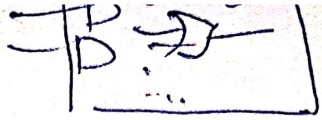


Combinational ckts

- PROM → Programmable ROM
- PAL → Programmable Array Logic
- PLA → Programmable Logic Array
- ALU — Arithmatical logical unit

Data

- Binary, Hex, Octal

PLA

- Programmable logic array

Truth table

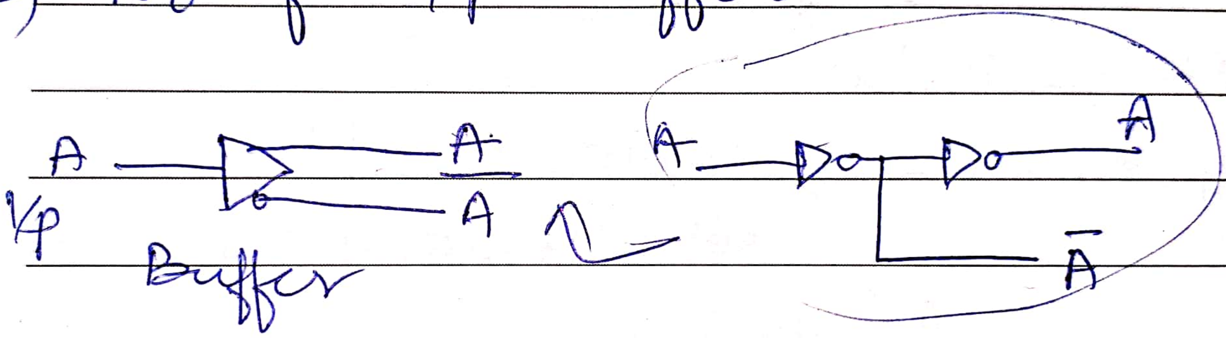
A	B	C	Y_1	Y_2
0	0	0	0	0
0	0	1	0	0
0	1	0	0	0
0	1	1	0	1
1	0	0	1	0
1	0	1	1	1
1	1	0	0	0
1	1	1	1	1

$Y_1 = A\bar{B}\bar{C} + A\bar{B}C + ABC$

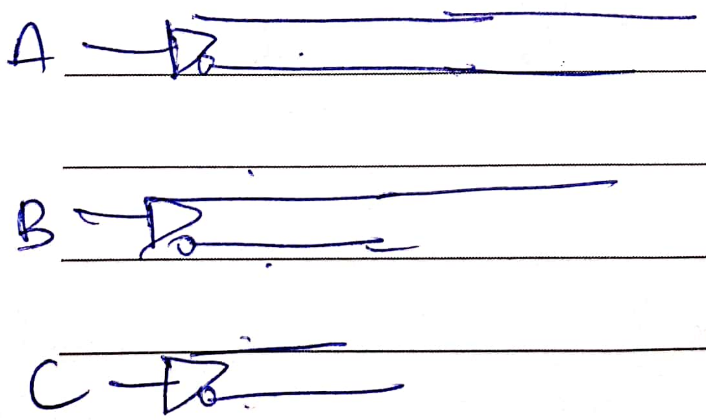
$Y_1 = A\bar{B} + AC$

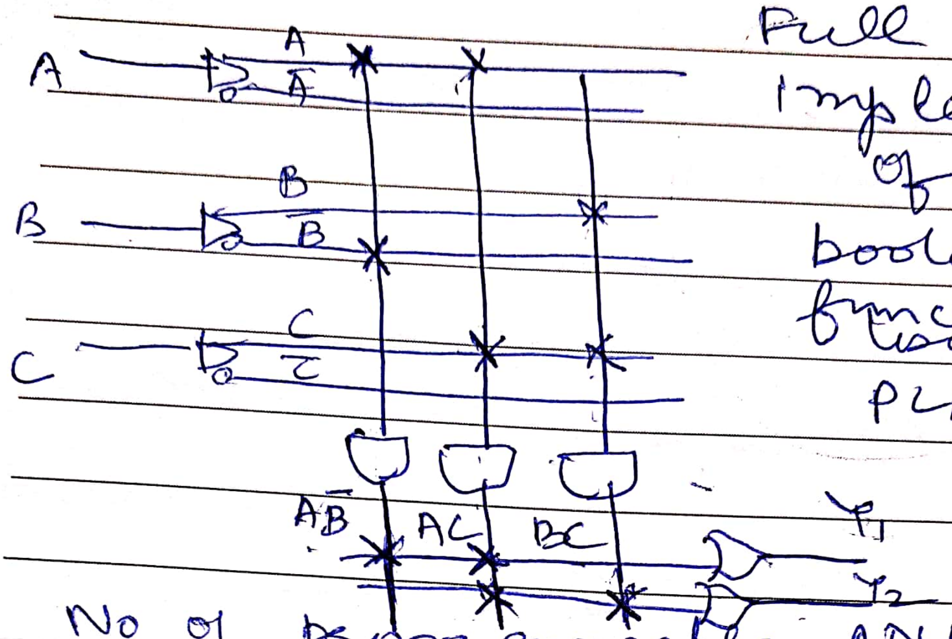
$\boxed{\begin{aligned} &\therefore Y_1 = A\bar{B} + AC \\ &\therefore Y_2 = BC + AC \end{aligned}} \rightarrow$ no of functions

