Institute of Space Technology Islamabad

Digital Logic Design Lab

Title: Design and Implementation of Adder and Subtractor.

Date of Experiment: 05-04-2023

Lab number: 08

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Objectives:

- To Understand and Implement Half Adder and Full Subtractor.
- To Understand and Implement Half Subtractor and Full Subtractor.
- To understand and implement 4-bit Adder.

Equipment:

- Proteus Software

Theory:

1 . Half Adder:

A half adder is a type of digital circuit which can be used to add two bits together. It takes two inputs, and produces two outputs, one sum bit, and one carry bit.

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 10

Truth Table

Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

2 . Full Adder:

To add three bits, we use a full adder. It adds 3 bits together, and produces to output bit, one sum bit and one carry bit.

A	B	C	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**

3 . Half Subtractor:

Like a half adder, a half subtractor can be used to perform subtraction of two bits, one bit is minuend, and one is subtrahend. It produces two outputs, one is a borrow bit and one is a difference bit.

A	B	D	B_0
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

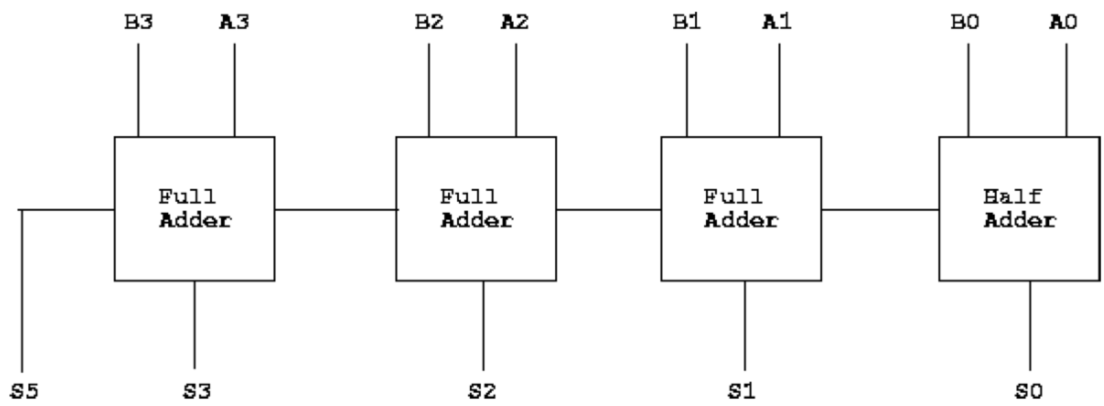
4 . Full subtractor:

A full subtractor can be used to find the difference between 3 bits, where one bit is a minuend, and two bits are subtrahend.

B-in	Y	X	Diff.	B-out
0	0	0	0	0
0	0	1	1	0
0	1	0	1	1
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

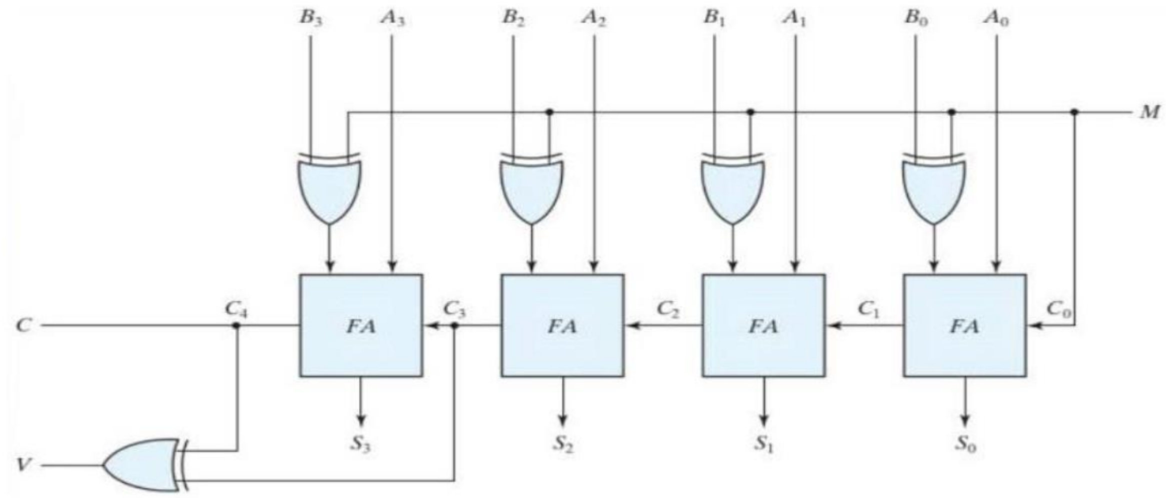
5 . 4 bit Adder:

