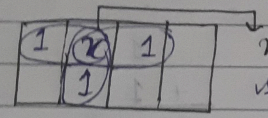
Combinational circuit (cc) is an electronic circuit in which the output depends upon the present combination of the input.

Don't care conditions Minterms that may produce either 0 or 1 for the function are said to be don't care conditions and are marked with an 'x' on the map.

It is a condition in which we can allocate a non occupied cell, a value X to make lesser number of groups. The value of X may be 0 or 1.

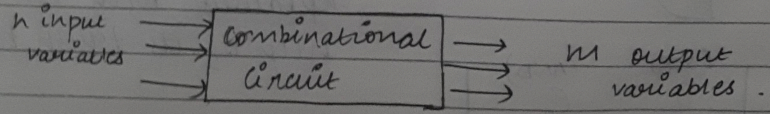


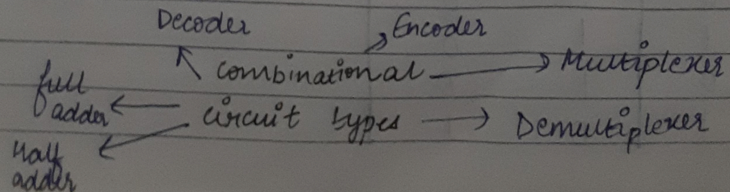
x here is don't care an can be supposed as 0 or 1.

Combinational Circuits is a connected arrangement of logic gates with a set of inputs and outputs.

- The n binary input variables come from an external source, the m binary output variables go to an external destination. In b/w there is an interconnection of logic gates.

A combinational circuit transforms binary info from the input data to the required output data.





Date :
Page no.

Half Adder The combinational circuit that performs the arithmetic ~~circuit~~ ~~is ed~~ addition of two bits is called a half adder.
It has 2 inputs and 2 outputs.
The first output is for sum(s) and the second output is for carry (c)

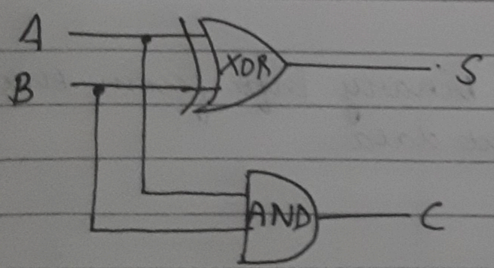
Q How are 2 bits added in a computer?

```
  0          0          1          1
+ 0        + 1        + 0        + 1
0  0       0  1       0  1       1  0
c  S       c  S       C  S       C  S
```

All 4 operations are done by half adder

It has 2 gates

① XOR   ② AND



The working of half adder can be explained with the help of its truth table

A	B	(XOR) S	(AND) C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Logic eqⁿ for half adder :

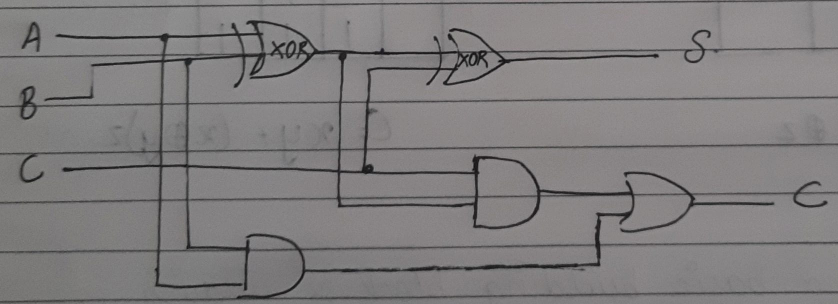
Sum = $A \oplus B = A'B + AB'$

Carry = $A.B$.

<u>Full Adder</u> is a combinational circuit that forms the arithmetic sum of 3 input digits.

It has 3 inputs and 2 outputs.
The third input is for carry generated by the previous digits.

It has 2 XOR gaes, 2 AND gates and 1 OR gate.



logic eqⁿ for full adder

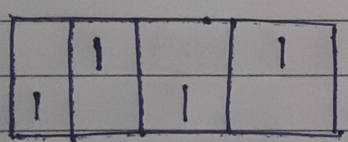
$S = x \oplus y \oplus z$

$C = xy + (x \oplus y)z$. $[xy + yz + xz]$

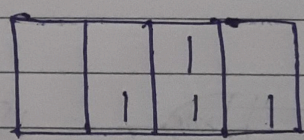
The truth table for full adder is :

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

Map for full adder :



$S = x \oplus y \oplus z$

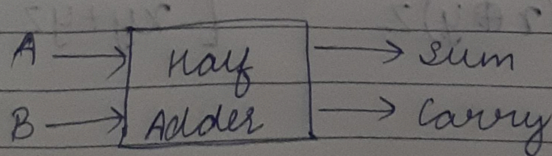


$C = xy + (x \oplus y)z$

HALF ADDER

Half adder is a basic building block of adding 2 numbers ~~at~~ as 2 inputs and produce out 2 outputs. The adder is used to perform OR operation of 2 single bit binary numbers.

