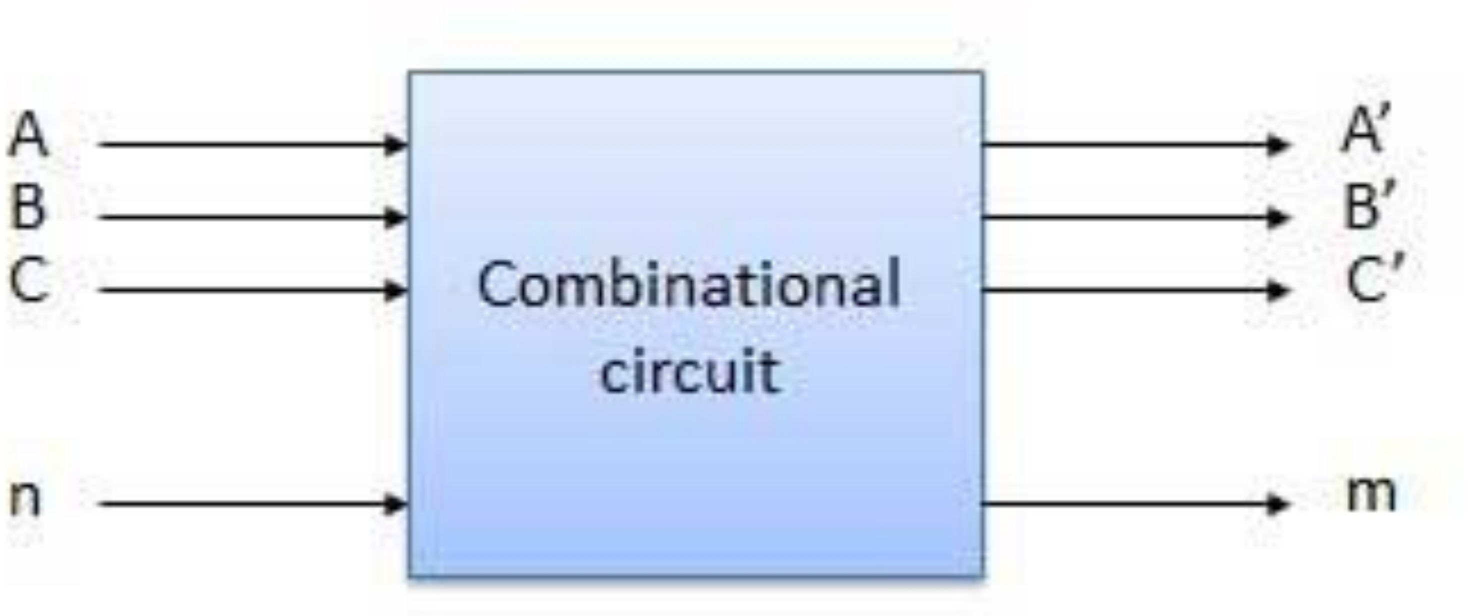
Unit-5: Combinational Circuit

Adders
Subtractor
Comparator
Parity Generator

Combinational Circuits

- output depends only on the present input
- The combinational circuit do not use any memory.
- The previous state of input does not have any effect on the present state of the circuit.



Half Adder

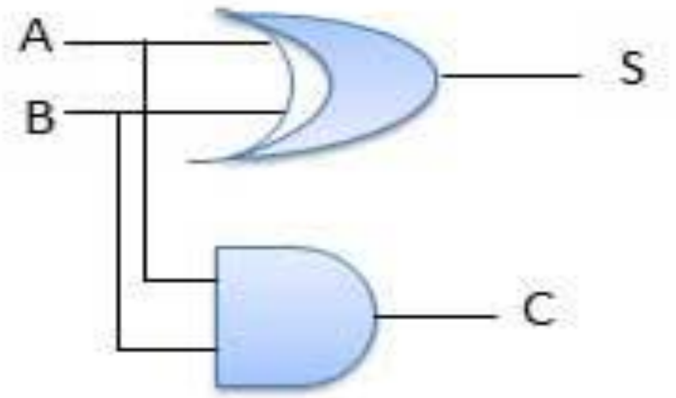
A combinational logic circuit with two inputs and two outputs.

The half adder circuit add two single bit Cary number

This circuit has two outputs **carry** and **sum**.

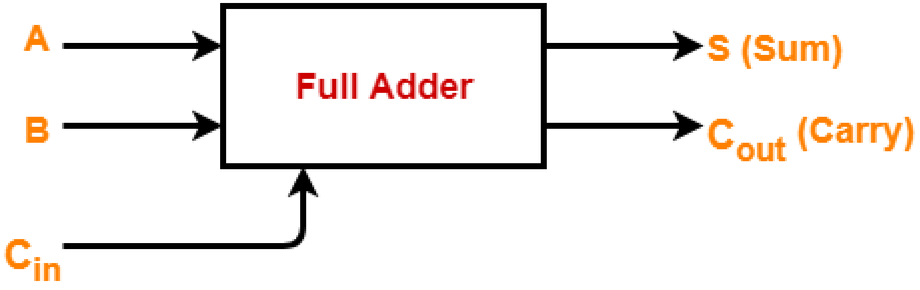
Inputs		Output	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

$S(A, B) = \sum m\ (1, 2)$
$CY(A, B) = \sum m\ (3)$



Full Adder (1-bit Adder)

A combinational logic circuit with 3 inputs and 2 outputs.
The Full adder circuit add 3 single bit Cary number
This circuit has two outputs **carry** and **sum**.



