The output of Combinational circuit is depends on present inputs only.

It does not depend on past and future inputs.

for example:-

Adder

Subtractor

Encoder

Decoder

Multiplexer and De-multiplexer.

Characteristics of combinational circuit:-

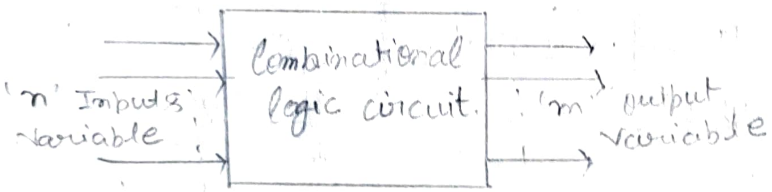
⇒ Working speed is fast

⇒ Time independent circuit

⇒ There is no feedback element

⇒ it doesn't required clock signal

⇒ Circuit design is not complex.



A Combinational circuit are three types which is describe below:-

1 Arithmetic and logic circuit

Adder, Subtraction, Multiplication, Comparator etc.

2. Data manipulation:-

Multiplexers, Demultiplexers, Encoder, Decoder and Priority.

3. Code Converter:-

Binary to gray, gray to binary etc.

Adders :-

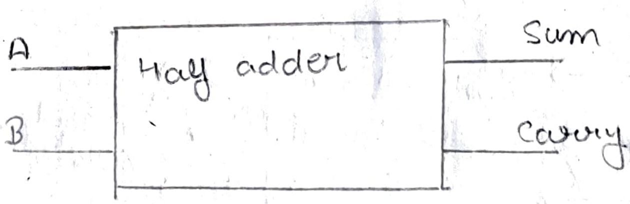
Adders circuit is a digital circuit that performs addition in computer. It is the basic circuit in and is found in arithmetic logic units.

The adder is two type

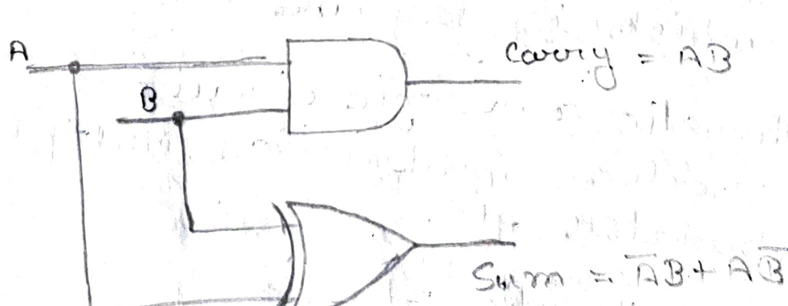
1. Half adder
2. full adder

Half adder :-

When we add two binary numbers, we start with the least-significant column. This means that we have to add two bits with the possibility of a carry. The circuit used for this is called a half-adder.



