

Vishal Kashyap

Digital System

E - 301

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Cat - 2

1Q Explain SOP and POS form.

Ans :- SOP :- SOP is a method of describing a Boolean expression using a set of minterms or product terms.

POS :- POS is a method of describing a Boolean expression using a set of max terms or sum terms.

2Q Define Pair, Guard and Octet.

Ans Pair :- • A pair can be formed by grouping two horizontal or two vertical '1'. • A pair of '1' reduces 1 variable.

Guard :- A group of 4 one's that are horizontally or vertically adjacent. End to end or in form of a square. A quad eliminates two variables and their complements.

Octet :- A group of 8 one's that are horizontally or vertically adjacent. An octet eliminates three variables and their complements.

3Q What are called don't care conditions?

Ans :- The "Don't Care" conditions allows us to replace the empty cell of a K-Map to form a grouping of the variables which is larger than

that of forming groups without don't care.

4Q. What is meant by Karnaugh map or K-Map?

Ans :- A Karnaugh map is a pictorial method used to minimize Boolean expression without having to use Boolean algebra theorems and equation manipulations.

5Q. Define Combinational logic

Ans :- Also known as "Combinational logic", it refers to a digital logic function made of primitive logic gates (AND, OR, NOT, etc) in which all outputs of the function are directly related to the current combination of values on its inputs.

6Q. Define Half adder and full adder

Ans :- Half Adder :- The Half Adder is a type of combinational logic circuit that adds two of the 1-bit binary digits. It generates carry and sum of both the inputs.

Full Adder :- The Full Adder is also a type of combinational logic that adds three of the 1-bit binary digits for performing an addition operation.

Q.7 What is Decoder and Encoder?

? Ans Decoder :-

Changes a code into a set of signals. It is called a decoder because it does the reverse of encoding, but we will begin our study of encoders and decoders with decoders because they are simpler to design.

Encoder :- An encoder or "Simple encoder" in digital electronics is a one-hot to binary converter. That is, if there are 2^n input lines, at most only one of them will ever be high, the binary code of this 'hot' line is produced on the n-bit output lines. A binary encoder is the dual of a binary decoder.

Q.8. Explain Applications of Multiplexer

Ans Multiplexer :- It is a combinational circuit that has maximum of 2^n data inputs. 'n' selection lines and single output line. One of these data inputs will be connected to the input based on the values of selection lines.

The Multiplexer is a combinational logic circuit designed to switch one or several input lines to a single common output line by the application of a control logic.

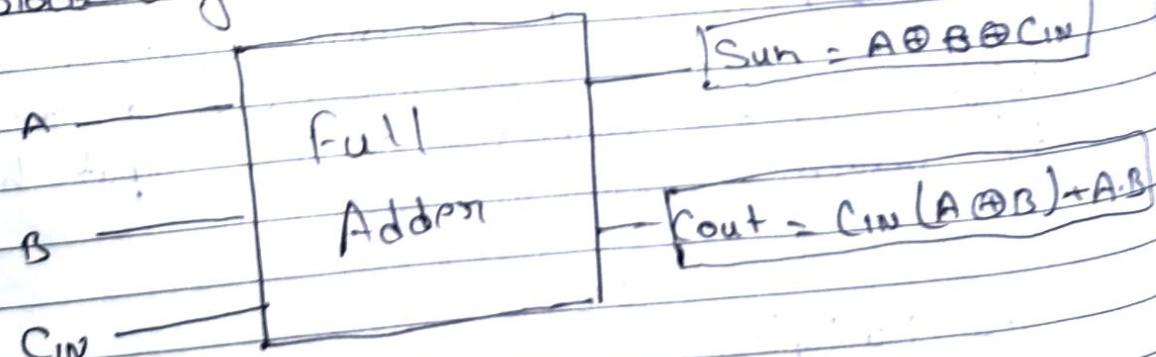
Multiplexers are used in various applications wherein multiple-data need to be transmitted by using a single line.

- Communication system
- Computer memory
- Serial to Parallel converter
- Arithmetic Logic unit

Q18. Explain and design the circuit diagram of Full Adder.

Ans Full Adder :- The full adder is combinational logic circuit that adds three or the 1-bit binary digits for performing an addition operation. A and B, and a carry in-bit C-IN is called a full adder.

Block diagram



Truth Table

Date _____
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Inputs			Outputs	
A	B	C _{in}	Sum(A ⊕ B ⊕ C _{in})	C _{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	0
1	0	0	1	1
1	0	1	0	0
1	1	0	0	1
1	1	1	1	1

K-map for sum

		B.C _{in}			
		00	01	11	10
A		0	1	1	1
		1	1	1	

$$\begin{aligned} \text{Sum} &= \bar{A} \cdot \bar{B} \cdot C_{in} + \bar{A} \cdot B \cdot \bar{C}_{in} + A \cdot \bar{B} \cdot \bar{C}_{in} + A \cdot B \cdot C_{in} \\ &= C_{in}(A \cdot B + \bar{A} \cdot \bar{B}) + \bar{C}_{in}(\bar{A} \cdot B + A \cdot \bar{B}) \end{aligned}$$