A	B	Cin	Sum	Cout
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

Sum(A, B,C) = ∑m (1, 2, 4, 7)
Cout(A, B, C) = ∑m (3,5,6,7)

For S:

A \ BC_{in}	$\overline{B}\,\overline{C}_{in}$	$\overline{B}C_{in}$	BC_{in}	$B\overline{C}_{in}$
$\overline{A}$		1		1
A	1		1	

$$\overline{A}\,\overline{B}C + \overline{A}B\overline{C} + A\overline{B}\,\overline{C} + ABC$$

$$\overline{A}(\overline{B}C + B\overline{C}) + A(\overline{B}\,\overline{C} + BC)$$

$$\overline{A}(B \oplus C) + A(B \odot C)$$

$$Let\ B \oplus C = D$$

$$\overline{A}D + A\overline{D}$$

$$A \oplus D$$

$$A \oplus B \oplus C$$

For Cout

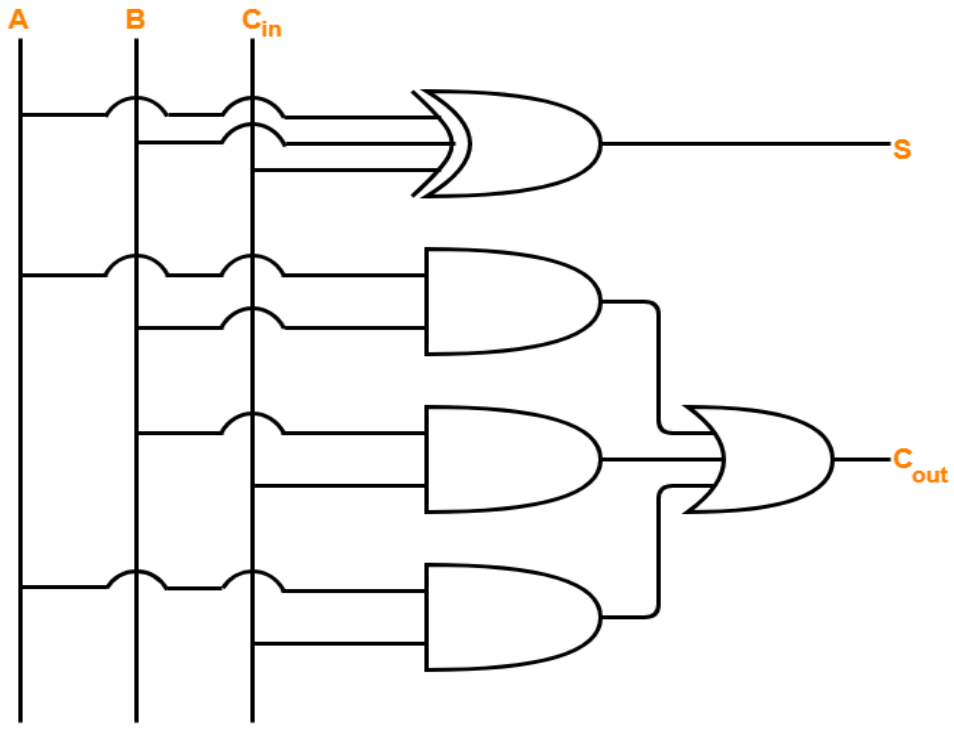
A \ BC_{in}	$\overline{B}\overline{C}_{in}$	$\overline{B}C_{in}$	BC_{in}	$B\overline{C}_{in}$
$\overline{A}$			1	
A		1	1	1