Block diagram of Half-adder

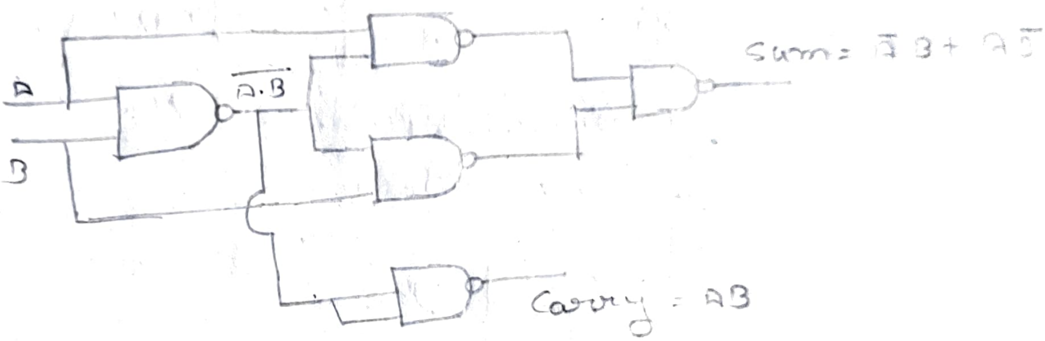


Logic of Half adder

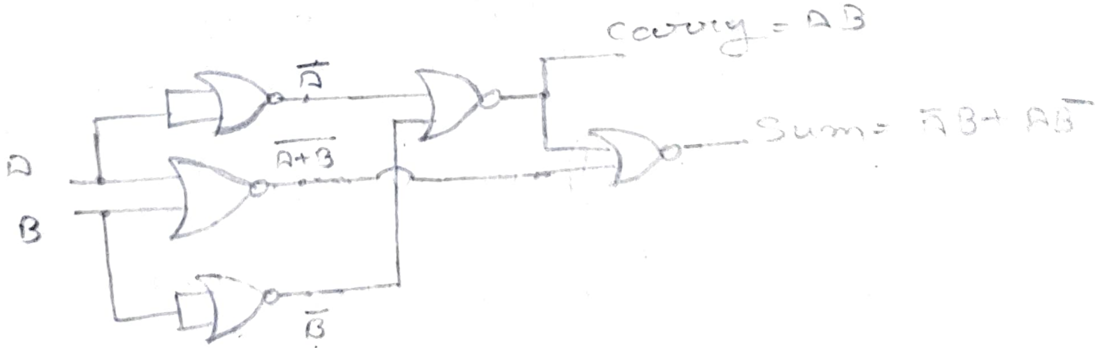
Truth table :-

A	B	Carry AB	Sum $\bar{A}B + A\bar{B}$
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Half adder implemented by NAND gates :-



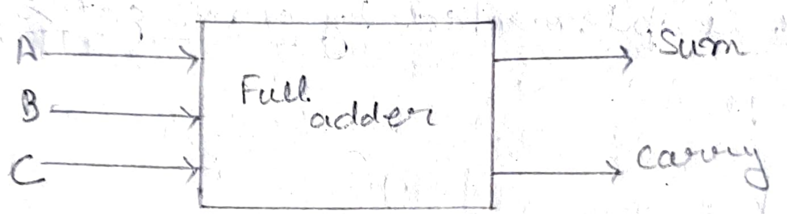
Half adder implemented by NOR gates :-



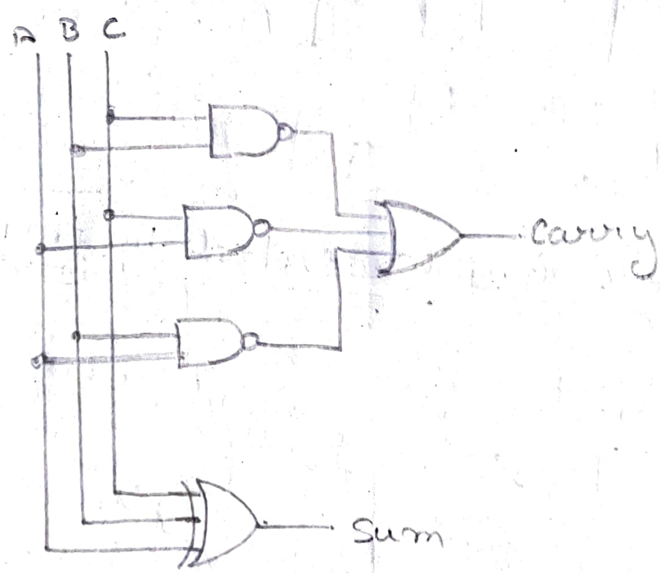
In half adder we only add two binary bits. we can not add three binary bits. It is the major limitation of half adder.

Full adder :-

For the higher-order columns, we have to use a full-adder, a logic circuit that can add 3 bits at a time. The third bit is the carry from a lower column. This implies that we need a logic circuit with three inputs and two outputs.



Block diagram of full adder.