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

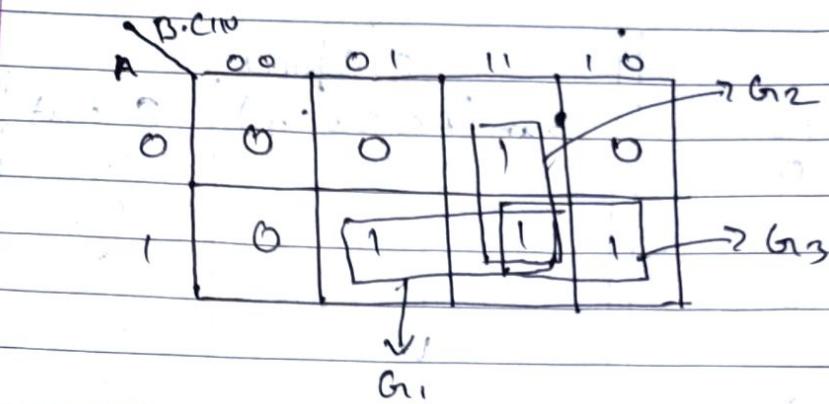
\bar{x} = not (XOR)

$$\text{Sum} = \bar{C}_{in} \cdot x + C_{in} \cdot \bar{x}$$

$$= C_{in} \oplus x$$

$$= C_{in} \oplus A \oplus B$$

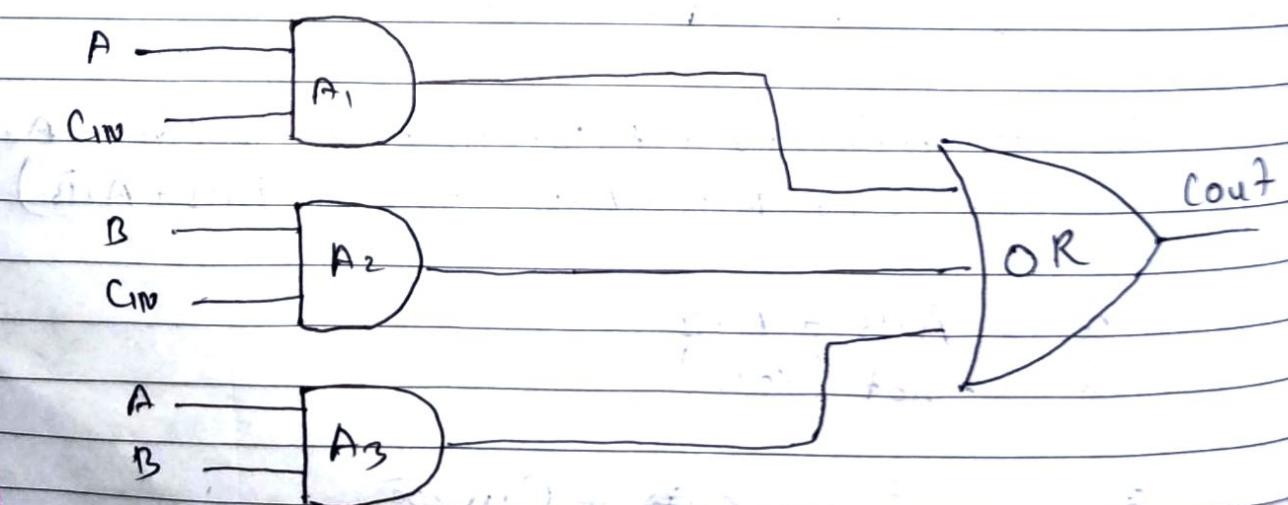
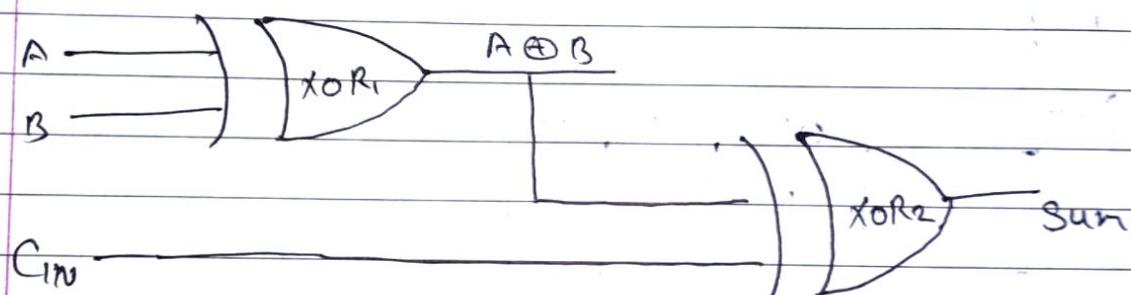
K-Map C-out



$$C\text{-out} = A \cdot \text{Cin} + B \cdot \text{Cin} + A \cdot B$$

$$C\text{-out} = \text{Cin} \cdot (A + B) + A \cdot B$$

Circuit Diagram



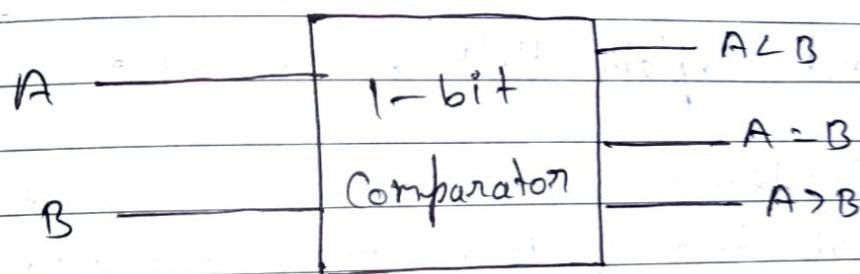
Q. Explain about 1-bit Magnitude Comparator?

Ans - 1-Bit Magnitude Comparator :-

used to compare two bits is called a single bit comparator. It consists of two input each for two single bit numbers and three outputs to generate less than, equal to and greater than between two binary numbers.