$$\overline{A}BC + A\overline{B}C + ABC + AB\overline{C}$$

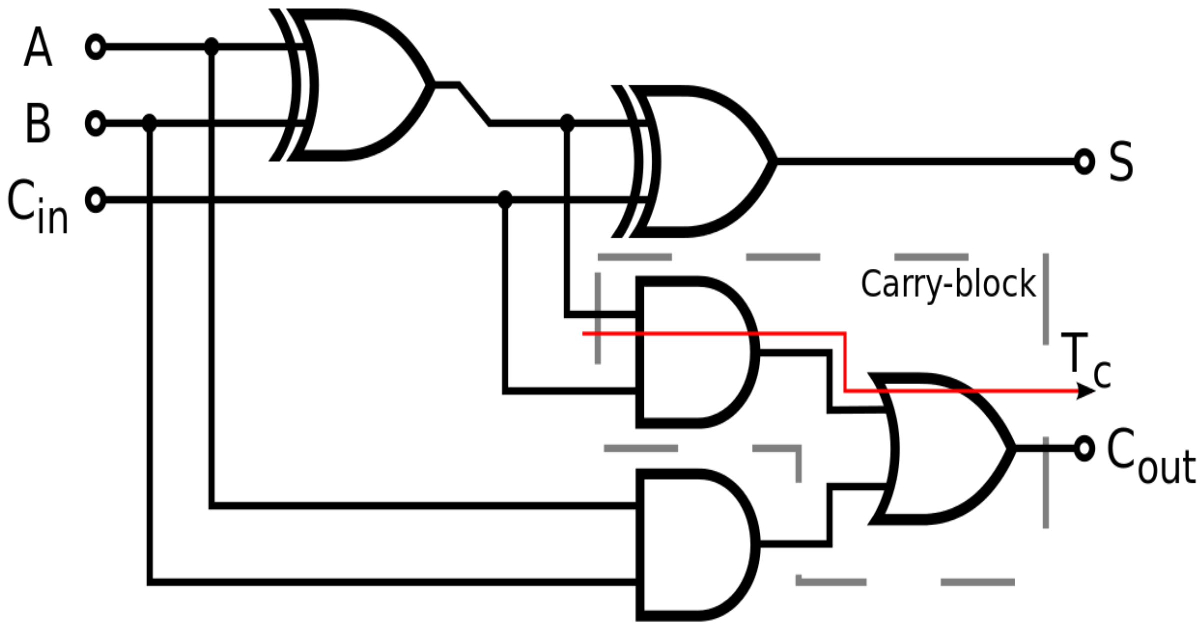
$$C(\overline{A}B + A\overline{B}) + AB(C + \overline{C})$$