Logic Diagram of Full adder

K-map :-

C \ AB	00	01	11	10
0	0	0	1	0
1	0	1	1	1

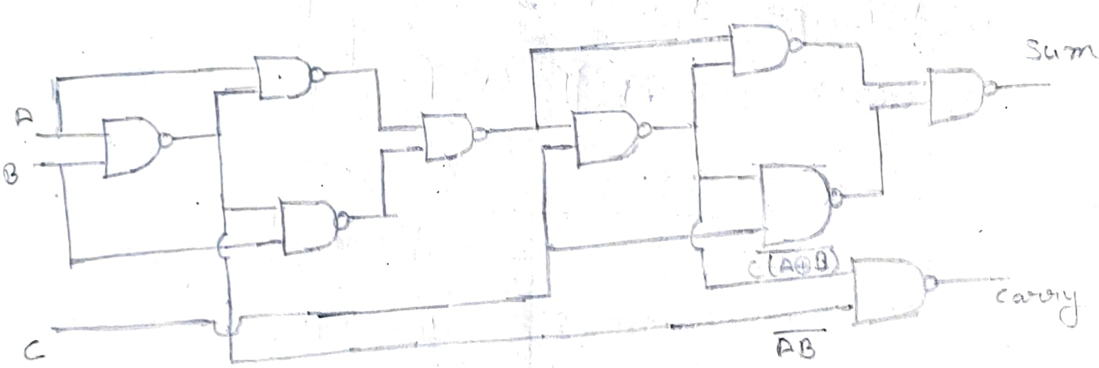
carry = AB + BC + AC

C \ AB	00	01	11	10
0	0	1	0	1
1	1	0	1	0

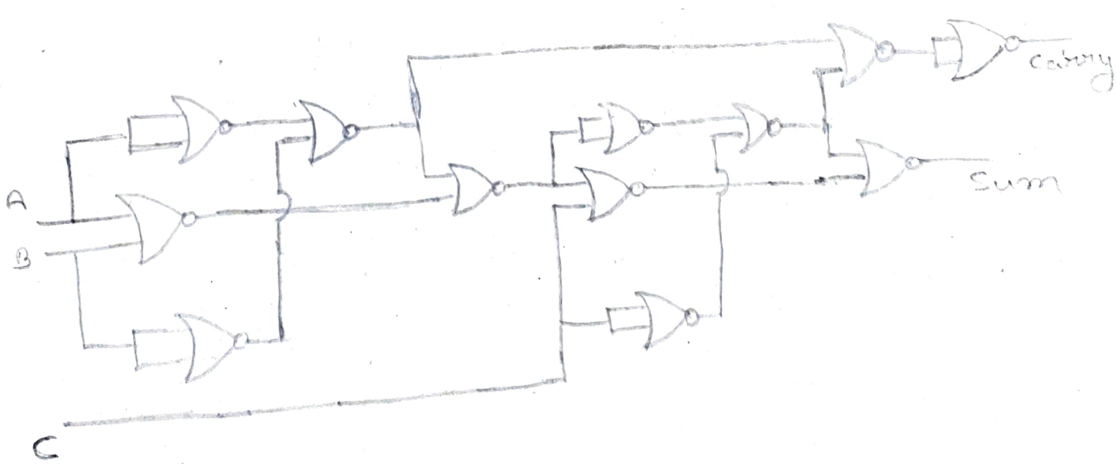
Truth table :-

A	B	C	Carry $AB + BC + AC$	Sum $A \oplus B \oplus C$
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Full adder implemented by NAND gates :-



Full adder implemented by NOR gates :-



Subtractor circuit:-

There are two type subtractor:
1. Half subtractor
2. full subtractor

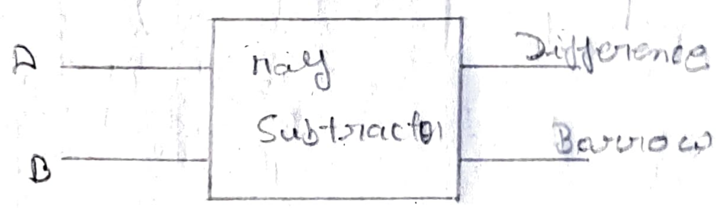
Half subtractor:-

A half subtractor is a combinational logic circuit that performs a subtraction operation of two binary digits.

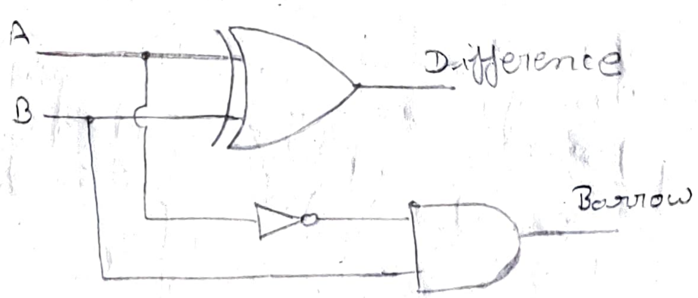
The expression of half ~~Su~~ subtractor is-

Difference $d = A \oplus B = \bar{A}B + A\bar{B}$

Borrow $b = \cancel{A \cdot Y}\ \bar{A} \cdot Y$



Block diagram of Half Subtractor:



Logic Diagram of half subtractor

Truth table :-

A	B	Difference $\bar{A}B + A\bar{B}$	Borrow $\bar{A}B$
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

