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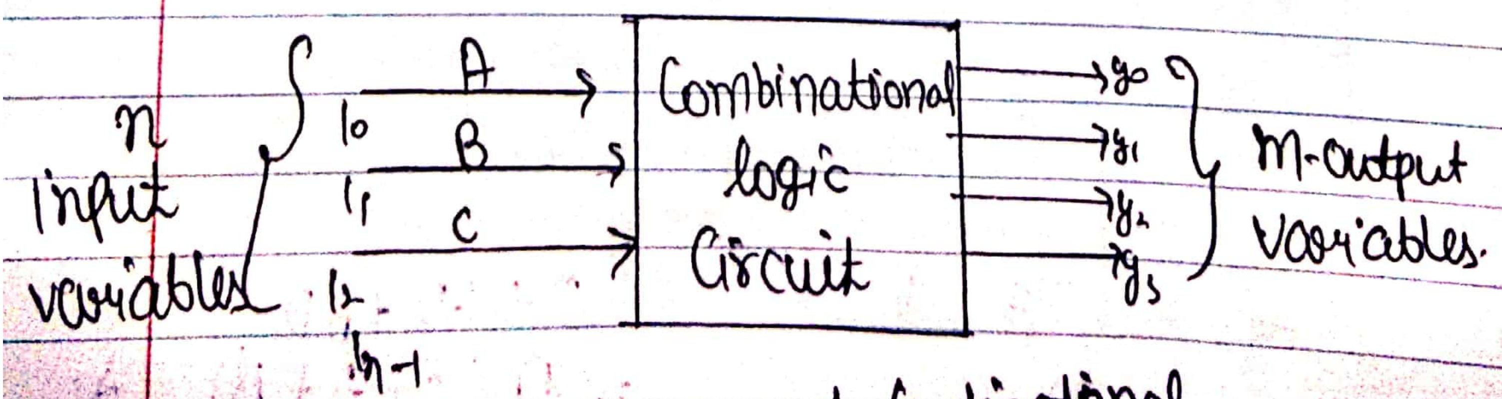
Combinational Logic Circuits.

- The combinational logic gates are the circuits that contain different types of logic gates.

- A circuit in which different types of logic gates are combined is known as combinational logic gate.

- Combinational Circuits are Time Independent circuits, means the output at any time does not depend upon the perivious unit, because there is no memory unit in these circuits.

- The input variables, logic gates and output variables are the basic components of combinational logic circuit.



(Basic diagram of Combinational logic Gates)

There are different types of combinational logic circuits such as Adder, Subtractor, Decoder, Encoder, Multiplexer, and De-multiplexer.

1. Adder
2. Subtractor.

① **Adder:-** Adder are the combinational logic (Arithmetic) circuits which are used for adding two or three binary bits.

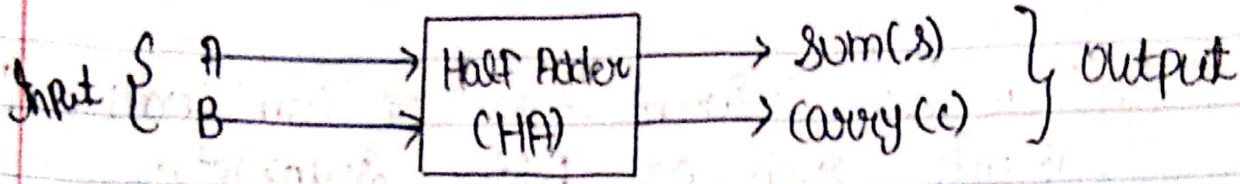
Types of Adder

(i) Half Adder
(ii) Full Adder
(iii) Parallel Binary Adder.

(i) **Half Adder:-**

Half Adder add two binary digits and produces two binary outputs called sum and carry.