$$(A \oplus B)C + AB$$

Cout=AB+BC+AC



Full Adder Logic Diagram



Full Adder using Half Adder

FA

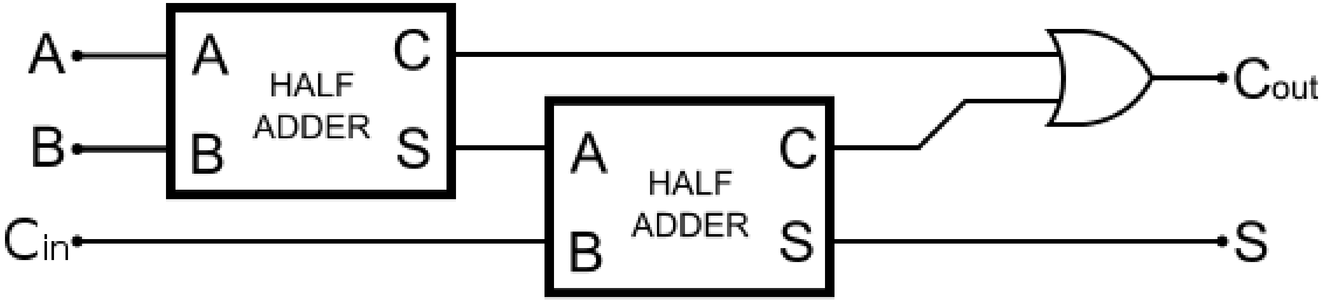
Sum= A⊕B⊕C

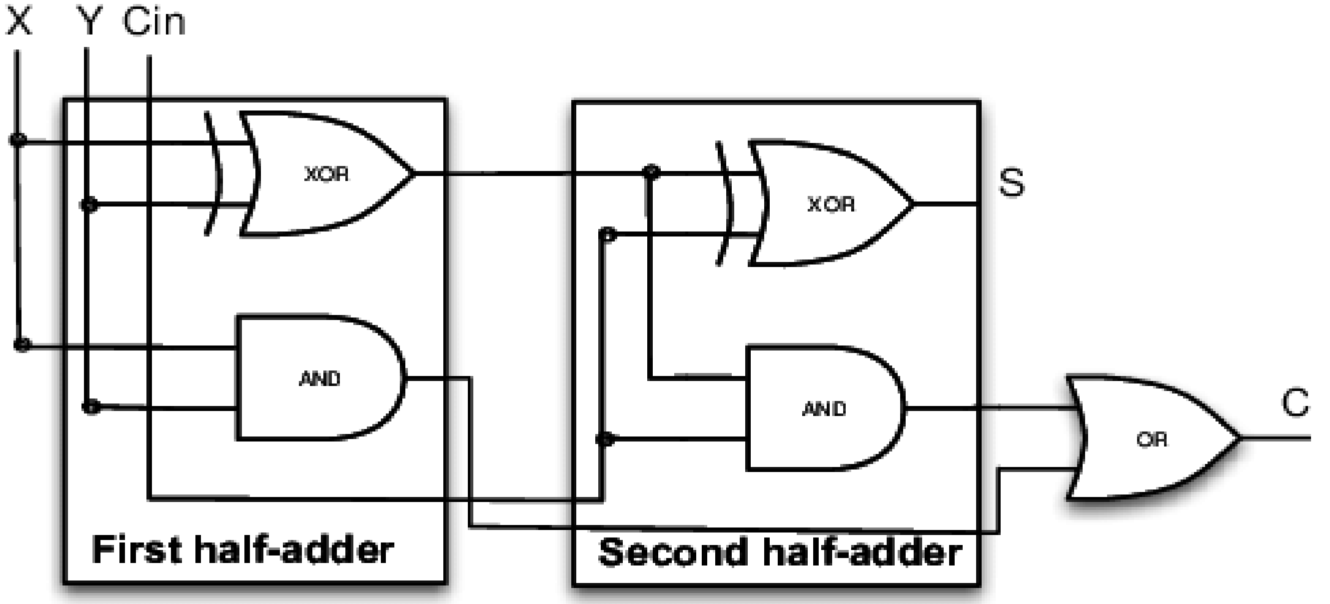
Carry=AB+(A⊕B)C

HA

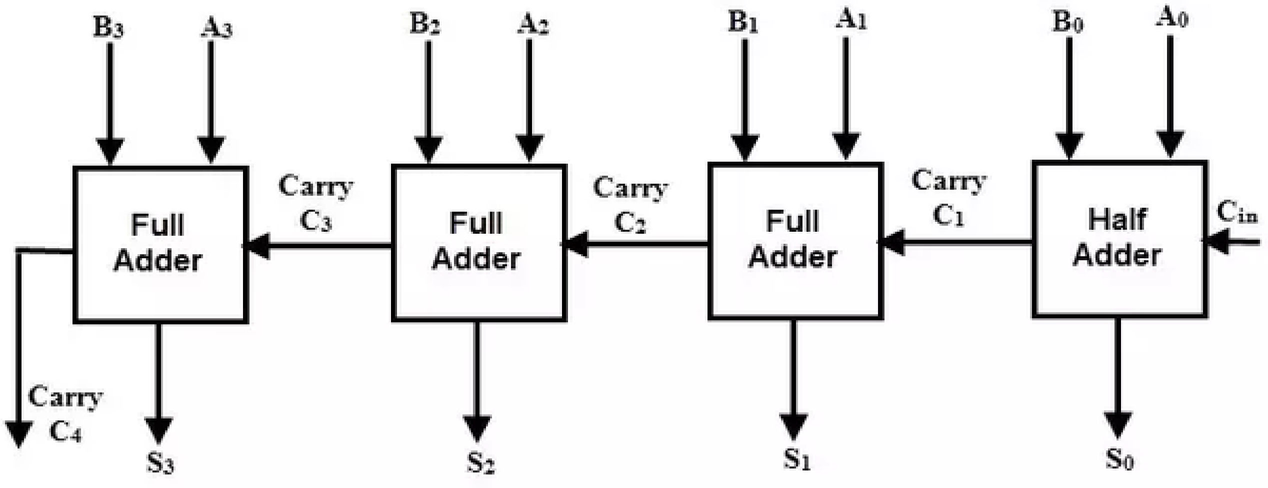
Sum= A⊕B

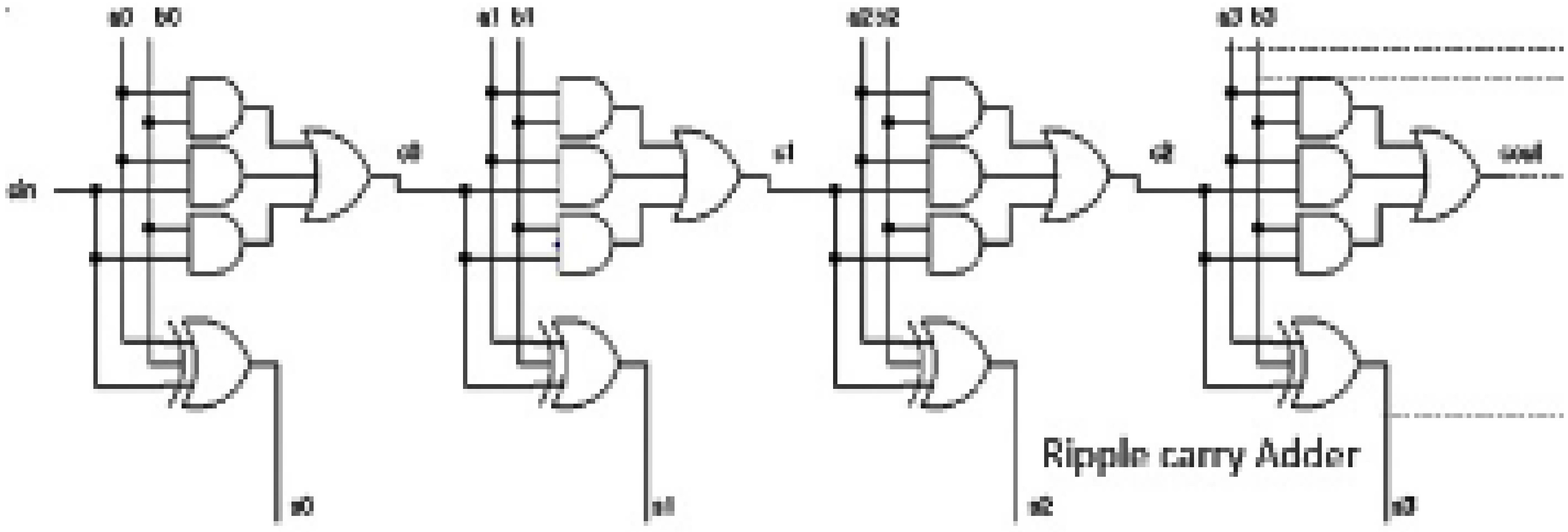
Carry=AB





4-bit Ripple Carry Adder