K- Map :-

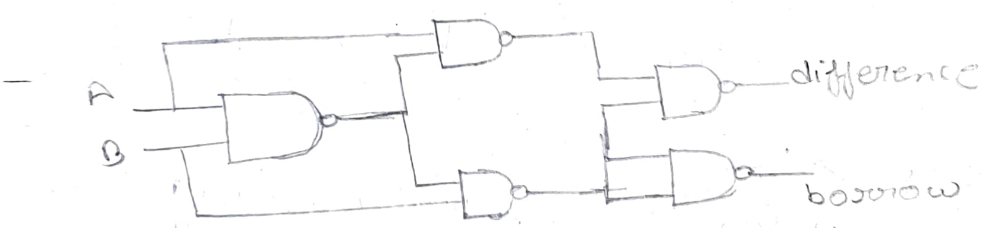
A \ B	$\bar{B}$	B
$\bar{A}$		1
A	1	

K-map of Difference

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

K-map of Borrow

Half subtractor using NAND gates



Full subtrator :-

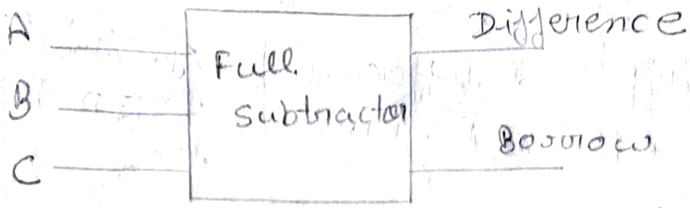
A full subtrator is a combinational logic circuit that performs a subtraction operation of three binary digits.

The third input is borrow-in.

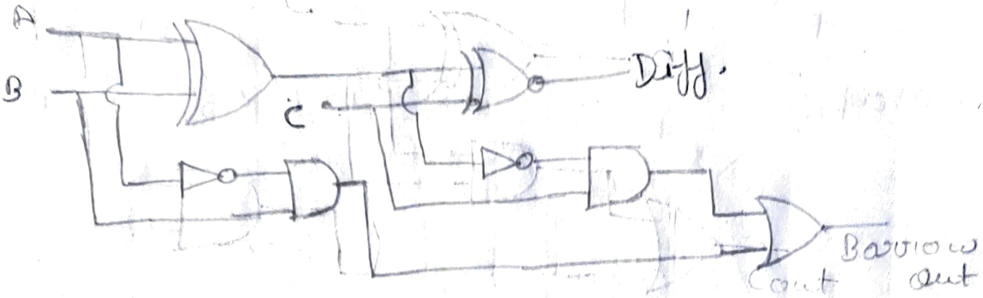
The expression of full subtractor is -

difference $d = (A \oplus B) \oplus C$

Borrow $b = \bar{A}B + \overline{(A \oplus B)}$



block diagram of Full subtractor



Logic diagram of Full subtractor

Truth table :-

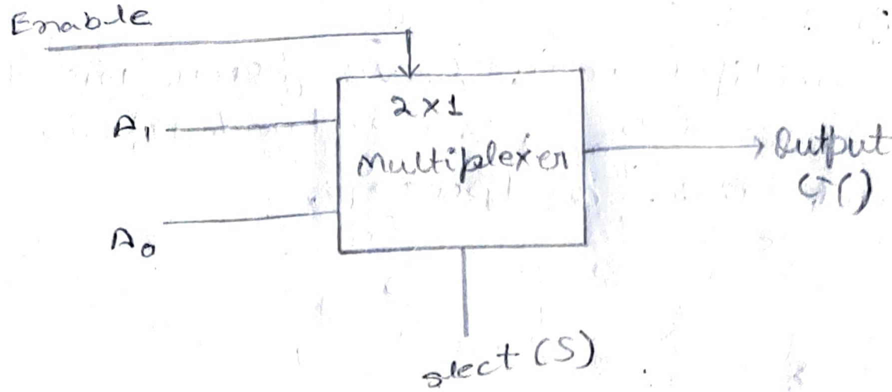
A	B	C (Borrow in)	Diff.	Barrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

Multiplexers :-

Multiplexer means many into one.
A multiplexer is a circuit with many inputs but only one output.
it is also called a data selector and control inputs are termed select inputs.

2x1 multiplexer :-

In 2x1 multiplexer there are only two inputs, 1 selection line and single output.