(I) No of I/p buffer



No of i/p buffer = 3





Full implementation of boolean functions using PLA

III) No of programmable AND gates = No of minterms which are not repeated = 3

$A\bar{B}$, AC, BC

IV) No of programamabee OR gates = No of functions = Y_1, Y_2 = 2

$Y_1 = A\bar{B} + AC$

$Y_2 = BC + AC$

PLA – programmable AND array
– programmable OR array

PAL

→ Programmable Array Logic
→ Programmable AND gates array
→ Fixed OR gates Array

~~Ep XA~~ Q) Given:

$f_1(A,B,C) = \sum m(2,3,5,7)$

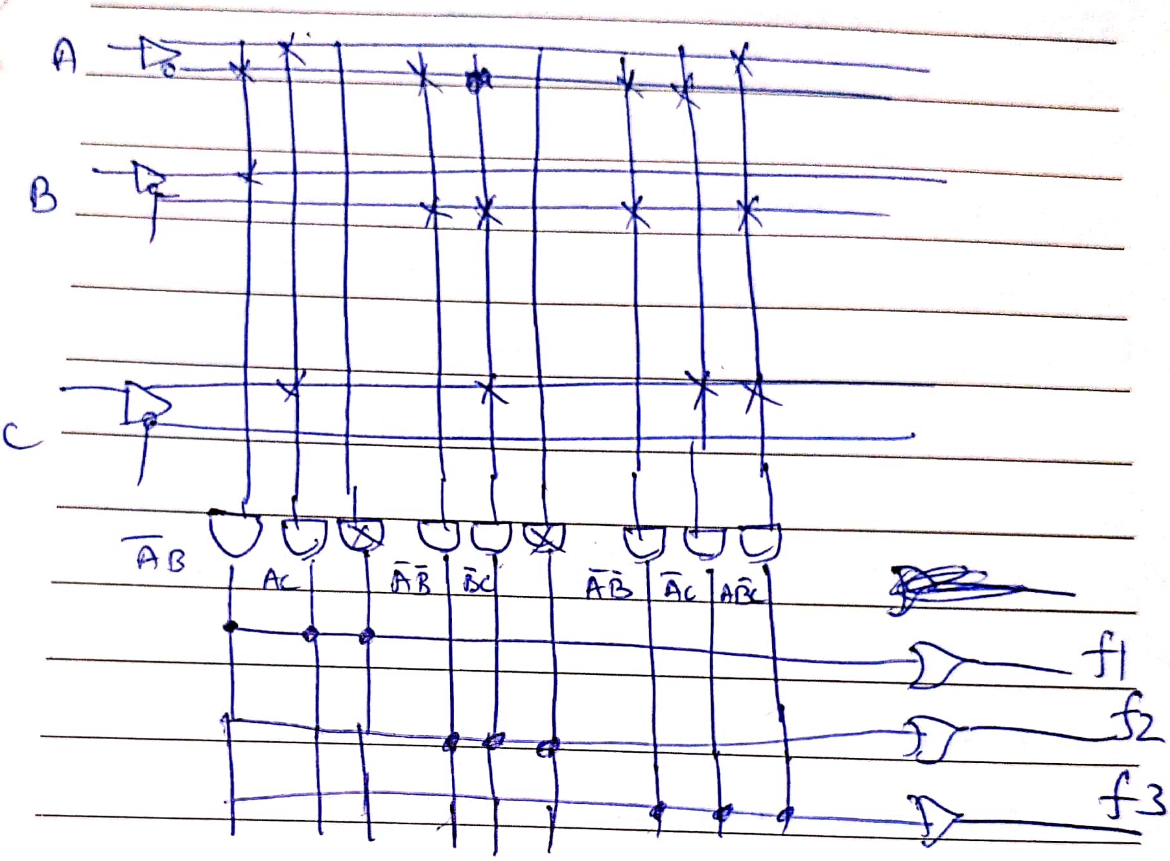
$f_2(A,B,C) = \sum m(0,1,5)$

$f_3(A,B,C) = \sum m(0,2,3,5)$

$f_1(A,B,C) = \bar{A}B + AC$] 2

$f_2(A,B,C) = \bar{A}\bar{B} + \bar{B}C$]

$f_3(A,B,C) = \bar{A}B + \bar{A}C + A\bar{B}C$] 3.



No of OR gates = No of functions
No of AND gates in each OR gate = No of minterms (highest)

No of input buffers = No of variables

Minimization

Method Quine-McCluskey

QM method

- minimization method
- Prime Implicant - No of 1's
- Essential Prime Implicant - Prime implicant which can not be combined with any other.

Ex $Y(A,B,C,D) = \sum m(0,1,3,7,8,9,11,15)$

	ABCD	
0 -	0000	M_0
1 -	0001	M_1
3 -	0011	M_3
7 -	0111	M_7
8 -	1000	M_8
9 -	1001	M_9
11 -	1011	M_{11}
15 -	1111	M_{15}

Step 1

column-1	column 2	column-2			
Group	Minterm	Binary Representation			