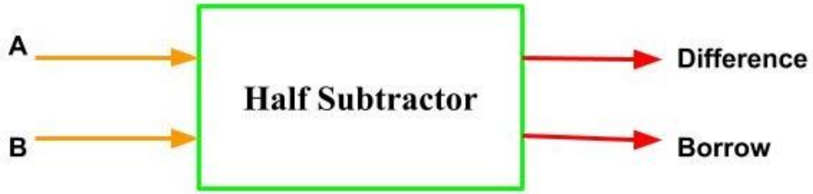




Half Subtractor

Combinational circuit perform binary Subtraction

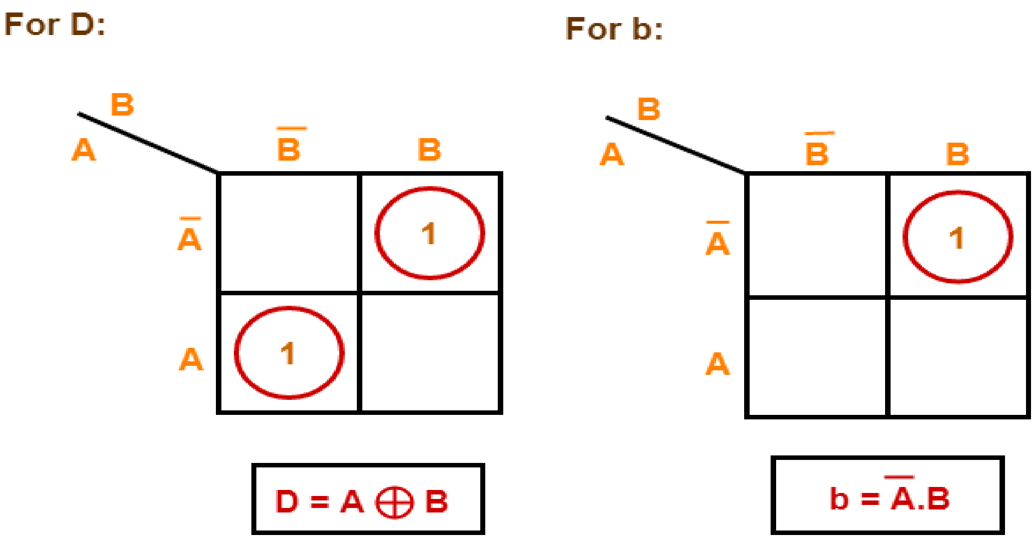
Accepts 2 input and Two output Difference and Borrow



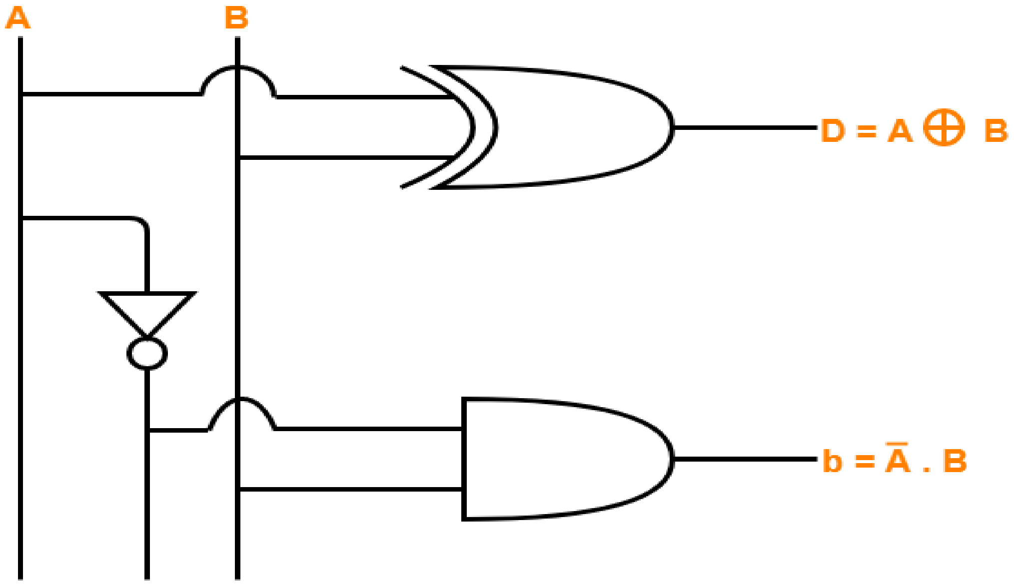
Inputs		Outputs	
A	B	D (Difference)	b (Borrow)
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