A Comparator

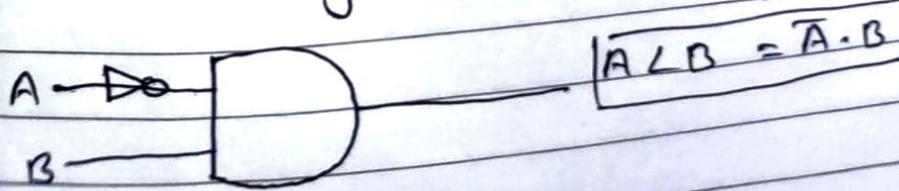
Block Diagram

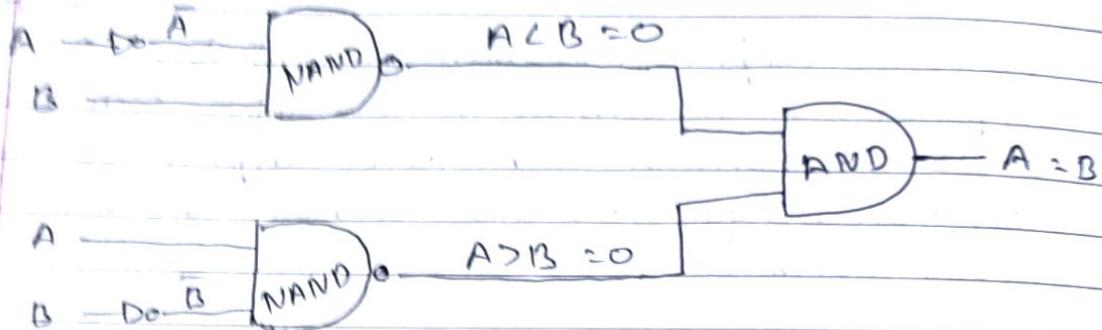


Excitation Table

A	B	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

Circuit Diagram



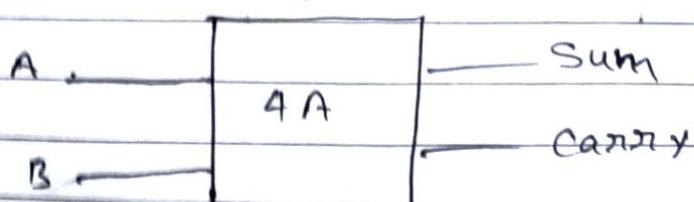


Q.20 Design and explain Half binary adder in Detail.

Ans:- Half Adder :- It is a combinational logic circuit that performs the addition of two data bits, A and B.

Addition will result in two output bits, one of which is the sum bit S, and the other is the carry bit C.

Block diagram .



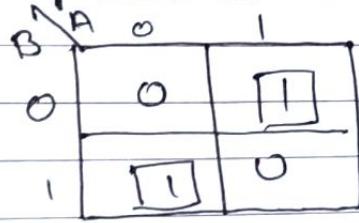
Truth Table

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

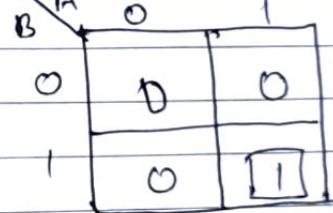
Logical Expression for sum :-

$$A'B'C'm_1 + A'B'cm_2 + AB'C'm_3 + ABC'm_4$$

K-Map for sum



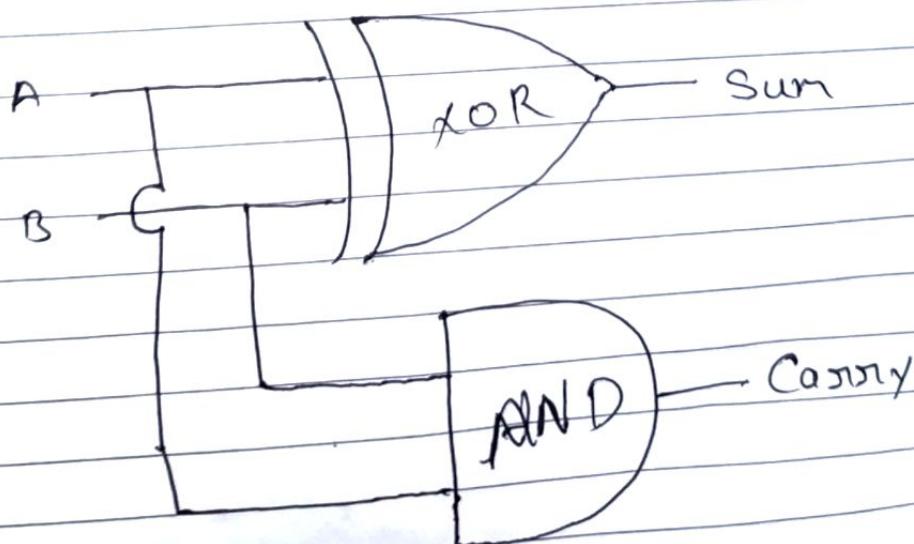
K-Map for Carry



$$\text{Sum} = A \oplus B$$

$$\text{Carry} = A \text{ AND } B$$

Logical implementation or diagram



Note:- Half adder has only two inputs and there is no provision to add a carry coming from the lower order bits. When multi addition is performed.

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Q.21. What is Multiplexer? Design and explain the circuit diagram of 4x1 Multiplexer.