It generates a sum (s) and carry (c) as output

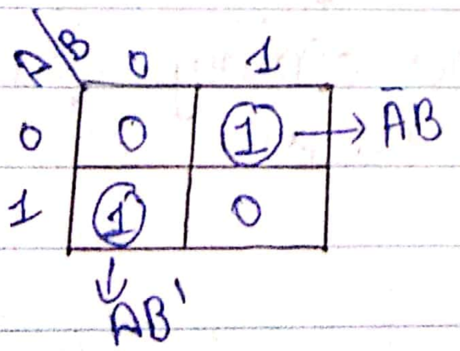


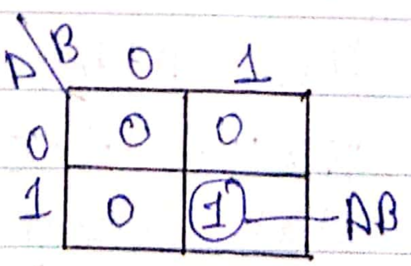
Inputs:- In half Adder there are 2 inputs (A,B)
Output:- There are 2 outputs.
- → sum(s)
- → carry (c)

Truth Table:-

Input bits		Output	
A	B	Sum(s)	Carry(c)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

K-map for Half Adder:-

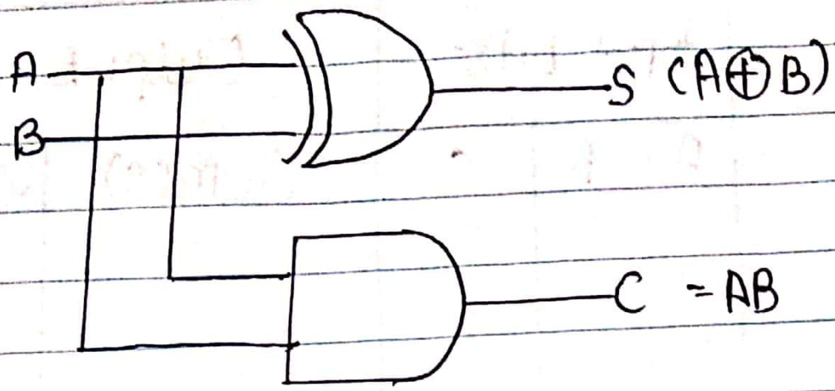




C = AB

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

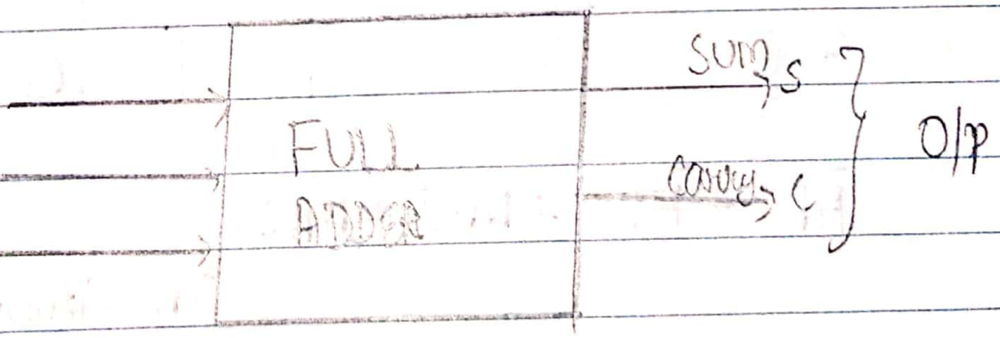
Logic circuit



(ii) Full Adder :-

Full Adder has three inputs A, B and additional carry-in (Cin).
It is used to add three bits and generate two output . sum (s) , carry(c)

Block Diagram



Inputs:- There are 3 inputs

Outputs: There are 2 O/p.

Truth Table

Input bits			Output	
A	B	C	Sum(S)	Carry (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

K-map for Full Adder.

(S)

A \ BC	00	01	11	10
0		1		1
1	1		1	

(Carry (C))

A \ BC	00	01	11	10
0			1	
1		1	1	1

GI, G(II), GIII

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

In Group I (GI)