Block diagram of a 2x1 multiplexer

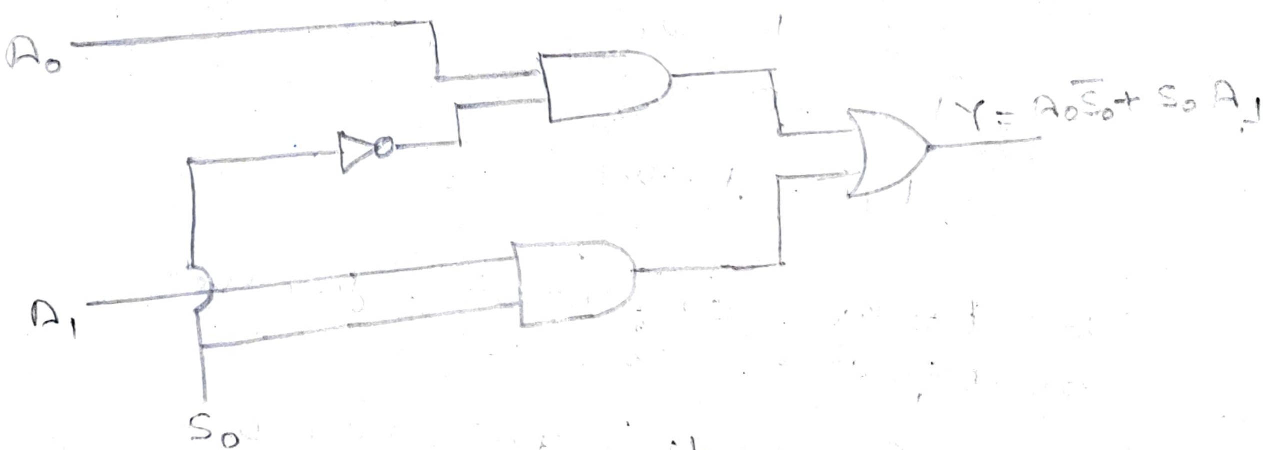
Truth table :-

S_0	Y
0	A_0
1	A_1

two input A_0, A_1
One contral input S_0
and output Y

The logic expression for 2x1 multiplexer is -

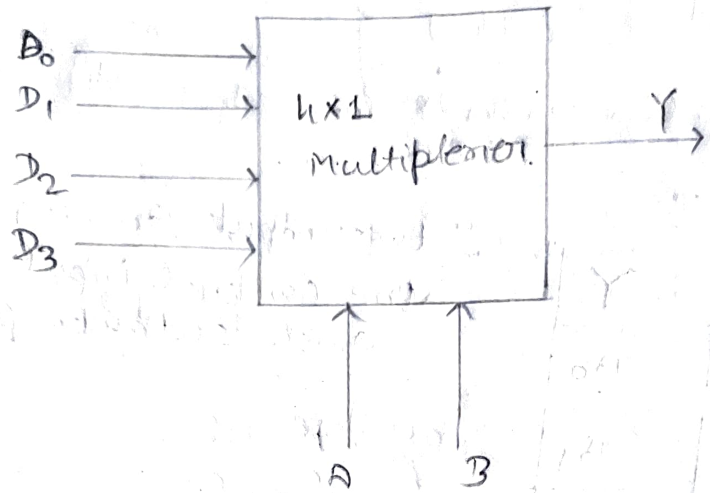
$$Y = \bar{S}_0 A_0 + S_0 A_1$$



Logic circuit of 2x1 Multiplexer

4×1 multiplexer :-

In 4×1 multiplexer have four input D_0, D_1, D_2 and D_3, 2 control inputs A, B and one output Y.



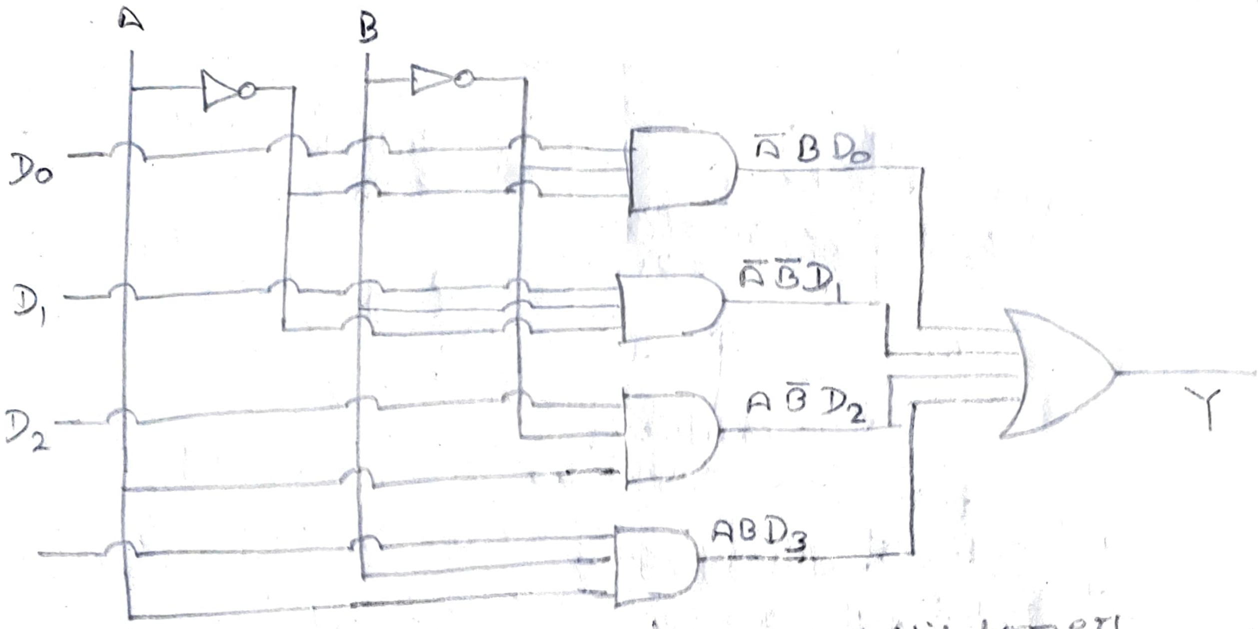
Block diagram

Truth table :-

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

The boolean expression for 4×1 multiplexer is.