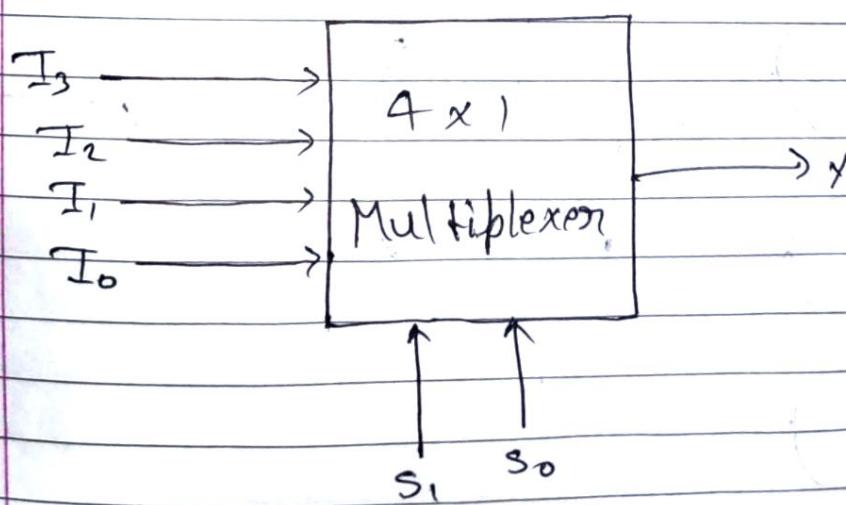
Ans Multiplexer :- It is a combinational circuit that has maximum of 2^n data inputs. 'n' selection lines and single output line. One of these data inputs will be connected to the input based on the values of selection lines.

Since these are 'n' selection lines, there will be 2^n possible combination will select only one data input. Multiplexer is also called as MUX.

4x1 Multiplexer :-

4x1 Multiplexer has four data inputs I_3, I_2, I_1 & I_0 two selection lines S_1 & S_0 and one output y .

Block diagram



One of those 4 inputs will be connected to the output based on the combination of input present at

these two selection lines.