A	0,1
B	1,1
C	1,1

$= BC$

Group- II

A	1,1
B	0,1
C	1,1

value change $= AC$

Group III

A	1,1
B	1,1
C	0,1

$= AB$

$C_{out} = BC + AC + AB$

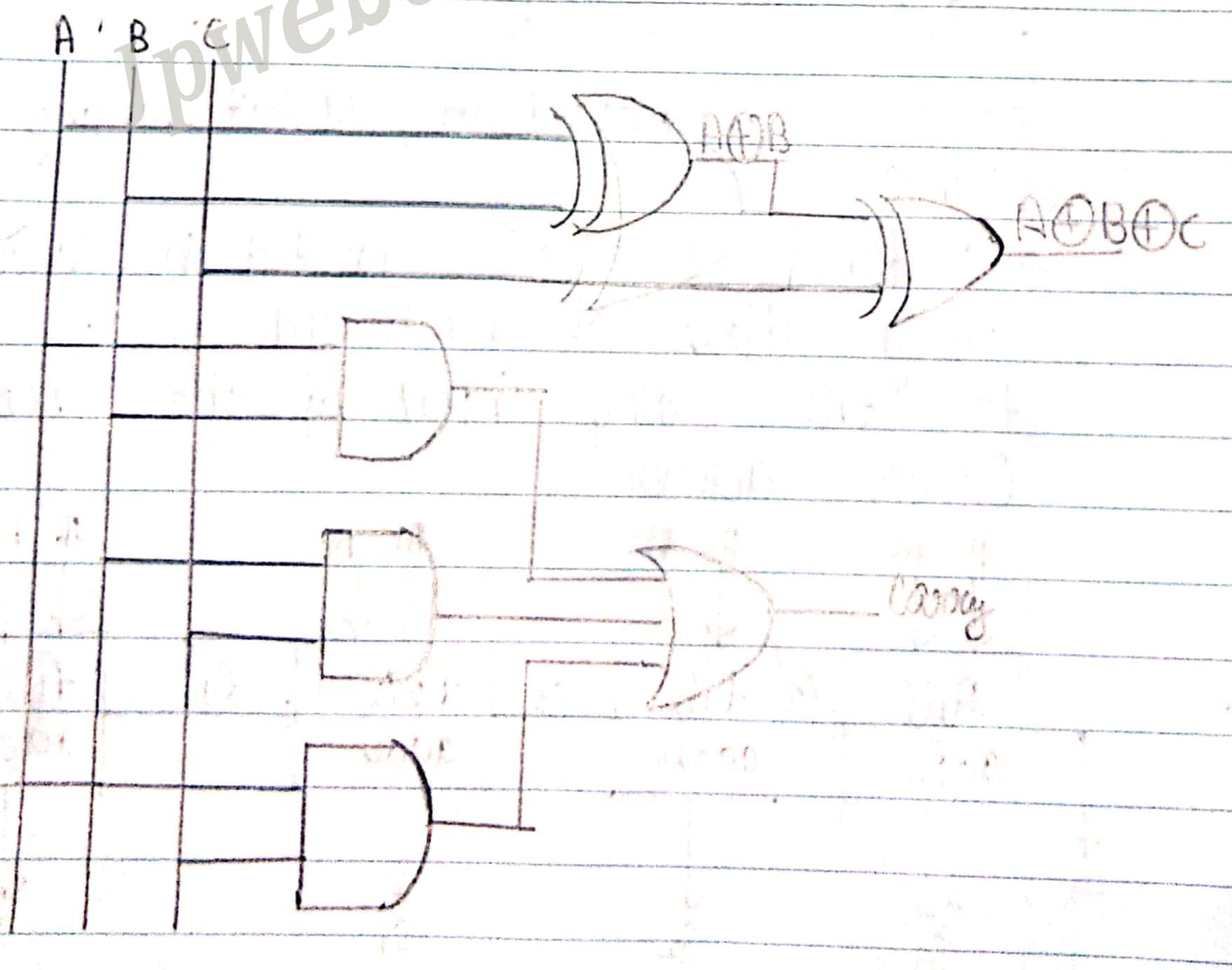
$S = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$

$= \bar{A}[\bar{B}C + B\bar{C}] + A[\bar{B}\bar{C} + BC]$

$= \bar{A}[B \oplus C] + A[B \odot C]$

$S = A \oplus B \oplus C$

$C_{out} = AB + BC + AC$



(iii) Parallel Binary Adder :-

Parallel Binary Adder is a digital circuit which add two binary numbers of any lenegth.