$$Y = \bar{A}\bar{B}D_0 + \bar{A}BD_1 + A\bar{B}D_2 + ABD_3$$

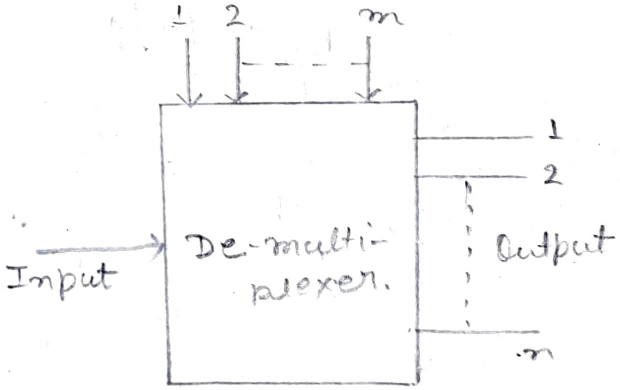


Logic Diagram of 4 x 1 multiplexer

Demultiplexers:-

Demultiplexer means one into many.

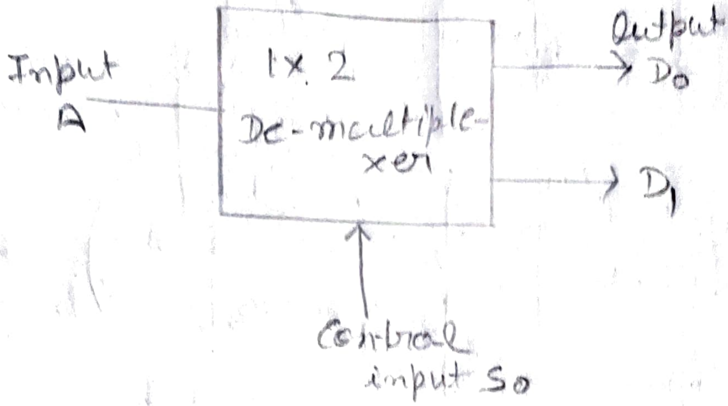
A demultiplexer is a logic circuit with one input and many outputs. By applying control signals, we can steer the input signal to one of the output lines.



Block diagram of De-multiplexer

1x2 Demultiplexer

In 1x2 De-multiplexer, there are only two outputs D_0 & D_1 and one control input S_0 and single input A.



Block diagram

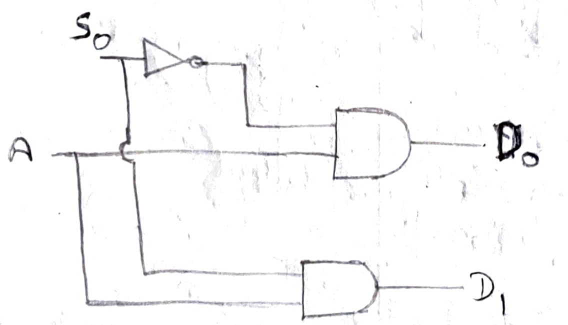
Truth table

S_0	D_1	D_0
0	0	A
1	A	0

The logic expression of the term Y is as follows :

$D_0 = \overline{S_0} A$

$D_1 = S_0 A$



Logic circuit of 1×2 Demultiplexer

1×4 De-multiplexer :-

There are four outputs Y_0, Y_1, Y_2 and Y_3, 2 control ~~unit~~ inputs S_0 and S_1 and single input A.