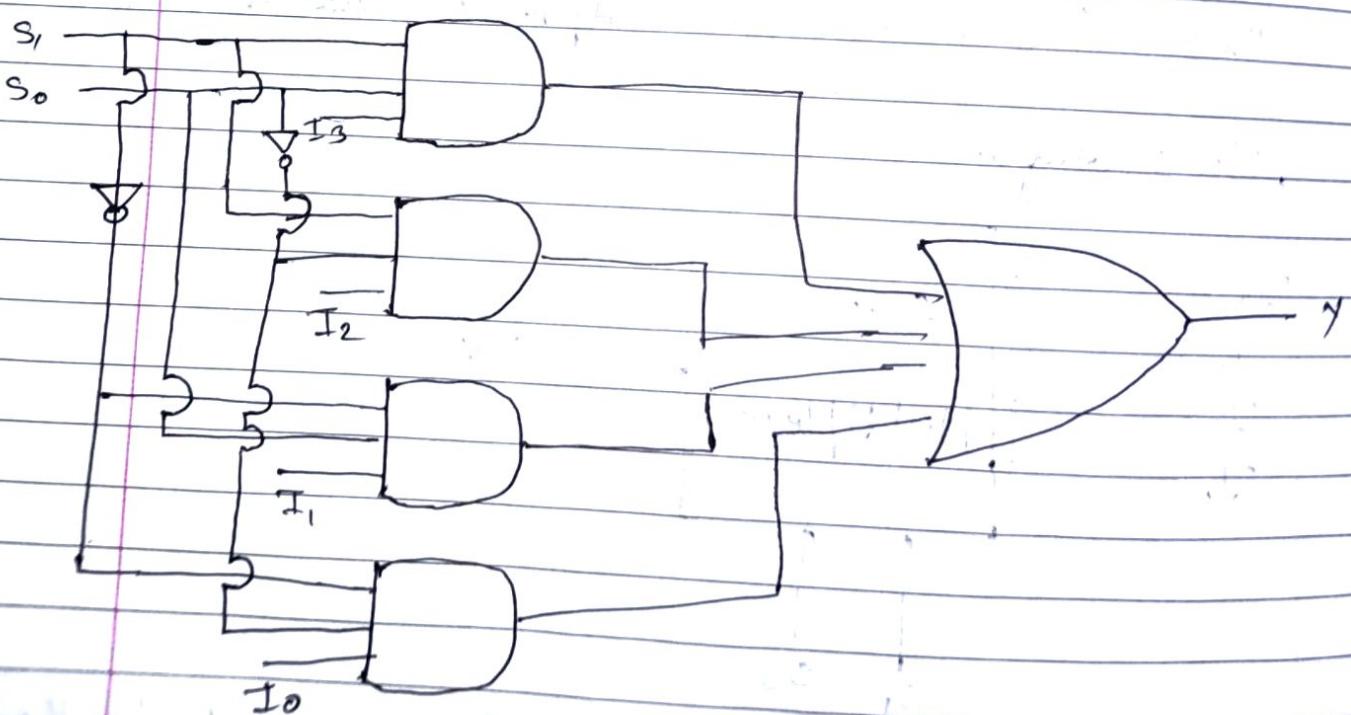
Truth Table

Selection (S ₁)	lines (S ₀)	Output (x)
0	0	I ₀
0	1	I ₁
1	0	I ₂
1	1	I ₃

From the truth table, we can directly write the Boolean function for output x as

$$Y = S_1 S_0' I_0 + S_1 S_0 I_1 + S_1' S_0 I_2 + S_1' S_0' I_3$$

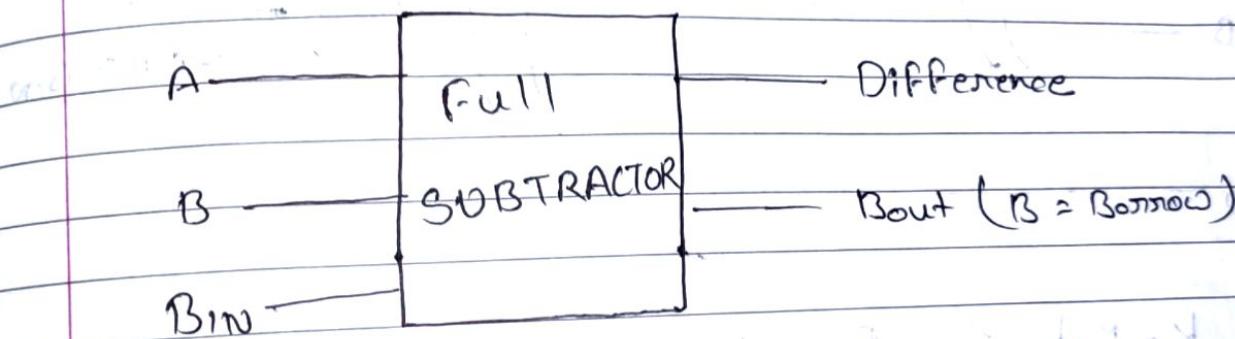
Circuit diagram



Q.22. Design and explain the combinational circuit of full subtractor.

Ans. Full subtractor :-

A full subtractor is a combinational circuit that performs subtraction of two bits one is minuend and other is subtrahend, taking into account borrow from the previous adjacent lower minuend bit. This circuit has three input and two output.



Input			Output	
A	B	Bin	Diff.	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	1
1	1	1	1	0

K-Map for Difference

$$\text{Diff} = A \cdot \bar{B} \cdot \bar{B}_{IN} + \bar{A} \cdot B \cdot B_{IN} + A \cdot B \cdot B_{IN} + \bar{A} \cdot \bar{B} \cdot \bar{B}_{IN}$$

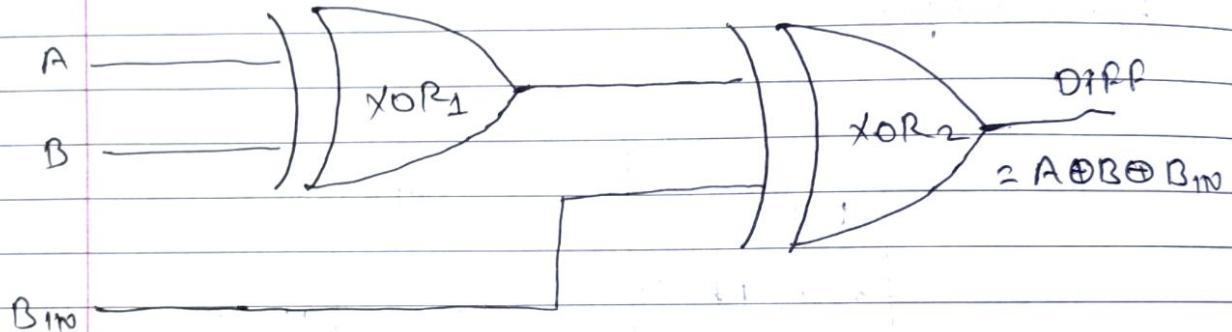
$$= \bar{B}_{IN} (\bar{A} \cdot \bar{B} + A \cdot B) + B_{IN} (\bar{A} \cdot \bar{B} + A \cdot B)$$

$A \cdot \bar{B} + \bar{A} \cdot B = \bar{x} \text{ (XOR)}$
$\bar{A} \cdot \bar{B} + A \cdot B = \bar{\bar{x}} \text{ (XOR-NOT)}$

$$= \bar{B}_{IN} \cdot \bar{x} + B_{IN} \cdot \bar{\bar{x}}$$

$$= B_{IN} \oplus x$$

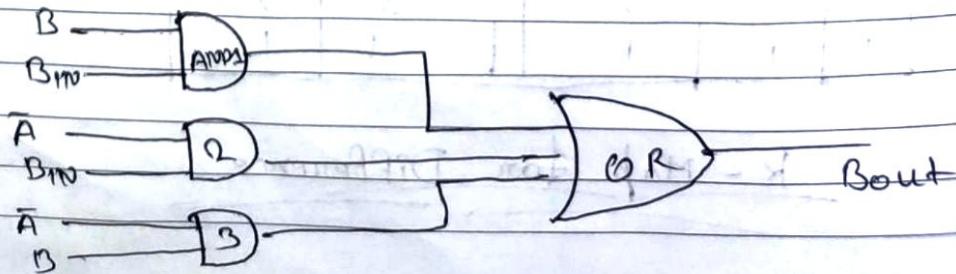
$$= B_{IN} \oplus A \oplus B$$



K-Map for B-out

		B _{IN}	
		00	01
A		00	0
0		1	1
1		0	10

$$B_{out} = B \cdot B_{IN} + \bar{A} \cdot B_{IN} + \bar{A} \cdot B$$



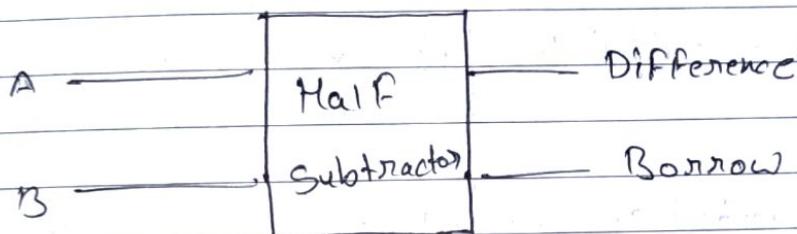
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Q.24 Explain Half binary Subtractor (in detail). (18)