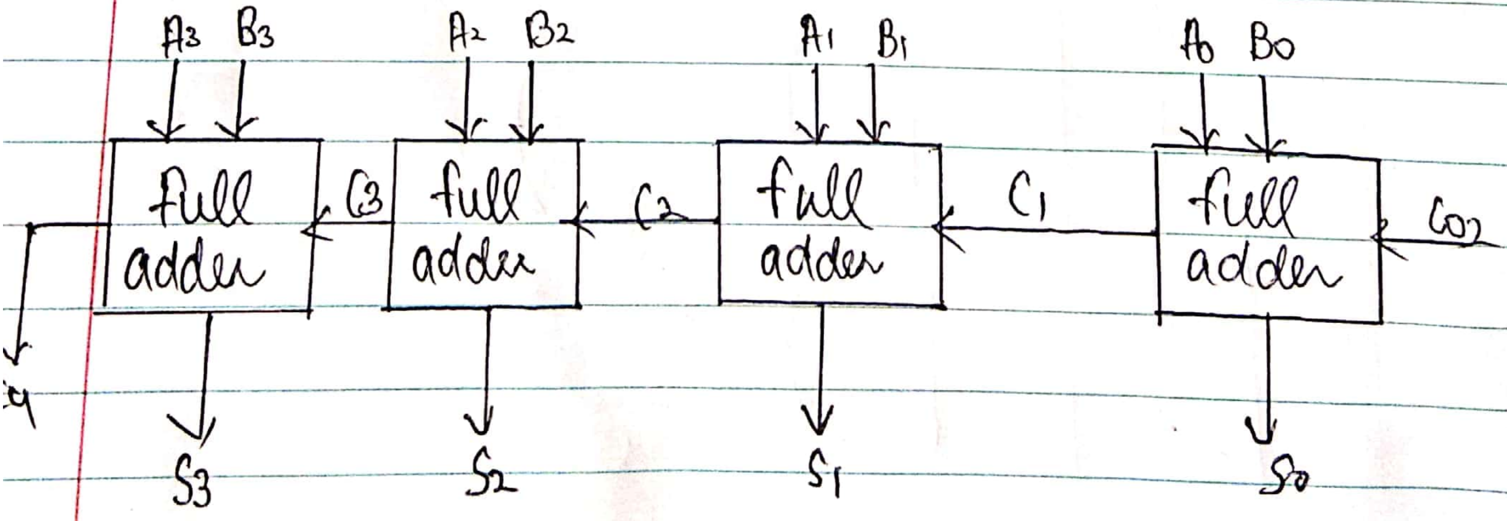
In this addition of more than 1 bit is carried out.

The addition of multibit numbers can be performed using sevral full adder.

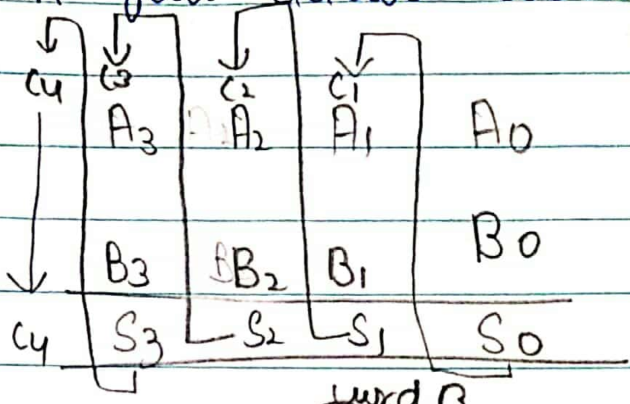
4-bit Parallal adder / Ripple adder.

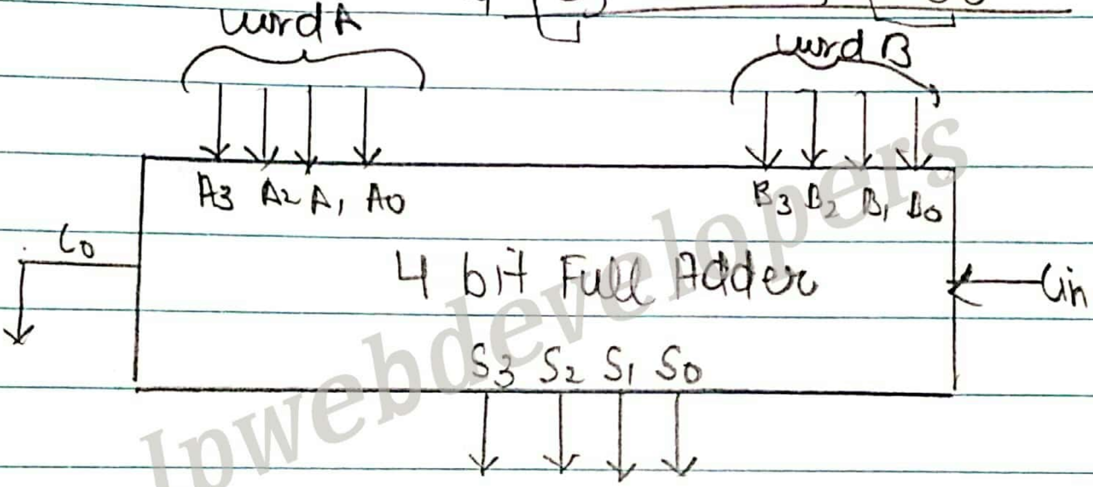
→ which can add two, 4 bit binary number.