Block diagram



Biffoo
Date :
Page no.

Truth Table

Inputs		Outputs	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Logic eq^n

$S = x'y + xy' = x \oplus y$

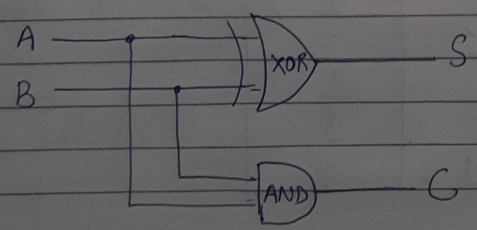
$C = x.y$

Half Adder

↙ AND Gate

↘ XOR Gate

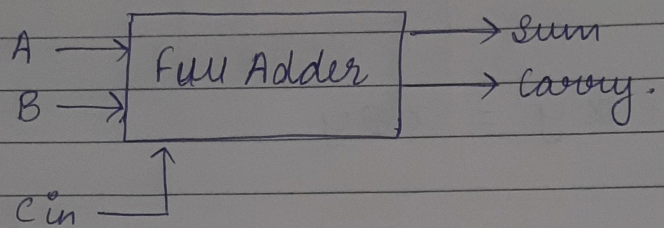
Logical Circuit



FULL ADDER

The Full adder is used to add three 1-bit binary numbers, A, B and carry C.
The full adder has 3 input states and 2 output states i.e. sum and carry.

Block Diagram



Truth Table.

Inputs.			Outputs	
A	B	Cin	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

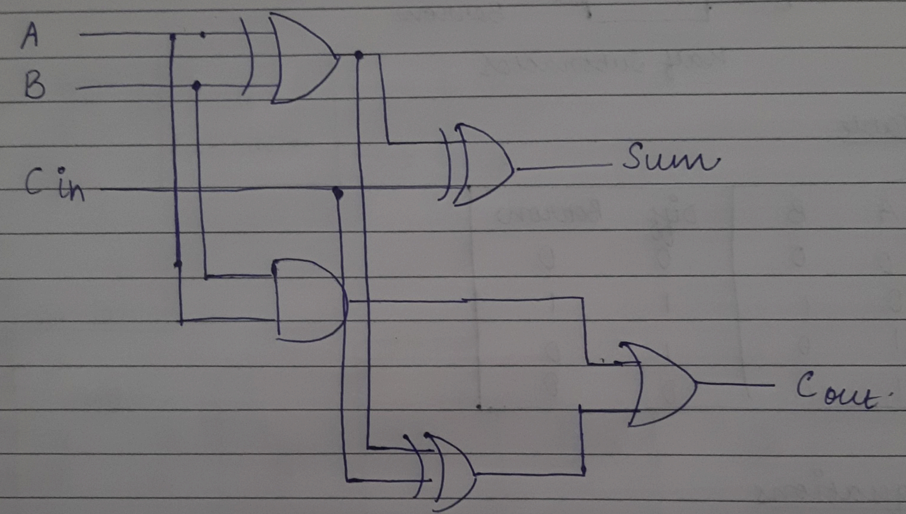
- A and B are the input variables. These are the 2 significant bits that will be added.
- Cin is the third input which represents the carry, which is fetched from the previous lower significant position.

Date :
Page no.

Logic eqn.

$S = x'y'z + x'yz' + xy'z' + xyz = x \oplus y \oplus z$.

$C = xy + xz + yz$. or $xy + z(x \oplus y)$



HALF SUBTRACTOR

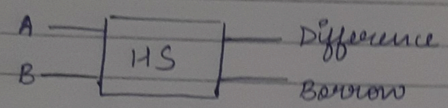
Half subtractor is a digital logic circuit that performs binary subtraction of two single bit binary numbers. It has 2 inputs, A and B, and two outputs, Difference and Borrow.

2 gates
↳ XOR and NOT Gates.

D = XOR Gate
B = NOT Gate.