Ans - Half Subtractor :-

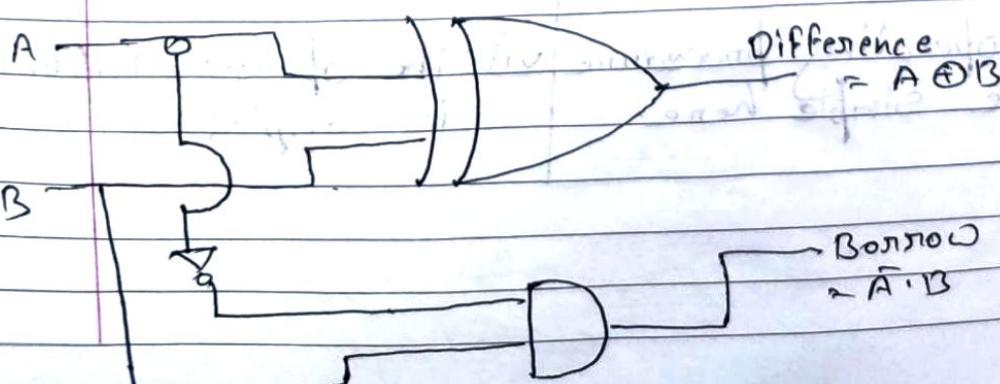
A half subtractor is a logical circuit that performs a subtraction operation on two binary digits. The half subtraction produces a sum and a borrow bit for the next stage.



Excitation Table

Inputs		Outputs	
A	B	Diff	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

CIRCUIT DIAGRAM



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proper answer. As soon as g will
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25. Difference between encoder and decoder

Ans.

ENCODER

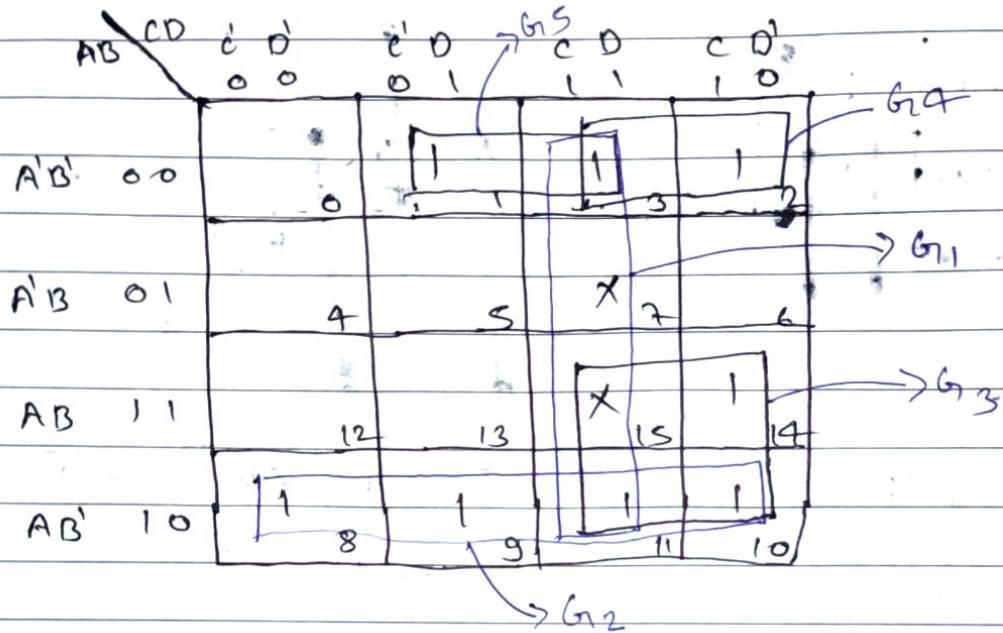
- i] The combinational circuits that modify the binary data into N output lines are known as Encoders.
- ii] In this the output lines are n .
- iii] The implemented signal is considered as actual signal input.
- iv] It is utilized in videos, E-mail, and more.
- v) When it comes to the communication mode the encoder is situated at the transmitting end.
- vi] The operating procedure is quite simple here.

DECODER

- i] The combinational circuits that convert the binary data into $2N$ output lines are called Decoders.
- ii] In this the output lines are 2^n .
- iii] It receives coded binary data as its input.
- iv] It is mostly utilized in memory chips, microprocessors and more.
- v) Here, the decoder is situated at the receiving side.
- vi] The operating procedure is complex.