$D(A, B) = \sum m\,(1, 2)$

$Br(A, B) = \sum m\,(1)$



K Maps



Half Subtractor Logic Diagram

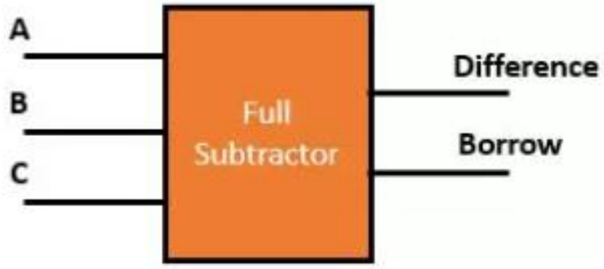
Full Subtractor

Performs subtraction of 3 bits

This circuit **has three inputs and two outputs**.

The three inputs A, B and C, denote the minuend, subtrahend, and previous borrow, respectively.

The two outputs, D and Bout



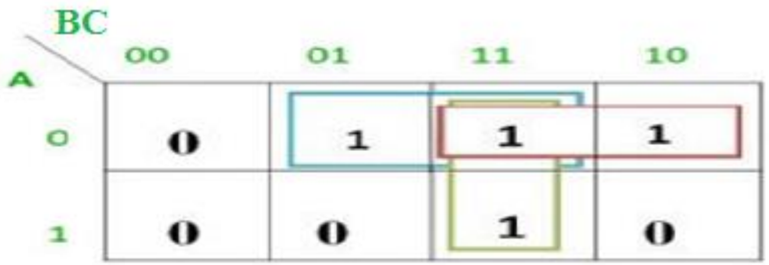
Input			Output	
A	B	C	Difference	Borrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

Sum(A, B,C) = ∑m (1, 2, 4, 7)

Bout(A, B,C) = ∑m (1,2,3,7)

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

$$
\begin{aligned}
Difference &= \overline{A}\,\overline{B}\,C + \overline{A}\,B\,\overline{C} + A\,\overline{B}\,\overline{C} + ABC \\
&= C\,(\overline{A}\,\overline{B} + AB) + \overline{C}\,(\overline{A}\,B + A\,\overline{B}) \\
&= C\,(A \odot B) + \overline{C}\,(A \oplus B) \\
&= C\,(\overline{A \oplus B}) + \overline{C}\,(A \oplus B) \\
&= C \oplus (A \oplus B)
\end{aligned}
$$