Half subtractor is a combination circuit with 2 inputs and 2 outputs difference and ~~bou~~ borrow

Block Diagram



Half Subtractor

Truth Table

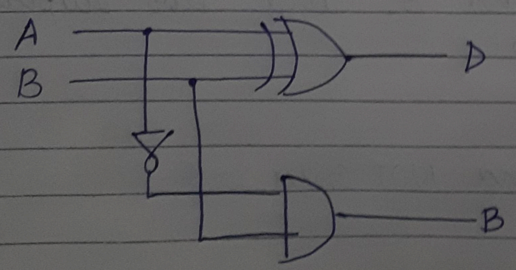
A	B	Diff	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

logic equations

$D = A \oplus B$

$B = A'B$

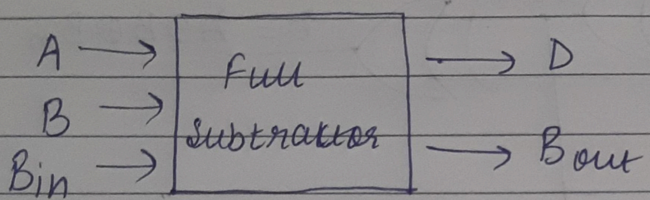
logic diagram



Full Subtractor

A full subtractor is a combinational circuit that performs subtraction of 2 numbers. It has 3 inputs and 2 outputs. Borrow out and Diff.

Block diagram



Truth Table

Input			Output	
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

$$D = A'B'B_{in} + A'B.B_{in}' + AB'B_{in} + ABB_{in}$$

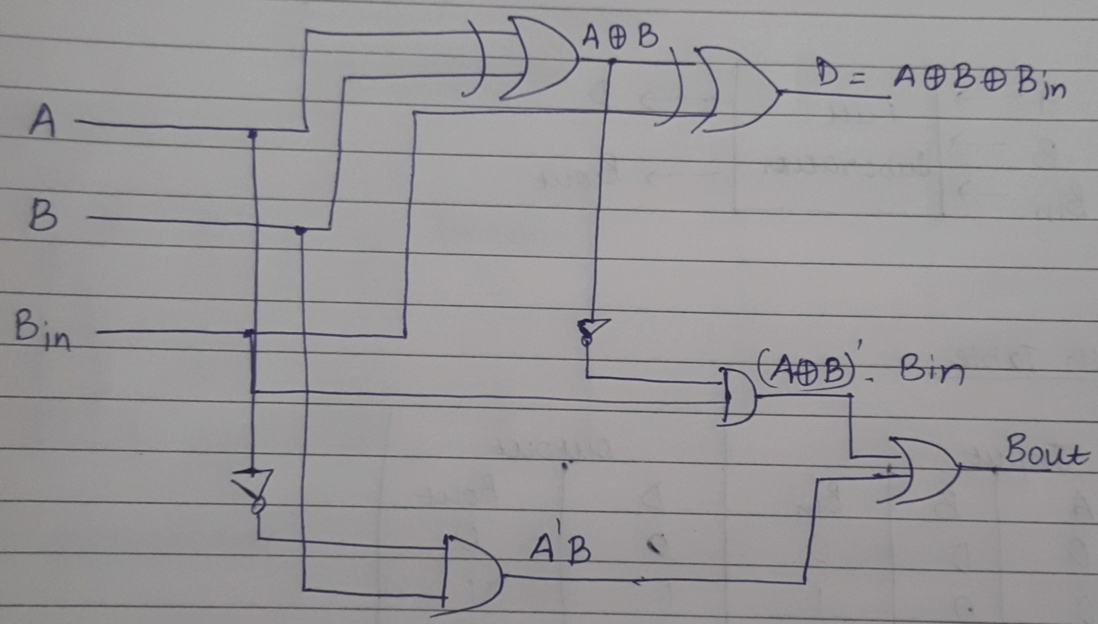
$$B_{out} = A'B'B_{in} + A'BB_{in}' + A'BB_{in} + A.B.B_{in}$$

logic eq^n:

$$D = (A \oplus B) \oplus B_{in}$$

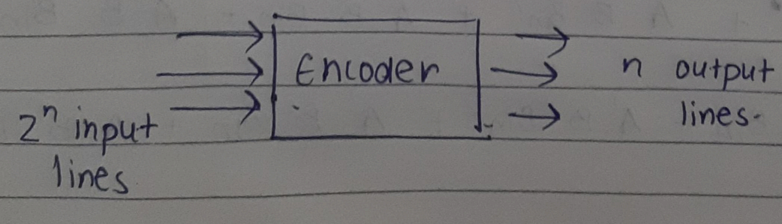
$$B_{out} = A' B_{in} + A'B + B B_{in} = (A \oplus B)' . B_{in} + A' B$$

logic diagram:



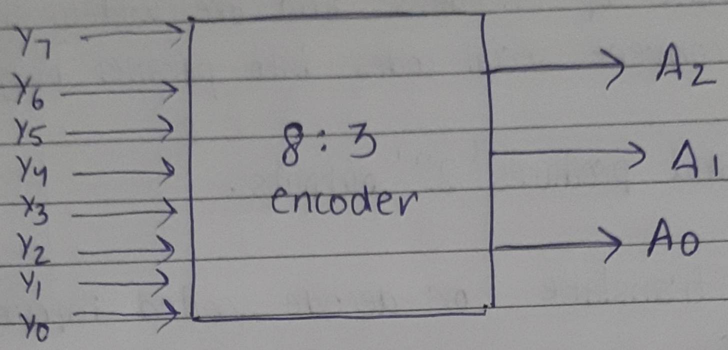
ENCODER. Encoder is a digital circuit that converts a set of binary inputs into a unique binary code.