Q.g. Simplify the Boolean expression, using K-Map

$$F(A, B, C, D) = \sum m(1, 2, 3, 8, 9, 10, 11, 14) + d(7, 15)$$

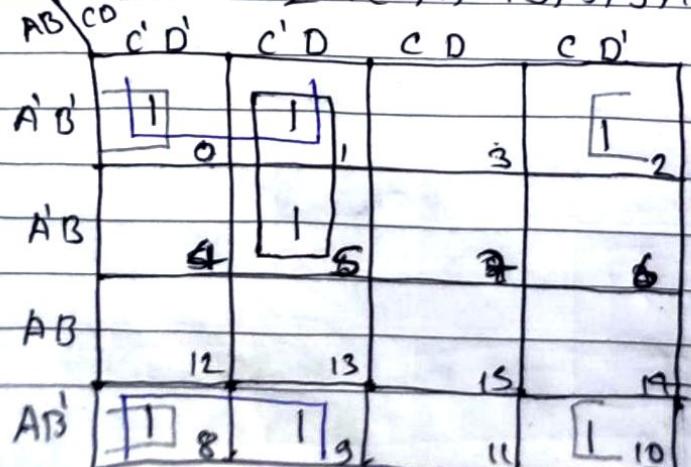


$$\gamma = G_1 + G_2 + G_3 + G_4 + G_5$$

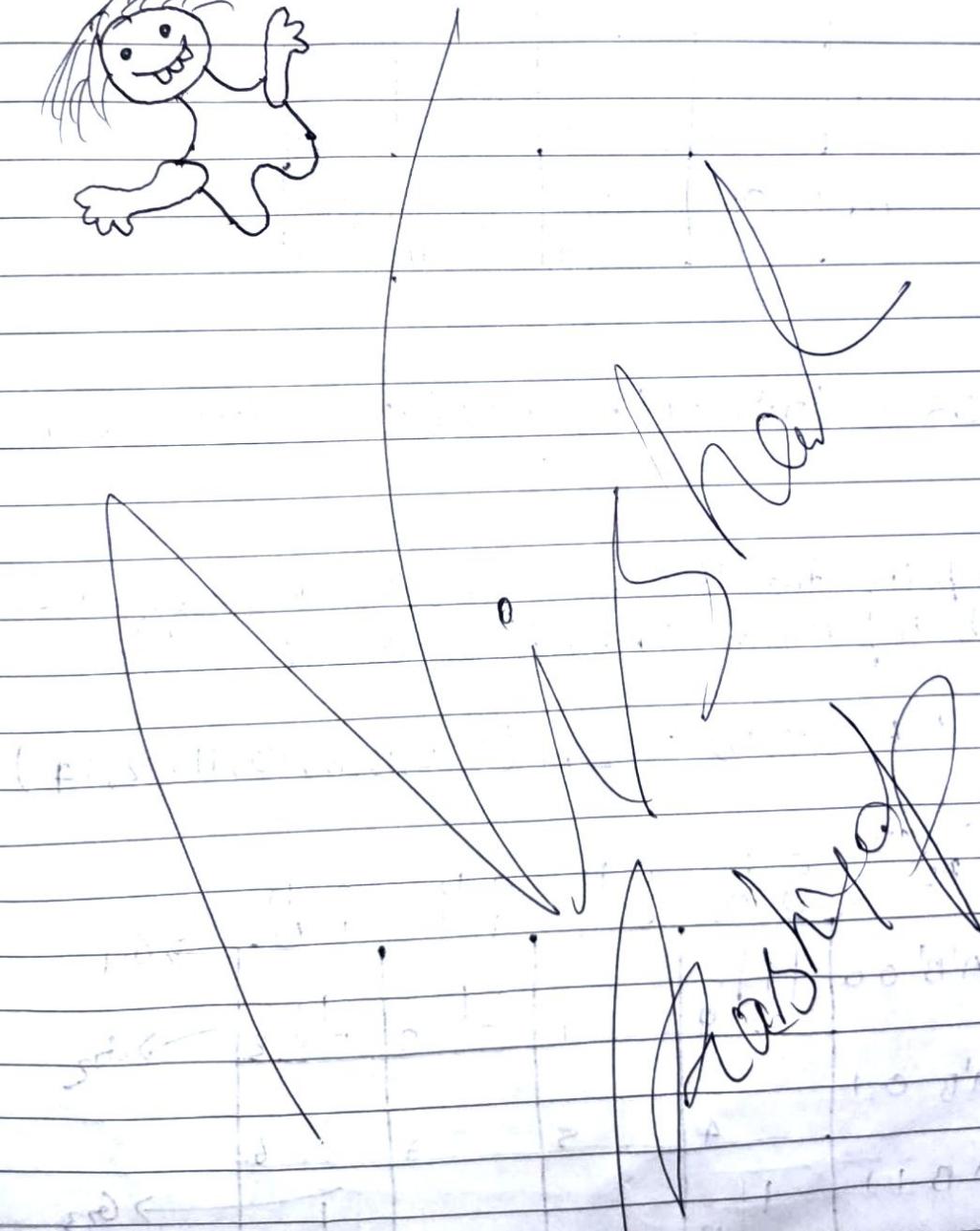
$$\therefore CD + A'B + A \cdot C + A'B' \cdot C + A'B' \cdot D$$

Q.10 Obtain the a) SOP b) POS expression for the function given below

$$F(A, B, C, D) = \sum m(0, 1, 2, 5, 8, 9, 10)$$



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



Q.11. Reduce the expression $F(x,y,z,w) = \sum m(0,2,7,8,9,10,11,15) \cdot d(3,4)$ using K-Map?

Solve-

xy'	yzw	00	01	11	10	
		0	x	0	0	$\rightarrow G_1$
		0	0	0	0	$\rightarrow G_2$
		1	1	0	0	$\rightarrow G_3$
		1	0	0	0	$\rightarrow G_4$
		0	0	0	0	
		0	0	0	0	

$$POS = (x' + y)(z' + w')(y + w)(x + z + w)$$

Q.1

Q.12. Simplify the Boolean expression F using K-Map and implement combinational circuit

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

CD	AB	$C'D'$	$C'D$	CD	$C'D'$	
		00	01	11	10	$\rightarrow G_1$
		1	0	1	1	$\rightarrow G_2$
		01	1	0	0	$\rightarrow G_3$
		11	1	1	1	$\rightarrow G_4$
		10	1	1	1	
		0	0	0	0	