Block diagram

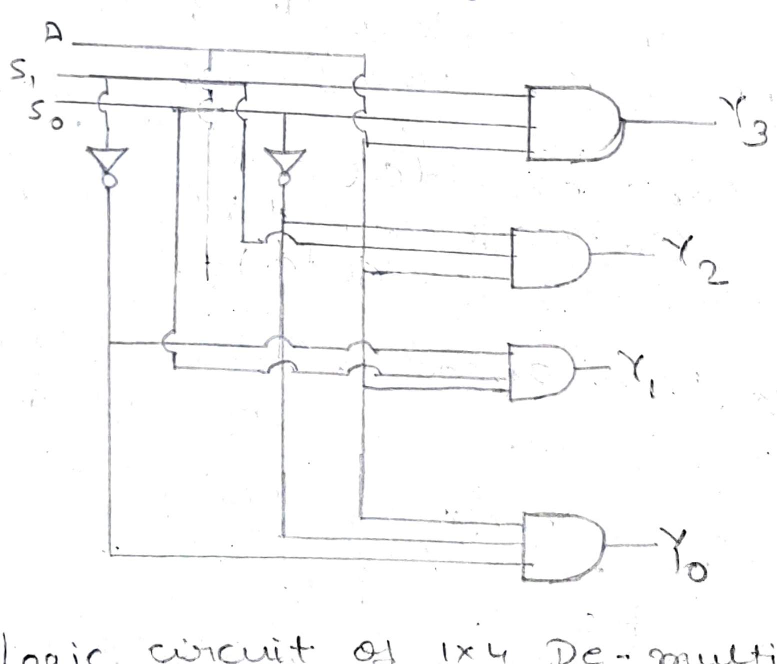
Truth table:-

Control inputs		Output			
S_1	S_0	Y_3	Y_2	Y_1	Y_0
0	0	0	0	0	A
0	1	0	0	A	0
1	0	0	A	0	0
1	1	A	0	0	0

The logic expression is.

$Y_0 = \overline{S_0}\,\overline{S_1}\,A$, $Y_1 = \overline{S_1}\,S_0\,A$

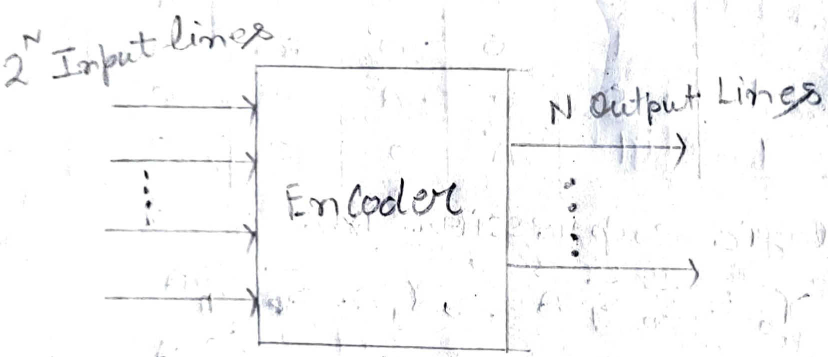
$Y_2 = S_1\,\overline{S_0}\,A$, $Y_3 = S_1\,S_0\,A$



Logic circuit of 1x4 De-multiplexer

Encoder :-

An encoder converts an active input signal into a coded output signal. ~~Encoder change the binary informati into N output lines are~~ The binary information is Passed in the form of 2^N input lines. The output lines define the N-bit code for the binary information. The Produced N-bit output code is equivalent to the binary information.



There are various type of encoders which are as follows :-

=> 4 to 2 line encoder (There are total four inputs and two outputs).

=> 8 to 3 line encoder (octal to binary encoder) (There are 8 inputs and 3 outputs

Decimal to BCD Encoder :-

The decimal to binary encoder usually consists of 10 inputs lines and 4 Outputs lines.

Each input line corresponds to the each decimal digit and 4 outputs correspond to the BCD code.

when button 3 is pressed, the C and D OR gates have high inputs; therefor the output is.

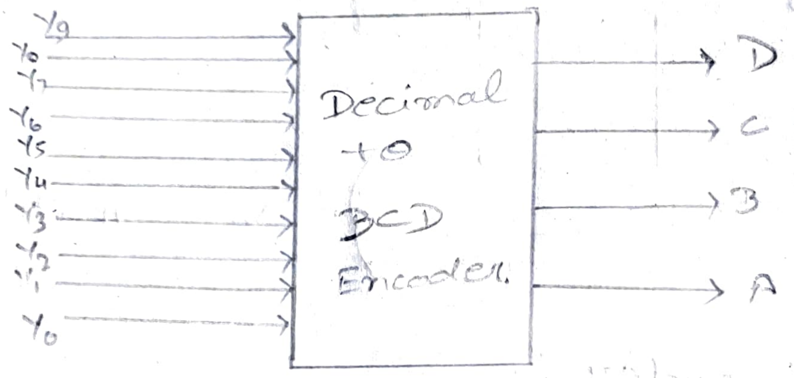
ABCD = 0011

if button 5 is pressed, the output becomes

ABCD = 0101

when switch 9 is Pressed,

ABCD = 1001



The truth table for decimal to BCD encoder is as follows:-

Y_9	Y_8	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0	A	B	C	D
0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	0	0	0	0	0	0	1	0	0	0	0	1	0
0	0	0	0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	0	1	0	0	0	0	0	1	0	0
0	0	0	0	1	0	0	0	0	0	0	1	0	1
0	0	0	1	0	0	0	0	0	0	0	1	1	0
0	0	1	0	0	0	0	0	0	0	0	1	1	1
0	1	0	0	0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	1	0	0	1