It has 2^n input lines and n output lines.



example 8:3 encoder [octal to binary].

8 inputs Y_7 to Y_0 and 3inputs A2, A1 and A0



Truth table for 8 to 3 line encoder

INPUTS								OUTPUTS		
Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0	A2	A1	A0
0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	1	0	0	0	1	0
0	0	0	0	1	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	0
0	0	1	0	0	0	0	0	1	0	1
0	1	0	0	0	0	0	0	1	1	0
1	0	0	0	0	0	0	0	1	1	1

logic eq^n

$$A2 = Y7 + Y6 + Y5 + Y4$$

$$A1 = Y7 + Y6 + Y3 + Y2$$

$$A0 = Y7 + Y5 + Y3 + Y1.$$

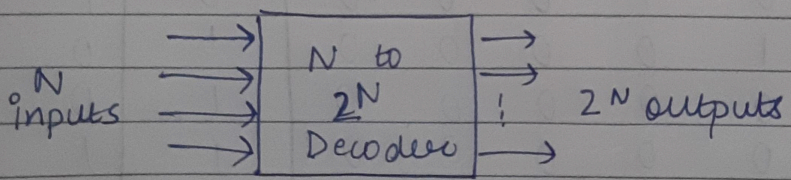
Decoder: A binary decoder is a digital circuit that converts a binary code into a set of outputs.

Decoders are the inverse of encoders and are widely used in digital systems to convert serial codes into parallel outputs.

It has 'n' inputs and produces '2^n' outputs.

'Decoder' means to translate or decode coded information from one format to another.
A digital decoder transforms a set of digital input signals into an equivalent decimal code at its output.

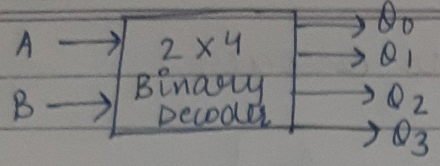
⇒ A decoder is a combinational circuit that converts binary information from n input lines to a maximum of 2^n unique output lines.



for ex:

A binary decoder that has 2 inputs ~~have~~ has $2^2 = 4$ outputs. and it is called

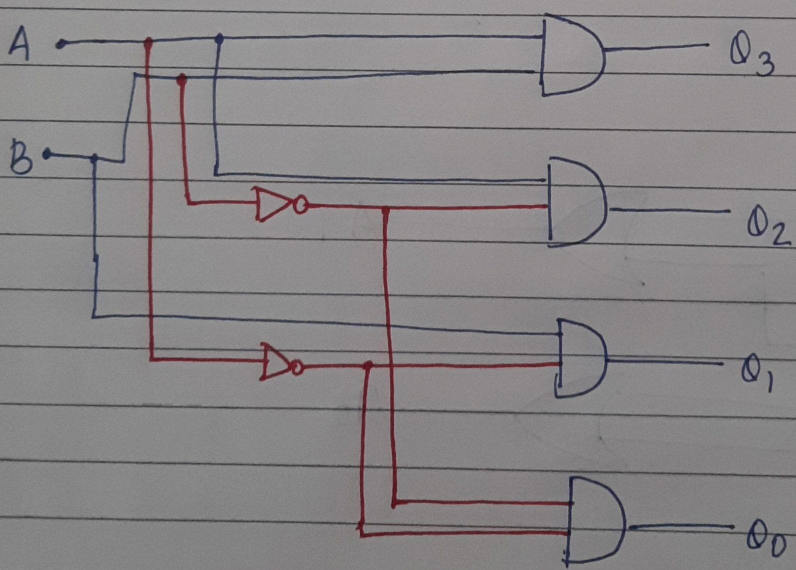
2-to-4 line binary decoder.



Truth Table for 2 to 4 line decoder:

A	B	Q_0	Q_1	Q_2	Q_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

logic circuit for 2 to 4 line decoder.



logic eq^n:

$Y_3 = A_1 . A_0$

$A . B$

$Y_1 = A_1' . A_0$

$A' . B$

$Y_2 = A_1 . A_0'$

$A . B'$

$Y_0 = A_1' . A_0'$

$A' . B'$

Date :
Page no.

Truth Table for 4 to 2 line encoder

Y_3	Y_2	Y_1	Y_0	A_1	A_0
1	0	0	0	0	0
0	1	0	0	0	1
0	0	1	0	1	0
0	0	0	1	1	1

Logic equations:

$$A_1 = Y_3 + Y_2$$

$$A_0 = Y_3 + Y_1$$

Logic circuit :