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

A B C D

A' B C' D

0 0 0 0

0 0 1 0

0 1 0 0

0 1 1 0

1 0 0 0

1 0 1 0

1 1 0 0

1 1 1 0

0 0 0 1

0 0 1 1

0 1 0 1

0 1 1 1

1 0 0 1

1 0 1 1

1 1 0 1

1 1 1 1

A1

A2

A3

Y

OR

Y

Q.13. Obtain the Complement of Boolean Expression

$$i) A + B + A'B'C$$

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

$$= A'B \cdot (A + B + C') \quad \text{Ans}$$

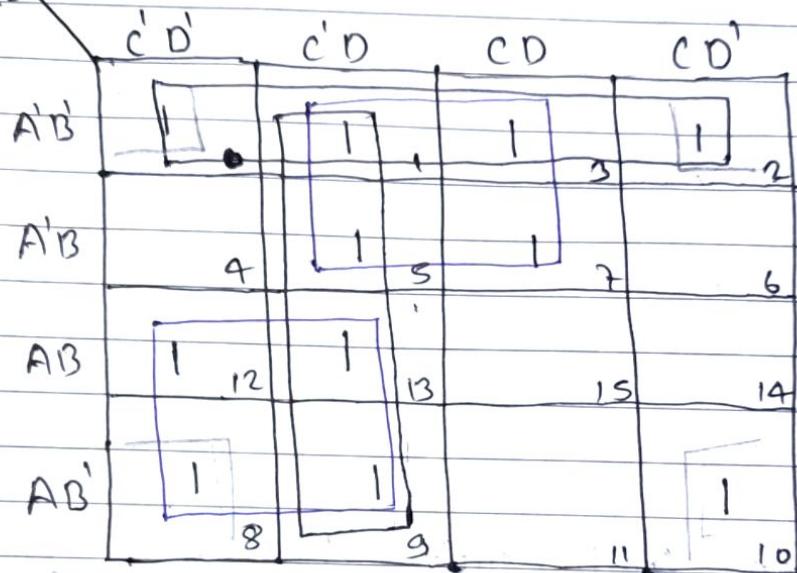
$$ii) AB + A(B+C) + B'(B+C)$$

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

$$= (A' + B') (A' + B'C') (B + B'C') \quad \text{Ans}$$

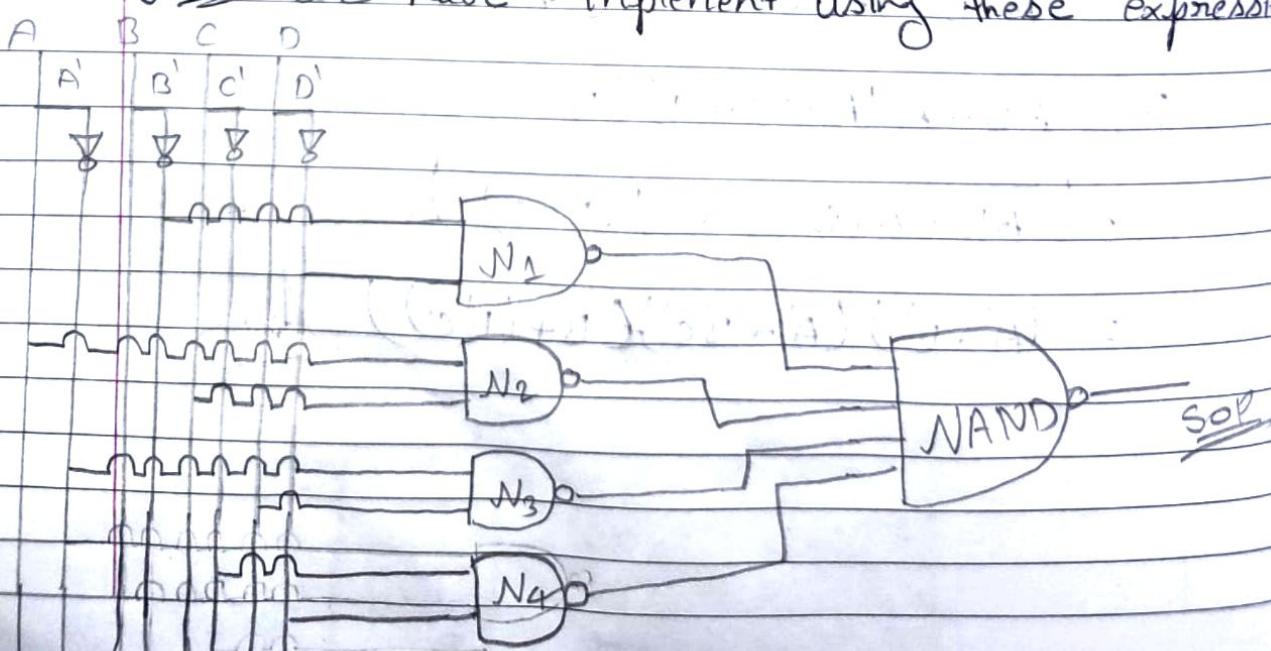
Q.16. Reduce using mapping the expression summation of Minterms (0, 1, 2, 3, 5, 7, 8, 9, 10, 12, 13) and implement it in universal logic.

Solution - ABCD



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

Now we have implement using these expression



Q.17. Determine the minimal sum or product form of

i) $f(w, x, y, z) = \sum(4, 5, 7, 12, 14, 15) + d(3, 8, 10)$

wx'	$y'z$	$y'z'$	yz	yz'	$y'z'$
wx'	0	1	X	3	2
$w'x$	1	1	1	7	6
wx	1	12	13	15	14
$w'x'$	X	8	9	11	X

$$SOP = w.z' + w'x.y' + w'.y.z + wxy$$

Ans

Q.28 Implement the following Boolean function using combinational circuit

$$F(A, B, C, D) = \sum(0, 1, 2, 5, 7, 8, 9, 14, 15)$$