		A	B	C	D
0 (0 1's)	M_0	0	0	0	0 ✓
1 (1 1's)	M_1	0	0	0	1 ✓
	M_8	1	0	0	0 ✓
2 (2 1's)	M_3	0	0	1	1 ✓
	M_9	1	0	0	1 ✓
3 (3 1's)	M_7	0	1	1	1 ✓
	M_{11}	1	0	1	1 ✓
4 (4 1's)	M_{15}	1	1	1	1 ✓

Signutra
signature nutrition

Step 2

① [Compare n^{th} with $(n+1)^{th}$ group]
[0 with 1   1 with 2
2 with 3   3 with 4]
② Single variable change

Group	Matched Pair	Bin. Rep. ABCD	
0	M_0-M_1	000_ ✓	(D eliminated)
	M_0-M_8	_000 ✓	(A eliminated)
1	M_1-M_3	00_1 ✓	(C eliminated)
	M_1-M_9	_001 ✓	(A eliminated)
	M_8-M_9	100_ ✓	
2	M_3-M_7	0_11 ✓	
	M_3-M_{11}	_011 ✓	
	M_9-M_{11}	10_1 ✓	
3	M_7-M_{15}	_111 ✓	
	$M_{11}-M_{15}$	1_11	

Pair
M_0-M_1 000_
M_1-M_3 00_1
} 2 variables changing, so not matched pair

Step 3

Group	Matched Pair	Binary Rep A B C D
0	$M_0 - M_1 - M_8 - M_9$	— 0 0 —
	$M_0 - M_8 - M_1 - M_9$	— 0 0 —
1	$M_1 - M_3 - M_9 - M_{11}$	— 0 — 1
	$M_1 - M_9 - M_3 - M_{11}$	— 0 — 1
2	$M_3 - M_7 - M_{11} - M_{15}$	— — 1 1
	$M_3 - M_{11} - M_7 - M_{15}$	— — 1 1

m0 – m1	0 0 0 –	2 variables change not matched pair
m1 – m2	0 0 – 1	
m0 – m1	0 0 0 –	2 variables change not matched pair
m1 – m9	– 0 0 1	
m0 – m1	$\boxed{0}$ 0 0 –	only 1 variable change
m8 – m9	$\boxed{1}$ 0 0 –	

Step 4

→ Again find matched pair.
→ But we will find that there are no matched pair after that.