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Bout = A’B’C + A’BC’ + A’BC + ABC
     = C(AB + A’B’) + A’B(C + C’)
     = C( A XNOR B) + A’B
     = C (A XOR B)’ + A’B
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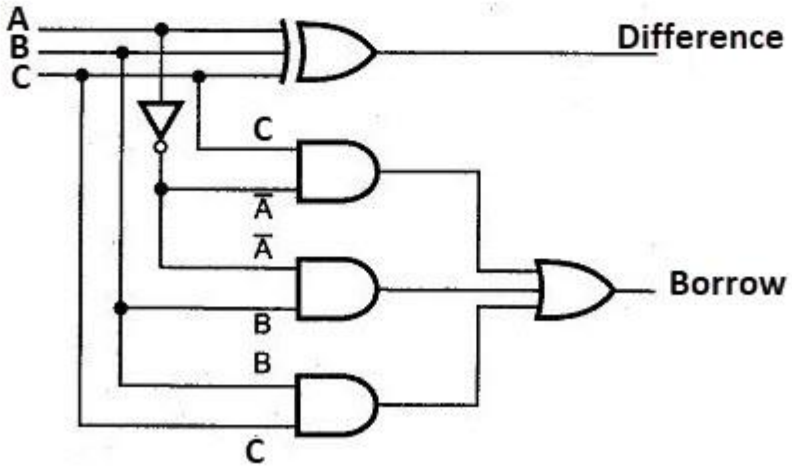
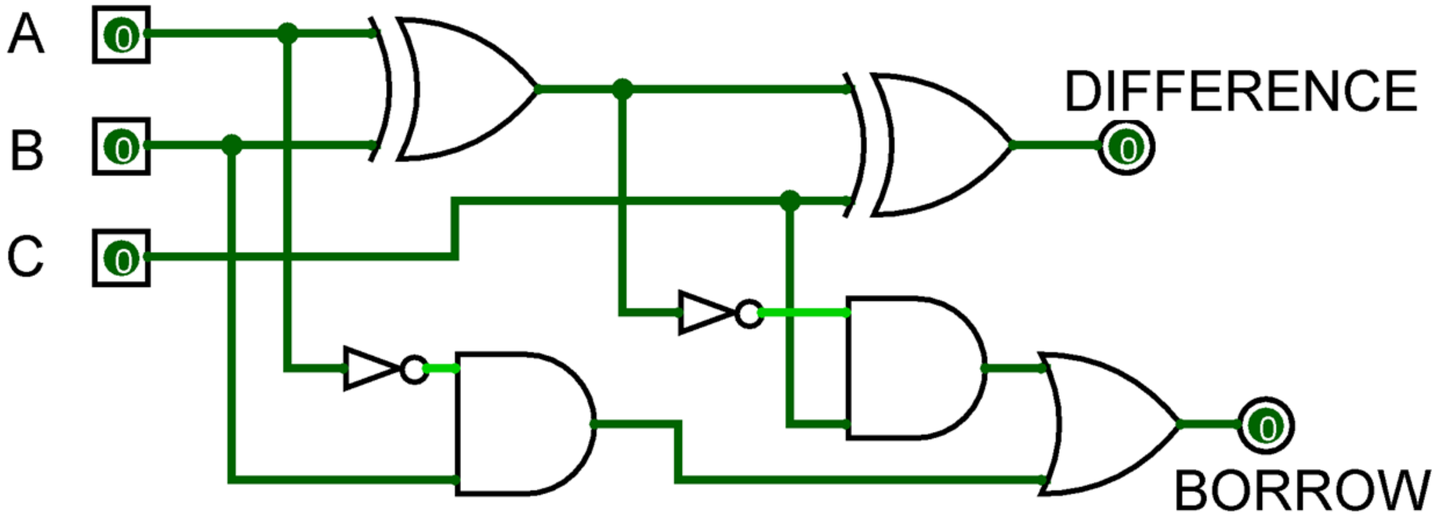
$$Borrow = \overline{A}\,\overline{B}\,C + \overline{A}\,B\,\overline{C} + \overline{A}\,BC + ABC$$
$$= \overline{A}\,B + \overline{A}\,C + BC$$