→ 4 full adder are connected in cascade carry output of each adder is connected to the carry input of the next high Order adder.



→ So if want to add two, n-bits numbers then we need n-full adder arranged in paralled.





(2) Subtractor :-

Subtractors are the combinational circuit which are used for subtracting two or three bits

→ It is opposite of the Binary Adder.
→ It subtracts two binary number from each other.

→ The output is (i) Difference
(ii) Borrow.

→ Binary Subtraction of two bits

(i) 0 − 0 → 0 (D)
→ Borrow is not required.

(ii) 1 − 0 → 1 (D)
→ Borrow is not required

(iii) 1 − 1 → 0 (D)
→ Borrow is not required

(iv) 0 − 1 → 1
→ Borrow (1)

→ There are two basic subtractors circuits are :-

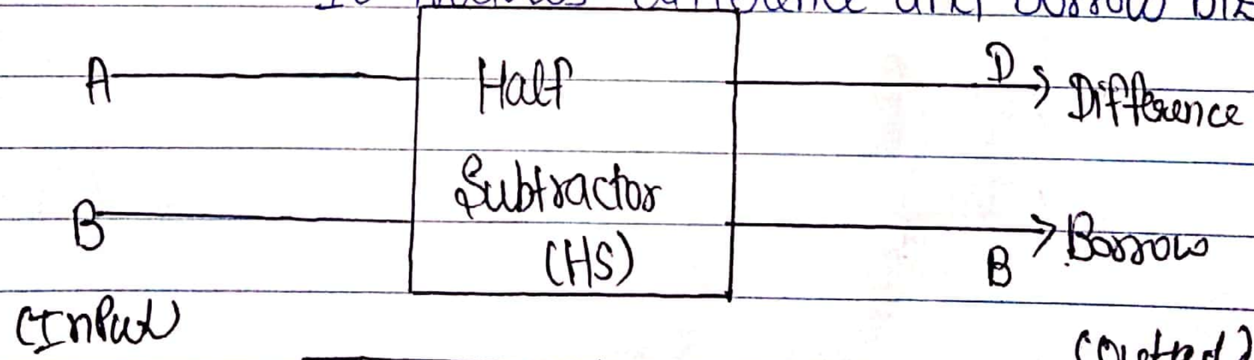
(i) Half Subtractor
(ii) Full Subtractor.

(i) **Half Subtractor** :- A Half Subtractor is a combinational logic circuit that subtracts the two Input bits.

Input :- There are 2 Input in Half Subtractor.
Output :- There are 2 output in Half Subtractor

* **Block Diagram** :-

It Produces difference and Borrow bit.



* **Truth Table** :-

Input bits		Output bits	
A	B	D	B
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

* K-Map Representation

(Difference) (D)

