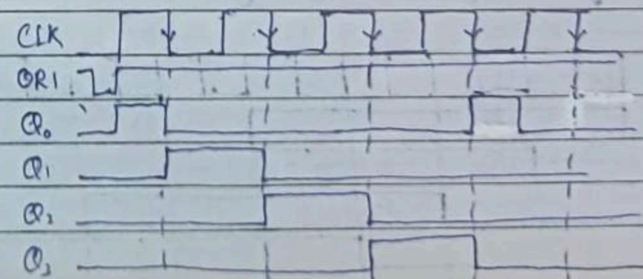
It is application of shift register
no. of states = no. of bits
no. of flip flop



ORI
overriding input

If CLR = 0, Q = 0

ORI	CLK	Q_0	Q_1	Q_2	Q_3
⎍	X	1	0	0	0
1	↓	0	1	0	0
1	↓	0	0	1	0
1	↓	0	0	0	1
1	↓	1	0	0	0

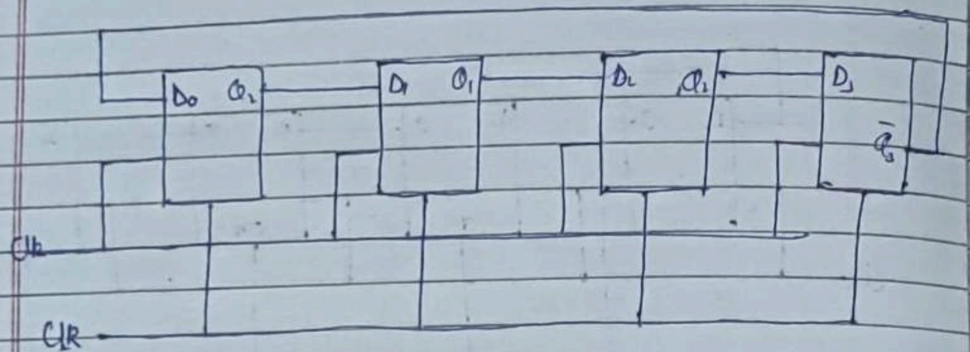


- Johnsons Counter / Twisted / Switch Tail

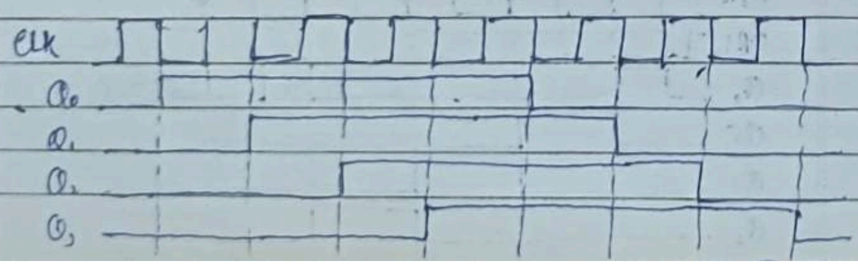
It's the application of shift register

No. of states = 2 × no. of flip flops

= 2 × no. of bits



CLR	CLK	Q_0	Q_1	Q_2	Q_3
⊔	×	0	0	0	0
1	↓	1	0	0	0
1	↓	1	1	0	0
1	↓	1	1	1	0
1	↓	1	1	1	1
1	↓	0	1	1	1
1	↓	0	0	1	1
1	↓	0	0	0	1
1	↓	0	0	0	0



(54) State Tables

Eg i)

$$A(t+1) = A(t)x(t) + B(t)x(t)$$
$$B(t+1) = \bar{A}(t)\,x(t)$$
$$y(t) = [A(t) + B(t)]\,\bar{x}(t)$$

draw state diagram using this

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

→ Next state

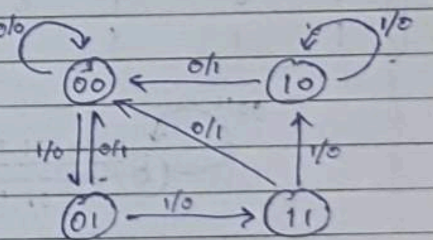
		x=0		x=1		x=0	x=1
A	B	A	B	A	B	y	y
0	0	0	0	0	1	0	0
0	1	0	0	1	1	1	0
1	0	0	0	1	0	1	0
1	1	0	0	1	0	1	0

00 → 00, 01

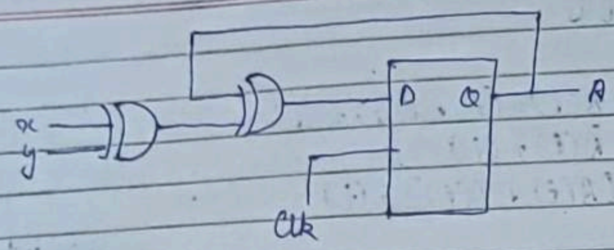
01 → 00, 11

10 → 00, 10

11 → 00, 10



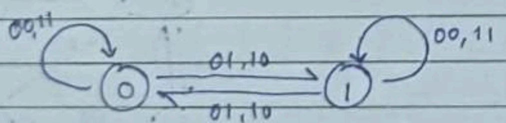
Eg ii)