Full Subtractor using Half Subtractor

FS

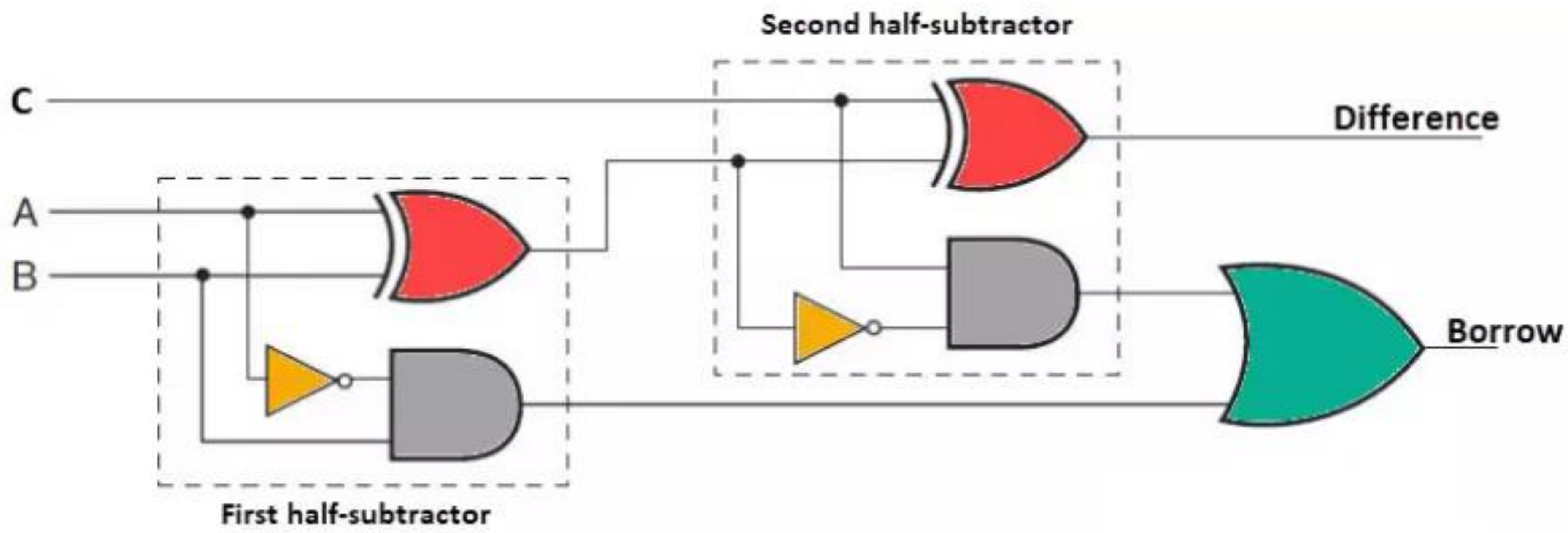
Sum= $A \oplus B \oplus C$

Carry=$A'B+(A \oplus B)'C$

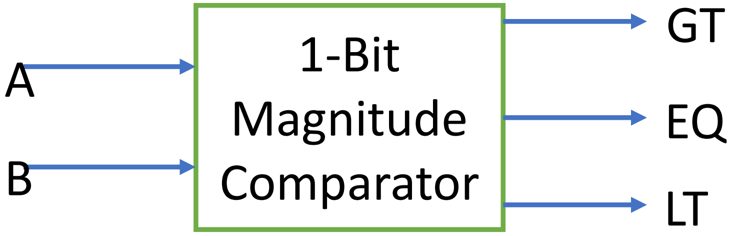
HS

Sum= $A \oplus B$

Carry=$A'B$

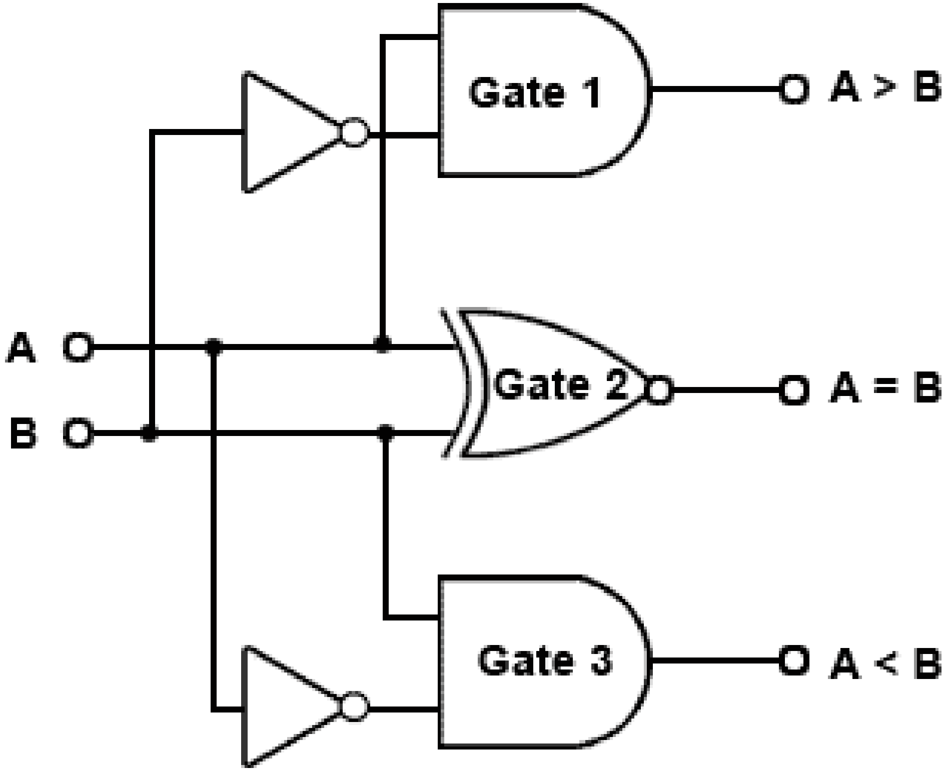


1-BIT Magnitude Comparator



Inputs		GT	EQ *Outputs*	LT
A	B	$A > B$	$A = B$	$A < B$
0	0	0	1	0
0	1	0	0	1
1	0	1	0	0
1	1	0	1	0

GT=AB’
EQ=A’B’+AB
LT=A’B



Parity Generator Circuit

Even Parity Generator

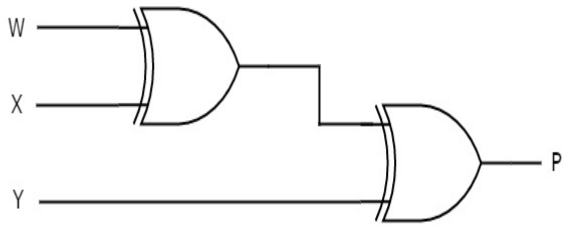
If odd number of ones present in the input, then even parity bit, P should be ‘1’ so that the resultant word contains even number of ones.

Binary Input WXY	Even Parity bit P
000	0
001	1
010	1
011	0
100	1
101	0
110	0
111	1

$$P = W'X'Y + W'XY' + WX'Y' + WXY$$

$$\Rightarrow P = W'(X'Y + XY') + W(X'Y' + XY)$$

$$\Rightarrow P = W'(X \oplus Y) + W(X \oplus Y)' = W \oplus X \oplus Y$$



Odd Parity Generator

If even number of ones present in the input, then odd parity bit, P should be ‘1’ so that the resultant word contains odd number of ones

Binary Input WXY	Odd Parity bit P
000	1
001	0
010	0
011	1
100	0
101	1
110	1
111	0