Group	A B C D	
0	– 0 0 –	$\bar{B}\bar{C}$
	– 0 0 –	
1	– 0 – 1	$\bar{B}D$
	– 0 – 1	
2	– – 1 1	CD
	– – 1 1	

PI

- If some pairs are not matched then write them as it is

Step 5

Prime Implicant Table (P I Table)

(given minterm)

P-I	Minterms Involved	0	1	3	7	8	9	11	15	
$\bar{B}\bar{C}$	0, 1, 8, 9	X	X			X	X			EPI
$\bar{B}D$	1, 3, 9, 11		X	X			X	X		
CD	3, 7, 11, 15			X	X			X	X	EPI

- This table helps to find essential P-I.
- circle those crosses which are alone in the column

$$\boxed{Y = \bar{B}\bar{C} + CD}$$

minimized expression

$\overline{B}D$ = eliminated because
not essential
prime implicant

carry look ahead adder

CLA

- Predicts the carry before it is actually calculated

A	B	Cin	Co	
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	1	$A \oplus B = 1$ & $Cin = 1$
1	0	0	0	
1	0	1	1	
1	1	0	1	$A \cdot B = 1$
1	1	1	1	

Go

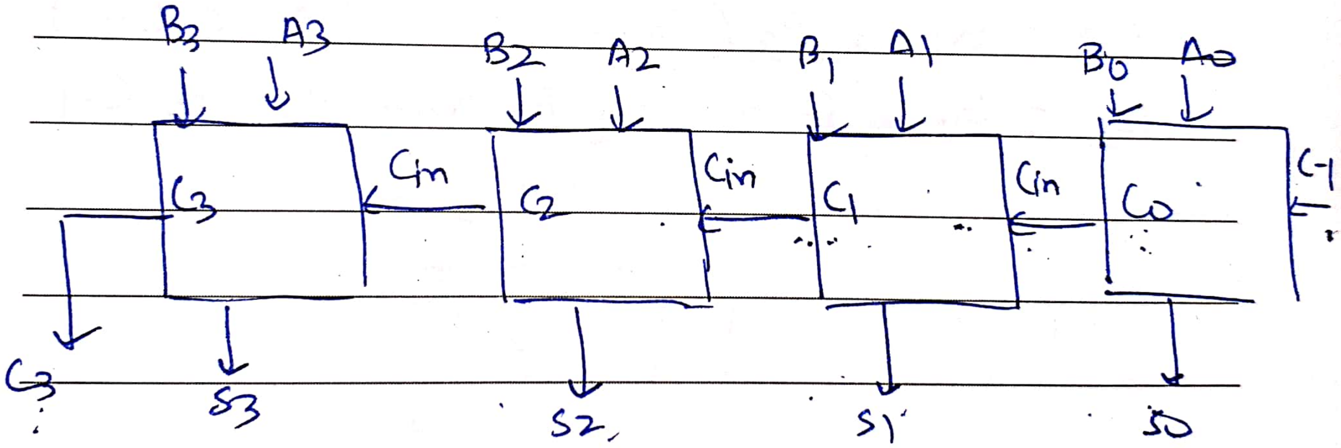
$$\begin{array}{ccccc} & C_2 & C_1 & C_0 & \\ & A_3 & A_2 & A_1 & A_0 \quad C_{-1} \\ & B_3 & B_2 & B_1 & B_0 \\ \hline C_3 & S_3 & S_2 & S_1 & S_0 \end{array}$$

$$\boxed{C_0 = \underbrace{A \cdot B}_{G} + \underbrace{(A \oplus B)}_{P} \cdot C_{in}}$$

carry generator (G) (No dependency on Cin)

carry propagator (P) (dependency on Cin)

$$\boxed{C_0 = G + P C_{in}}$$



$$\boxed{C_i = G_i + P_i C_{i-1}}$$ (Generalised form)

If $i = 0$

A $\quad C_0 = G_0 + P_0 C_{-1}$ ①

B $\quad$ If $i = 1$

C_{-1} $\quad C_1 = G_1 + P_1 C_0$ ②

$$C_1 = G_1 + P_1(G_0 + P_0 C_{-1})$$

$$= G_1 + P_1 G_0 + P_1 P_0 C_{-1}$$

(don't wait for any carry)

for 1st adder to wait for C_0)