A \ B	0	1
0	0	(1) → $\bar{A}B$
1	(1) ↑ $A\bar{B}$	0

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

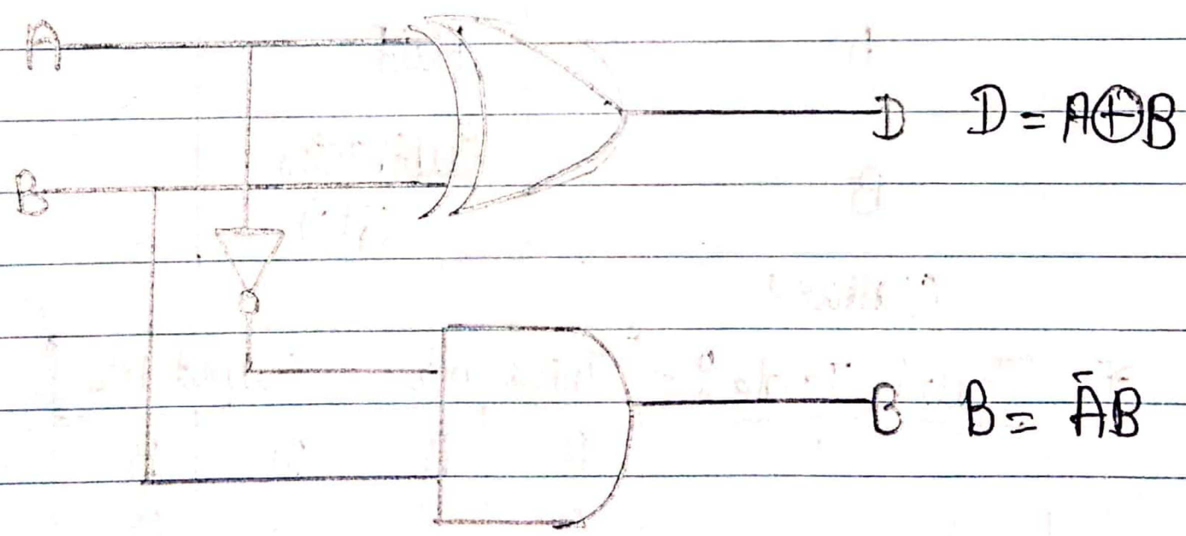
$(A \oplus B)$

Borrow (B)

A \ B	0	1
0	0	(1) → $\bar{A}B$
1	0	0

$B = \bar{A}B$

* Logic Circuit



$D = A \oplus B$

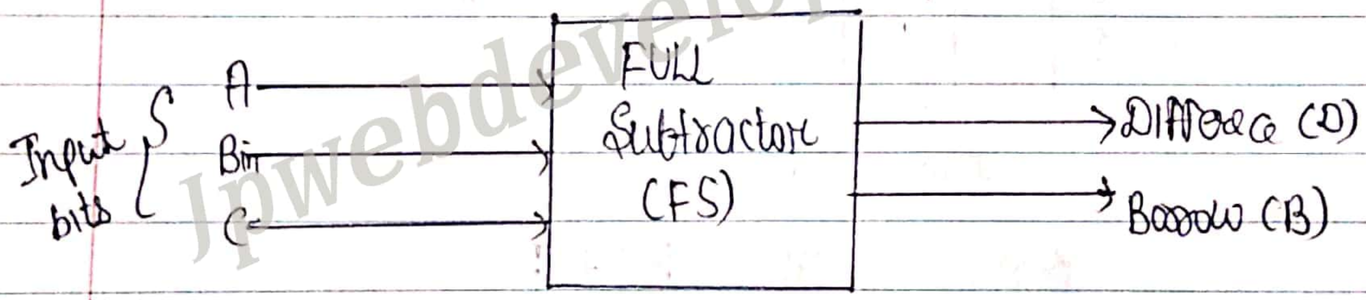
$B = \bar{A}B$

(II) Full Subtractor

- A full Subtractor is a combinational circuit that are used to subtract three Input bits and produces difference (D) and Borrow (B) at the output.

- It has three inputs, one additional Bin input.

* Block Diagram:-



Inputs :- There are 3 inputs A, Bin, C.
Outputs:- There are 2 outputs (i) Difference(D) (ii) Borrow(B)

* Truth Table :-

Input bits			Output bits	
A	B	C	(D) Difference	(B) Borrow
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

* K-Map Representation

Difference

A \ BC	00	01	11	10
0	0	(1)	0	(1)
1	(1)	0	(1)	0

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

$= A \oplus B \oplus C$

Borrow :-

A \ BC	00	01	11	10
0	0	1	1	1
1	0	0	1	0

← Group I (row A=0, BC = 01, 11, 10)

Group III (A=0, BC = 01 and 11); Group II (BC = 11, A = 0 and 1)

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

Logic Diagram :-