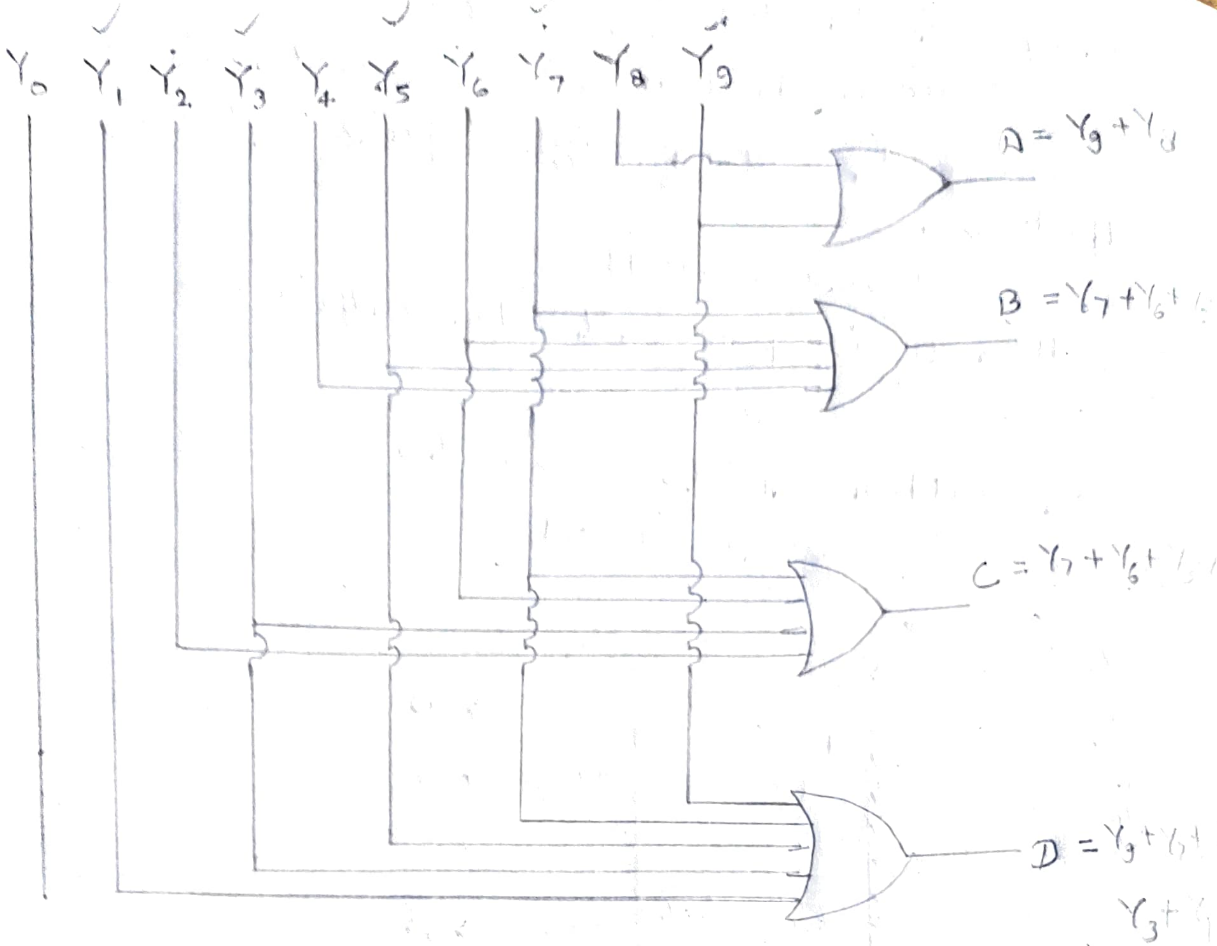
Logic expression for A, B, C, D :-

$A = Y_9 + Y_8$

$B = Y_7 + Y_6 + Y_5 + Y_4$

$C = Y_7 + Y_6 + Y_3 + Y_2$

$D = Y_9 + Y_7 + Y_5 + Y_3 + Y_1$



→ Priority Encoder :-

Uses of Encoder :-

These system are very easy to use in all digital system.

Encoders are used to convert a decimal number into the binary number. The objective is to Perform a binary operation such as addition, Substraction, multiplication. etc.

Decoder :-