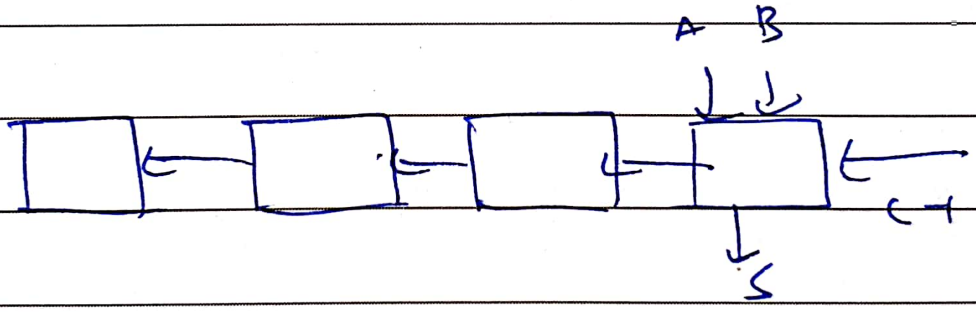
3

for $i = 2$

$$C_2 = G_2 + P_2 C_1$$

$$C_2 = G_2 + P_2(G_1 + P_1 G_0 + P_1 P_0 C_{-1})$$

$$C_2 = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_{-1}$$



for $i = 3$

$$C_3 = G_3 + P_3 C_2$$

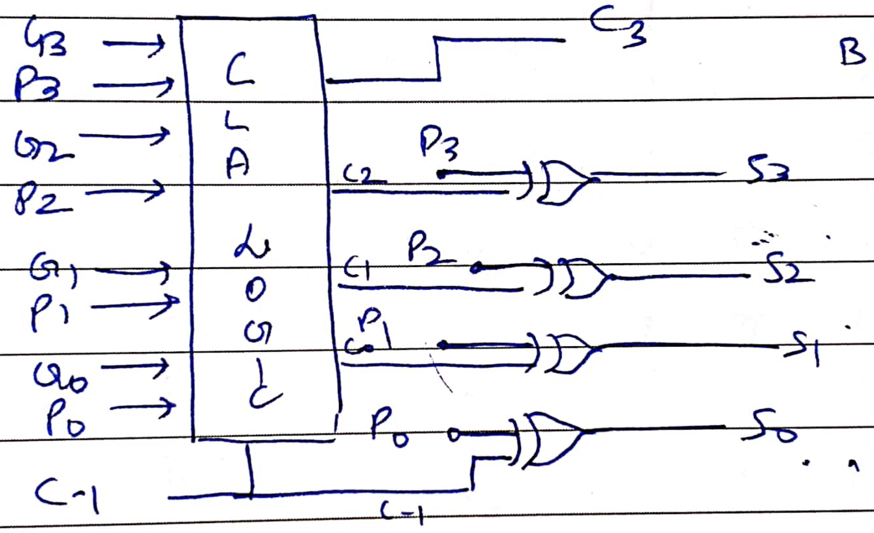
$$C_3 = G_3 + P_3(G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_{-1})$$

$C_3 = G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0 + P_3 P_2 P_1 P_0 C_{-1}$

All $C_3, C_2, C_1, C_0 \Rightarrow$ All have C_{-1}

$A = A_3 A_2 A_1 A_0$

$B = B_3 B_2 B_1 B_0$



$G_3 = A_3 \cdot B_3$

$P_3 = A_3 \oplus B_3$

$P_2 = A_2 \oplus B_2$

$P_1 = A_1 \oplus B_1$

$P_0 = A_0 \oplus B_0$

$S_3 = P_3 \oplus C_2$
$= A_3 \oplus B_3 \oplus C_2$

$S_2 = P_2 \oplus C_1$
$= A_2 \oplus B_2 \oplus C_1$

$S_1 = P_1 \oplus C_0$
$= A_1 \oplus B_1 \oplus C_0$

$S_0 = P_0 \oplus C_{-1}$
$= A_0 \oplus B_0 \oplus C_{-1}$

Even Parity Generator

~~carry save adder~~

Parity Generator

Design of 4 bit even Parity Generator

b_3	b_2	b_1	b_0	P_0	m
0	0	0	0	0	0
0	0	0	1	1	1
0	0	1	0	1	2
0	0	1	1	0	3
0	1	0	0	1	4
0	1	0	1	0	5
0	1	1	0	0	6
0	1	1	1	1	7
1	0	0	0	1	8
1	0	0	1	0	9
1	0	1	0	0	10
1	0	1	1	1	11
1	1	0	0	0	12
1	1	0	1	1	13
1	1	1	0	1	14
1	1	1	1	0	15

K-Map

4 variable K-MAP

(SOP)