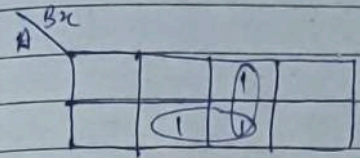
Present	Inputs		Next state
A	x	y	A
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

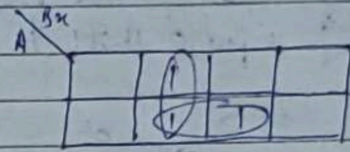
$$A(t+1) = (x \oplus y) \oplus A$$
$$= A \oplus x \oplus y$$

		A=0		A=1		A=0	A=1
x	y	x	y	x	y	A(t+1)	A(t+1)
0	0	0	0	0	0	0	1
0	1	0	1	0	1	1	0
1	0	1	0	1	0	1	0
1	1	1	1	1	1	0	1

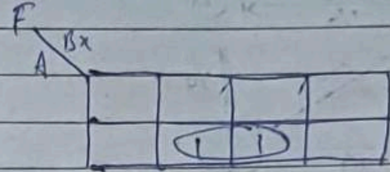


Eg iii) $D_A = 3,5,7$ $D_B = 1,5,7$





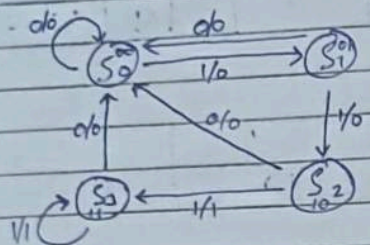
$F = 5,7$



$D_A = Ax + Bx$
$D_B = Ax + \bar{B}x$
$F = Ax$

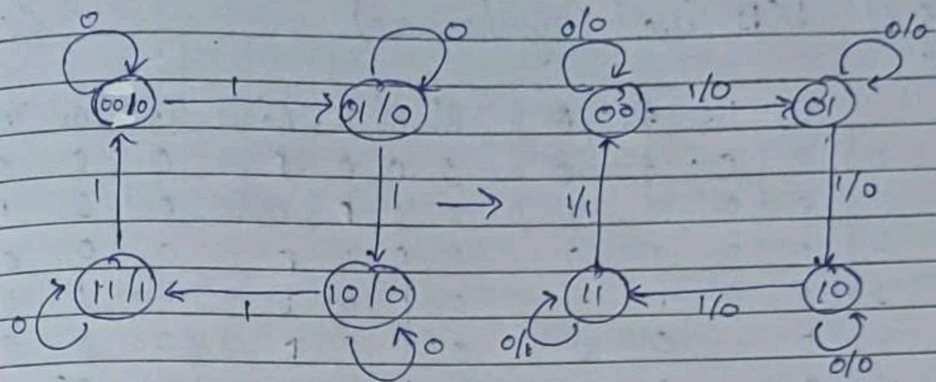
* If ff mentioned used that else default is D FF

Eg iii) If consecutive 3 (1's) then move to S_3
If input 1 move forward
If input 0 move to S_0



Present A	Present B	Input x	A(t+1)	B(t+1)	y
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	0	0
0	1	1	1	0	0
1	0	0	0	0	0
1	0	1	1	1	1
1	1	0	0	0	0
1	1	1	1	1	1

Eg iii)



andar 1 hai to uski se jane wali sabhi roots pe y = 1 hoga

A	B	x	A^+	B^+	y
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

Eg v) BCD decade (synchronous)

	B_3	B_2	B_1	B_0	B_3^+	B_2^+	B_1^+	B_0^+	T_{B_3}	T_{B_2}	T_{B_1}	T_{B_0}
0	0	0	0	0	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	1	0	0	0	1	1
2	0	0	1	0	0	0	1	1	0	0	0	1
3	0	0	1	1	0	1	0	0	0	1	1	1
4	0	1	0	0	0	1	0	1	0	0	0	1
5	0	1	0	1	0	1	1	0	0	0	1	1
6	0	1	1	0	0	1	1	1	0	0	0	1
7	0	1	1	1	1	0	0	0	1	1	1	1
8	1	0	0	0	1	0	0	1	0	0	0	1
9	1	0	0	1	0	0	0	0	1	0	1	1
10	1	0	1	0	x	x	x	x	x	x	x	x
11	1	0	1	1	x	x	x	x	x	x	x	x
12	1	1	0	0	x	x	x	x	x	x	x	x
13	1	1	0	1	x	x	x	x	x	x	x	x
14	1	1	1	0	x	x	x	x	x	x	x	x
15	1	1	1	1	x	x	x	x	x	x	x	x