MSB $b_3 b_2$ \ LSB $b_1 b_0$

$b_3 b_2$ \ $b_1 b_0$	$\bar{b}_1 \bar{b}_0$ 00	$\bar{b}_1 b_0$ 01	$b_1 b_0$ 11	$b_1 \bar{b}_0$ 10
$\bar{b}_3 \bar{b}_2$ 00	0 (0)	1 (1)	0 (3)	1 (2)
$\bar{b}_3 b_2$ 01	1 (4)	0 (5)	1 (7)	0 (6)
$b_3 b_2$ 11	0 (12)	1 (13)	0 (15)	1 (14)
$b_3 \bar{b}_2$ 10	1 (8)	0 (9)	1 (11)	0 (10)

– check board configuration

$$P_0 = \bar{b}_3 \bar{b}_2 \bar{b}_1 b_0 + \bar{b}_3 \bar{b}_2 b_1 \bar{b}_0 + \bar{b}_3 b_2 \bar{b}_1 \bar{b}_0 + \bar{b}_3 b_2 b_1 b_0 + b_3 b_2 \bar{b}_1 b_0 + b_3 b_2 b_1 \bar{b}_0 + b_3 \bar{b}_2 \bar{b}_1 \bar{b}_0 + b_3 \bar{b}_2 b_1 b_0$$

$$P_0 = \bar{b}_3 \bar{b}_2 (\bar{b}_1 b_0 + b_1 \bar{b}_0) + \bar{b}_3 b_2 (\bar{b}_1 \bar{b}_0 + b_1 b_0) + b_3 b_2 (\bar{b}_1 b_0 + b_1 \bar{b}_0) + b_3 \bar{b}_2 (\bar{b}_1 \bar{b}_0 + b_1 b_0)$$

$$P_0 = \overline{b_3}\,\overline{b_2}\,(b_1 \oplus b_0) + \overline{b_3}\,b_2\,(b_1 \odot b_0) + b_3 b_2\,(b_1 \oplus b_0) + b_3 \overline{b_2}\,(b_1 \odot b_0)$$

$$P_0 = b_1 \oplus b_0\,(\overline{b_3}\,\overline{b_2} + b_3 b_2) + b_1 \odot b_0\,(\overline{b_3} b_2 + b_3 \overline{b_2})$$

$$P_0 = b_1 \oplus b_0\,(b_3 \odot b_2) + b_1 \odot b_0\,(b_2 \oplus b_3)$$

$$P_0 = b_1 \oplus b_0\,(\overline{b_2 \oplus b_3}) + (\overline{b_1 + b_0})(b_2 \oplus b_3)$$

Let $A = b_1 \oplus b_0$

$B = b_2 \oplus b_3$

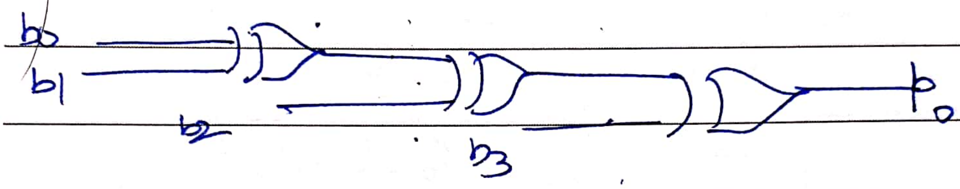
$$P_0 = A\overline{B} + \overline{A}B$$

$$P_0 = A \oplus B$$

So $\cancel{P_0 = b_q \oplus 1}$

So $P_0 = (b_1 \oplus b_0) \oplus (b_2 \oplus b_3)$

$$\boxed{P_0 = b_0 \oplus b_1 \oplus b_2 \oplus b_3}$$

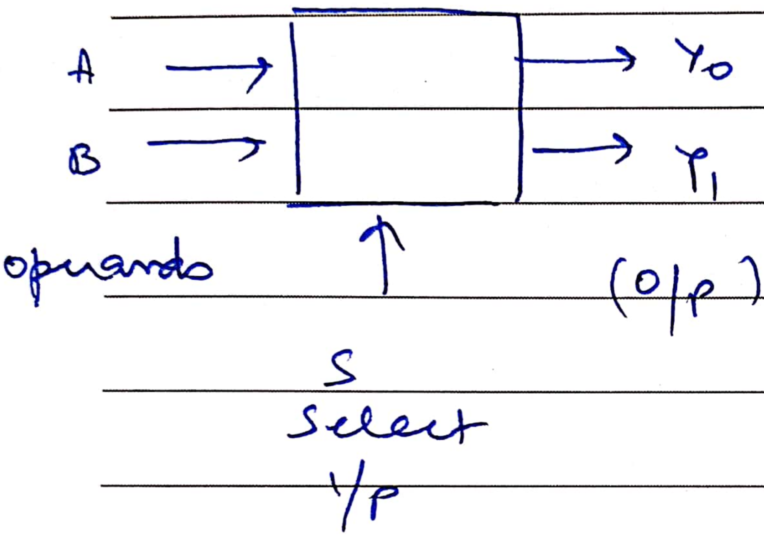


4-Bit Even Parity Generator

ALU

Arithmetic logic Unit

- Arithmetic operations
- Logic operations



If
$S = 0$

$Y_0 = (A \cdot B)'$ (NAND)

$Y_1 = (A + B)'$ (NOR)

If
$S = 1$

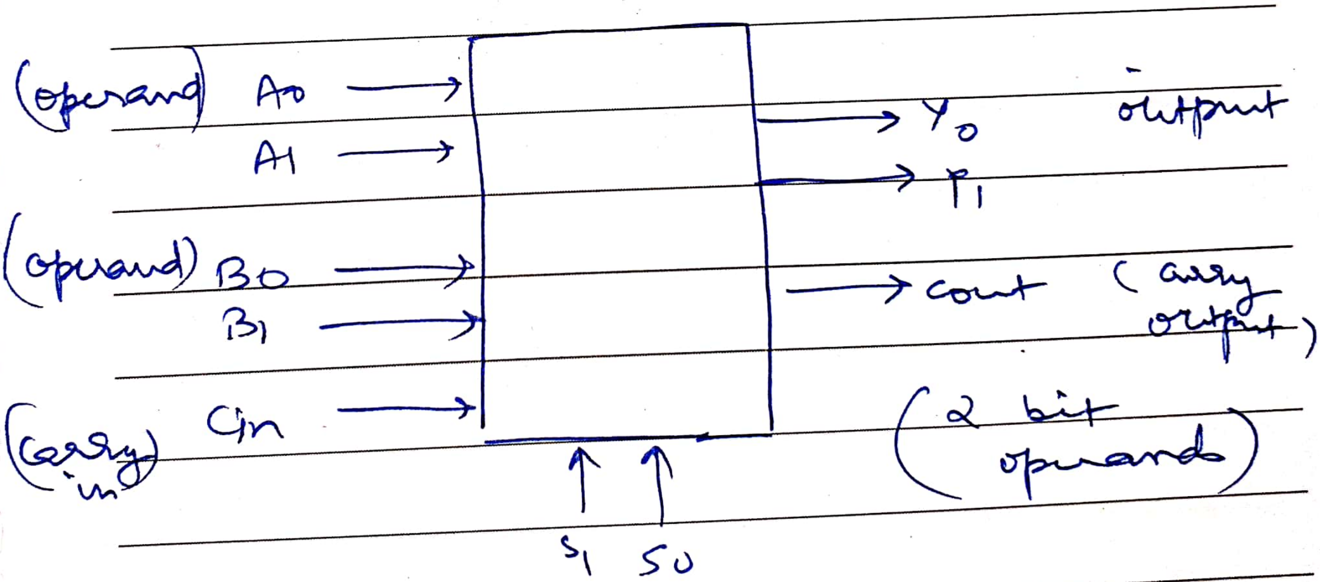
$Y_0 = \bar{A}B + A\bar{B}$
(sum bit of HA)

$Y_1 = AB$
(carry bit of HA)

$$Y_0 = \bar{S}(A \cdot B)' + S(A+B)'$$
$$Y_1 = \bar{S}(A+B)' + S(AB)$$

Function Table

S_1	S_0	C_{in}	O/P	
0	0	X	$Y = (A \cdot B)'$	(NAND)
0	1	X	$Y = (A + B)'$	(NOR)
1	0	0	$Y = A$	
1	0	1	$Y =$ A PLUS 1	
1	1	0	$Y =$ A PLUS B	
1	1	1	$Y =$ A PLUS B PLUS 1	



logic operation: Bitwise
Arithmetic operation: 2 bit Number

	$\bar{A_0}\bar{B_0}$	$\bar{A_0}B_0$	A_0B_0	$A_0\bar{B_0}$
$\overline{S_1 S_0}$	1	1	0	1
$\bar{S_1} S_0$	1	0	0	0
$S_1 S_0$	0	0	1	1
$S_1 \bar{S_0}$	0	1	0	1

Y_0

for $C_{in} = 0$