0 → 1 → 2 → 3 → 4
↑ ↓
9 ← 8 ← 7 ← 6 ← 5

T_{B_3} (B_3B_2 \ B_1B_0)

		1	
x	x	x	
	1	x	

T_{B_2} (B_3B_2 \ B_1B_0)

		1	
		1	
x	x	x	x
		x	x

T_{B_1} (B_3B_2 \ B_1B_0)

	1	1	
	1	1	
x	x	x	x
		x	x

T_{B_0} (B_3B_2 \ B_1B_0)

1	1	1	1
1	1	1	1
x	x	x	x
1	1	x	x

$T_{B_3} = B_3B_0 + B_2B_1B_0$

$T_{B_2} = B_1B_0$

$T_{B_1} = B_0\bar{B_3}$

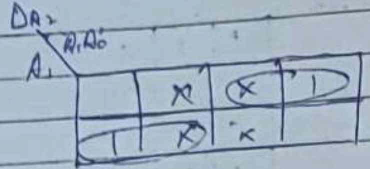
$T_{B_0} = 1$

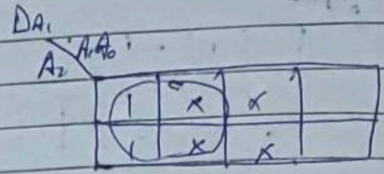
Eg vi)

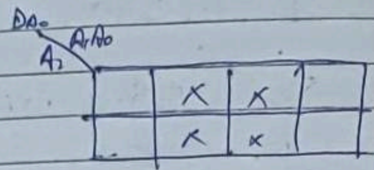
0 → 2 → 4 → 6 → 0

000 → 010
↑ ↓
110 ← 100

Present			Next					
A_2	A_1	A_0	A_2^+	A_1^+	A_0^+	D_{A_2}	D_{A_1}	D_{A_0}
0	0	0	0	1	0	0	1	0
0	0	1	x	x	x	x	x	x
0	1	0	1	0	0	1	0	0
0	1	1	x	x	x	x	x	x
1	0	0	1	1	0	1	1	0
1	0	1	x	x	x	x	x	x
1	1	0	0	0	0	0	0	0
1	1	1	x	x	x	x	x	x







$D_{A_2} = A_2\bar{A}_1 + \bar{A}_2 A_1 = A_2 \oplus A_1$

$D_{A_1} = \bar{A}_1$

$D_{A_0} = 1$

(55) 4 bit BCD adder

Decimal	Binary Sum					BCD Sum				
	C'	S_3'	S_2'	S_1'	S_0'	C	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	0	0	1	0
13	0	1	1	0	1	1	0	0	1	1
14	0	1	1	1	0	1	0	1	0	0
15	0	1	1	1	1	1	0	1	0	1
16	1	0	0	0	0	1	0	1	1	0
17	1	0	0	0	1	1	0	1	1	1
18	1	0	0	1	0	1	1	0	0	0
19	1	0	0	1	1	1	1	0	0	1
⋮										
32										

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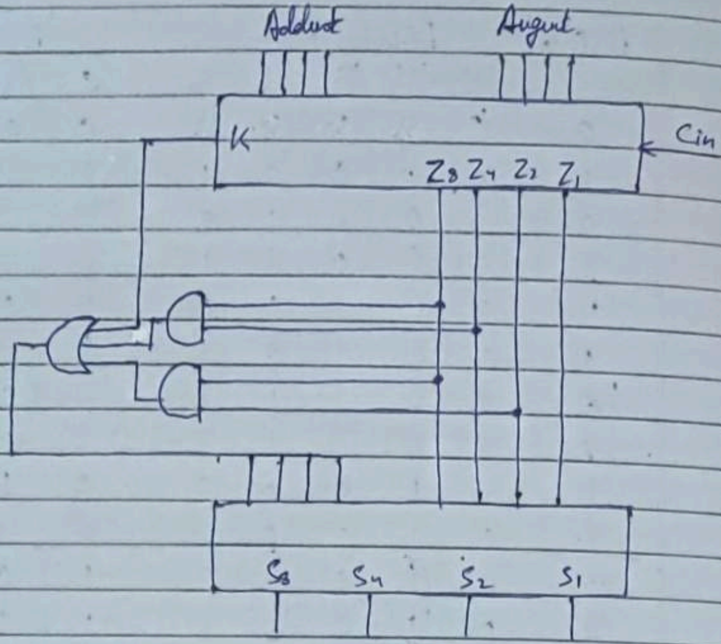
$C = K + Z_8 Z_4 + Z_8 Z_2$

equation for C : $C = C' + S_3' S_2' + S_1' S_1'$



5	0101	
+7	0111	
+12	1100	= 1100
		110
0001 | 0010		$(10010)_{BCD}$

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