We can combine N number of Full adders, to add N bits of binary. To add 4 bits of binary, we can use a combinatorial circuit of 4 full adders, or one half adder and 3 full adders. Each full adder gets the carry from previous full adder.



6 . Adder Subtractor:

An adder subtractor is a type of circuit which can be used to perform addition or subtraction based upon a control input. It is a single circuit working both as a adder and a subtractor.



Task 1:

Implement Half Adder and Full Adder circuits. Find out their output equation using any method and implement it. Form a truth table and verify it.

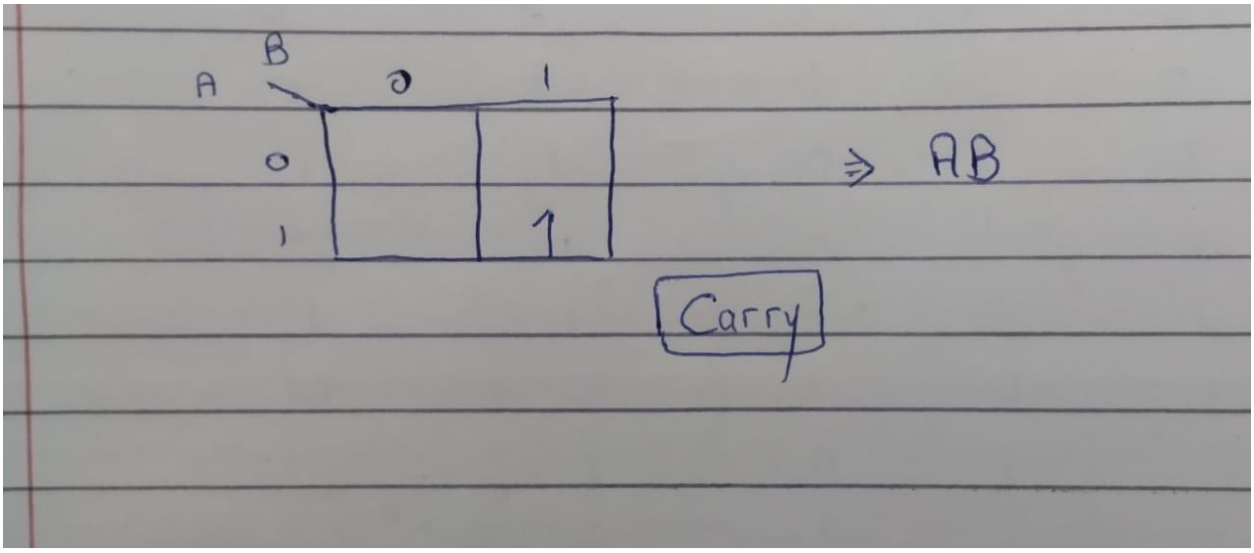
Half Adder

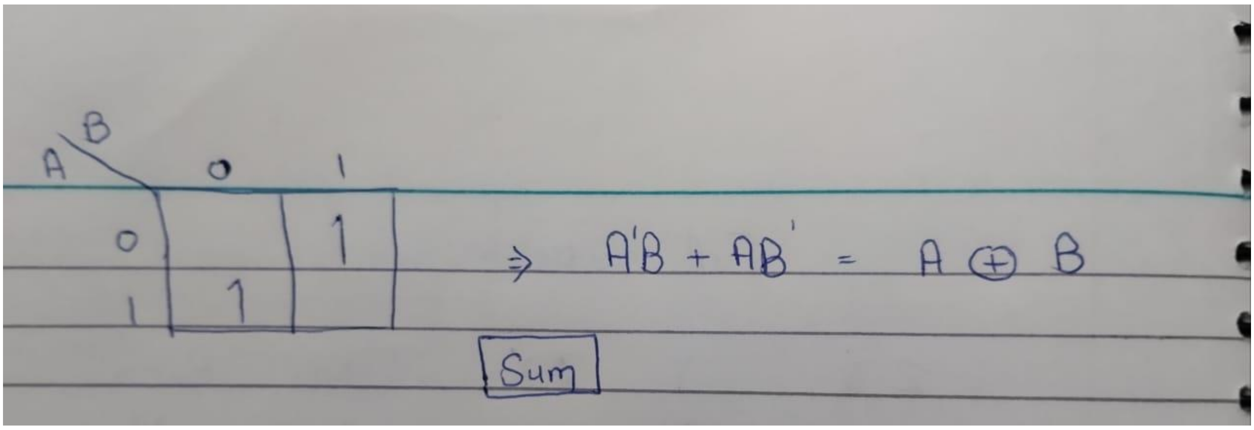
Truth Table:

Truth Table

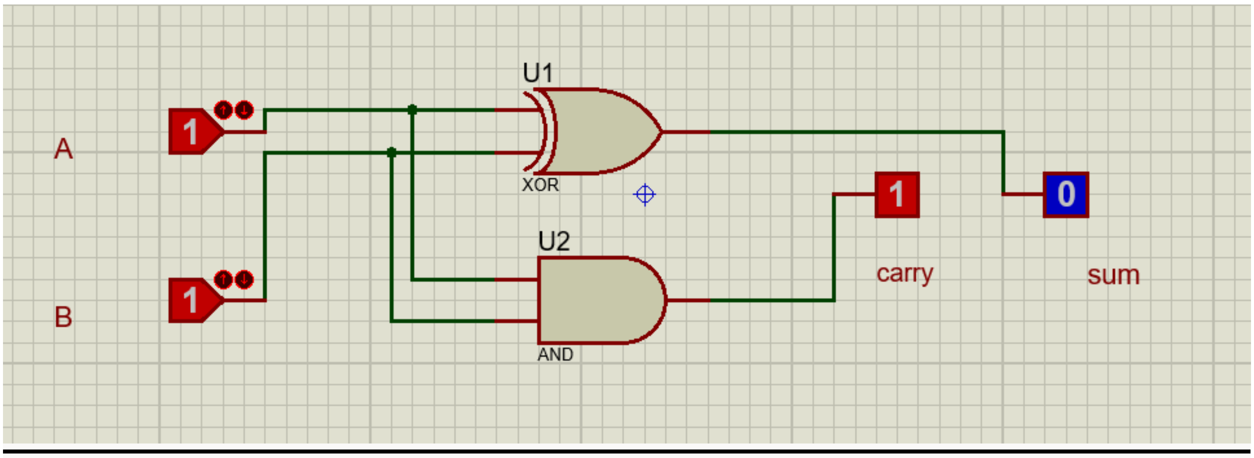
Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Equation:

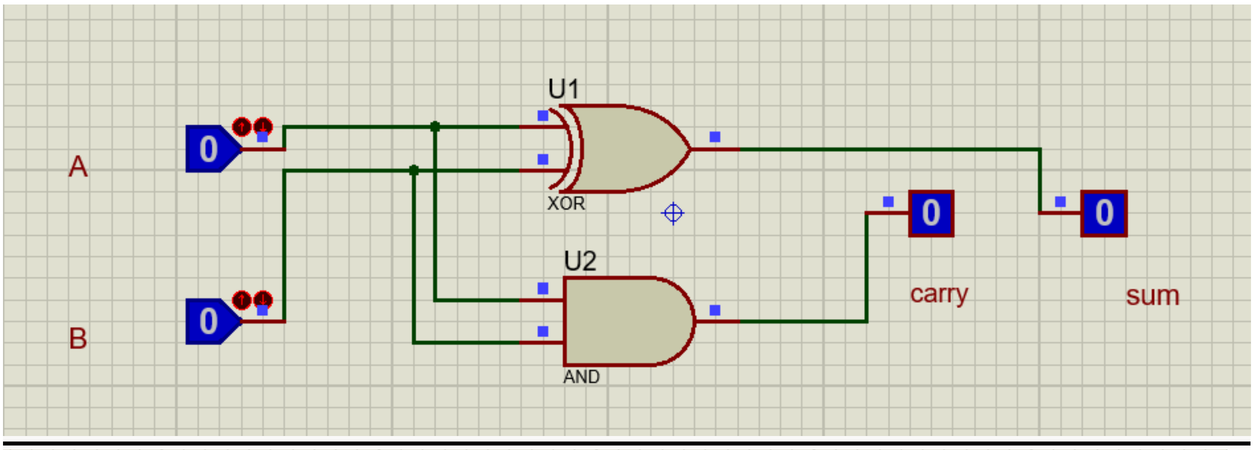


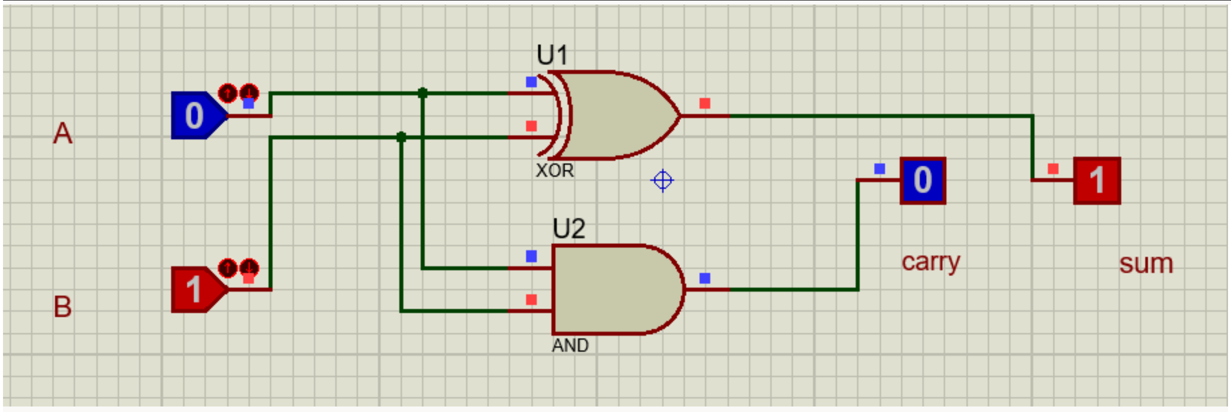


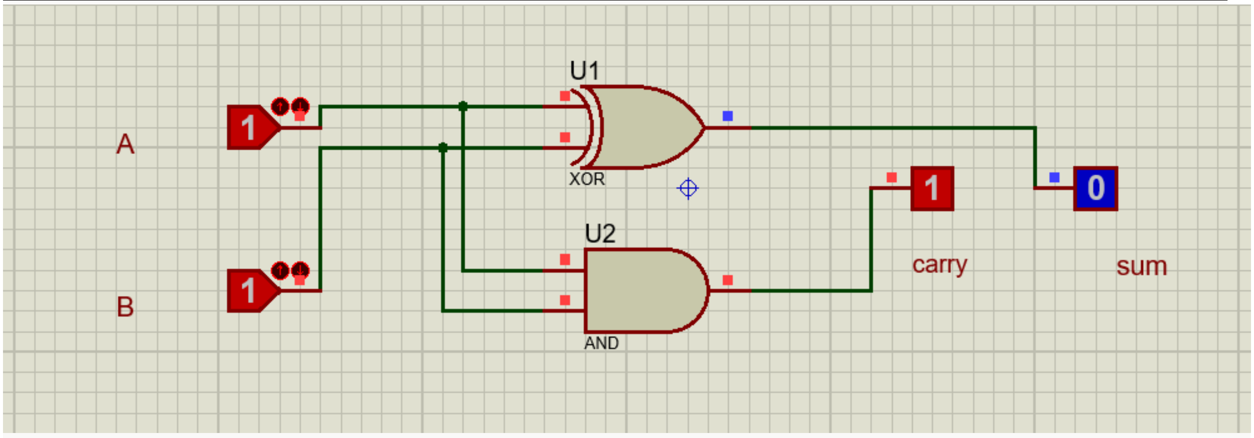
Circuit:



Working:





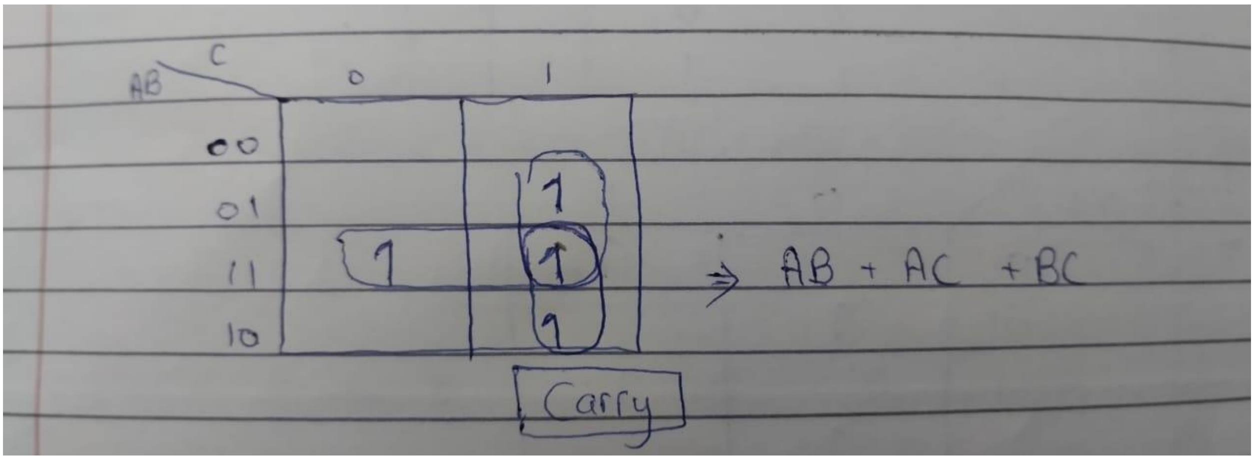


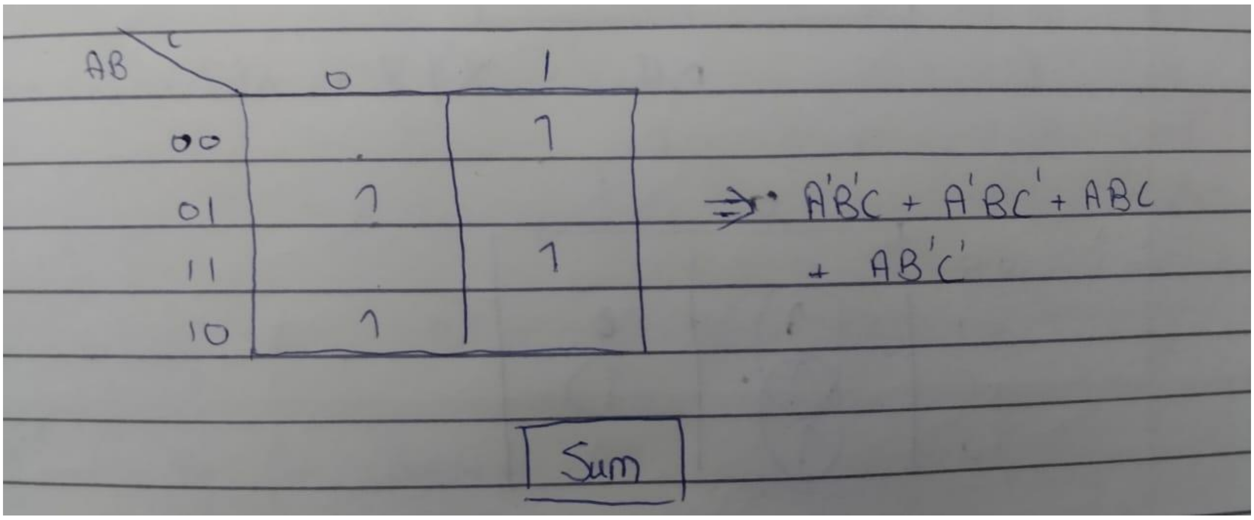
Full Adder

Truth Table:

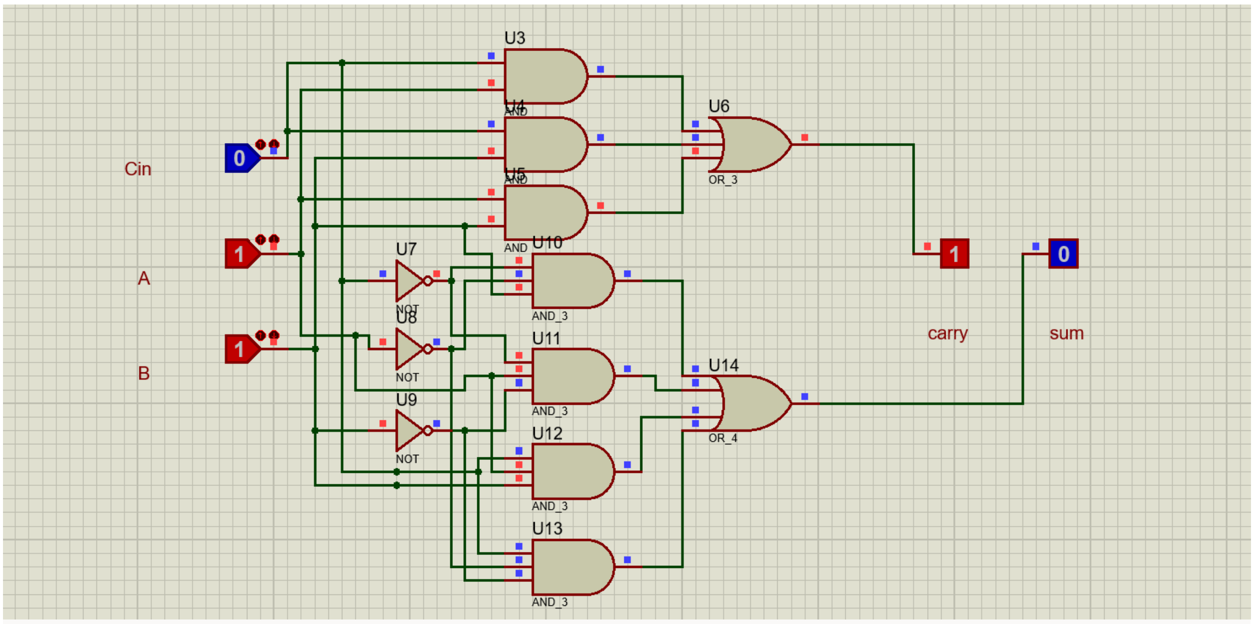
A	B	C	Sum	Carry
0	0	0	**0**	**0**
0	0	1	**1**	**0**
0	1	0	**1**	**0**
0	1	1	**0**	**1**
1	0	0	**1**	**0**
1	0	1	**0**	**1**
1	1	0	**0**	**1**
1	1	1	**1**	**1**

Equation:

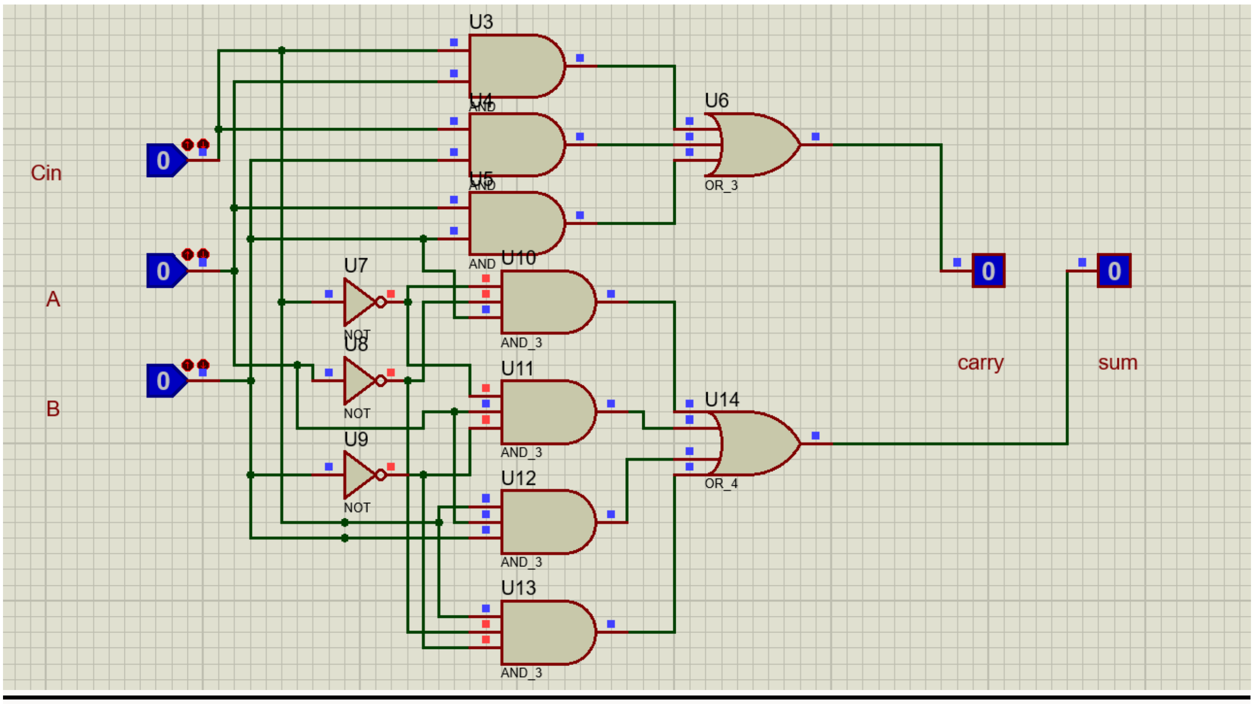


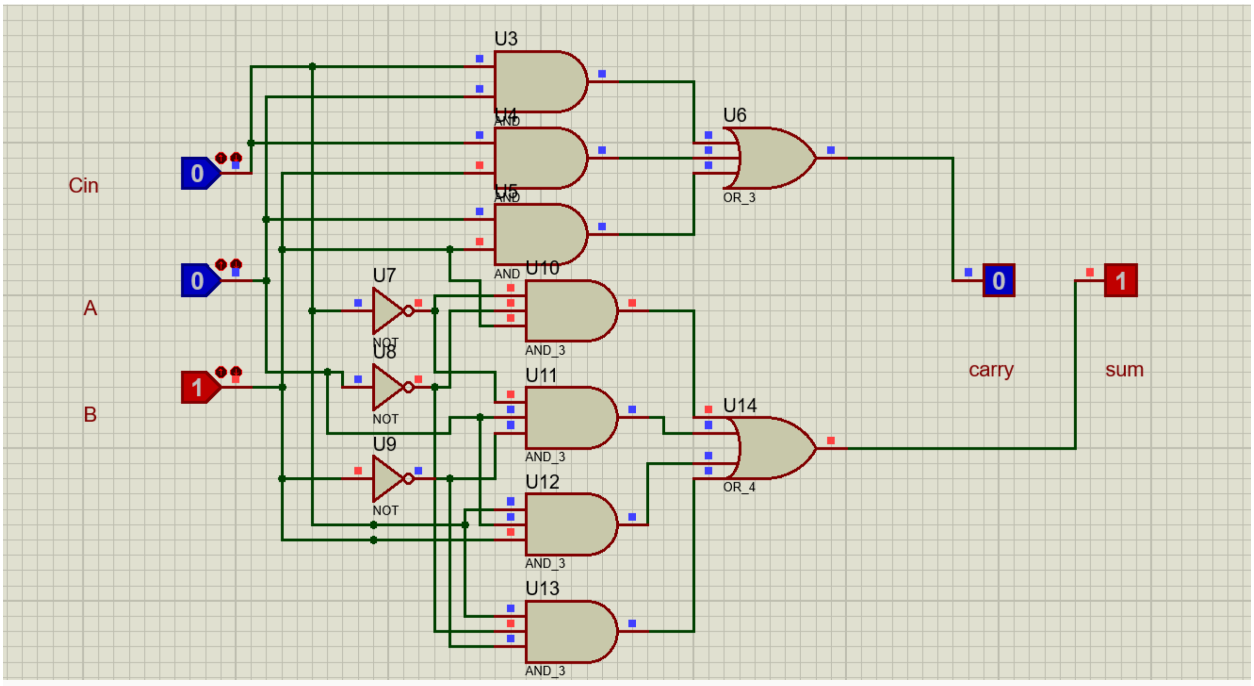


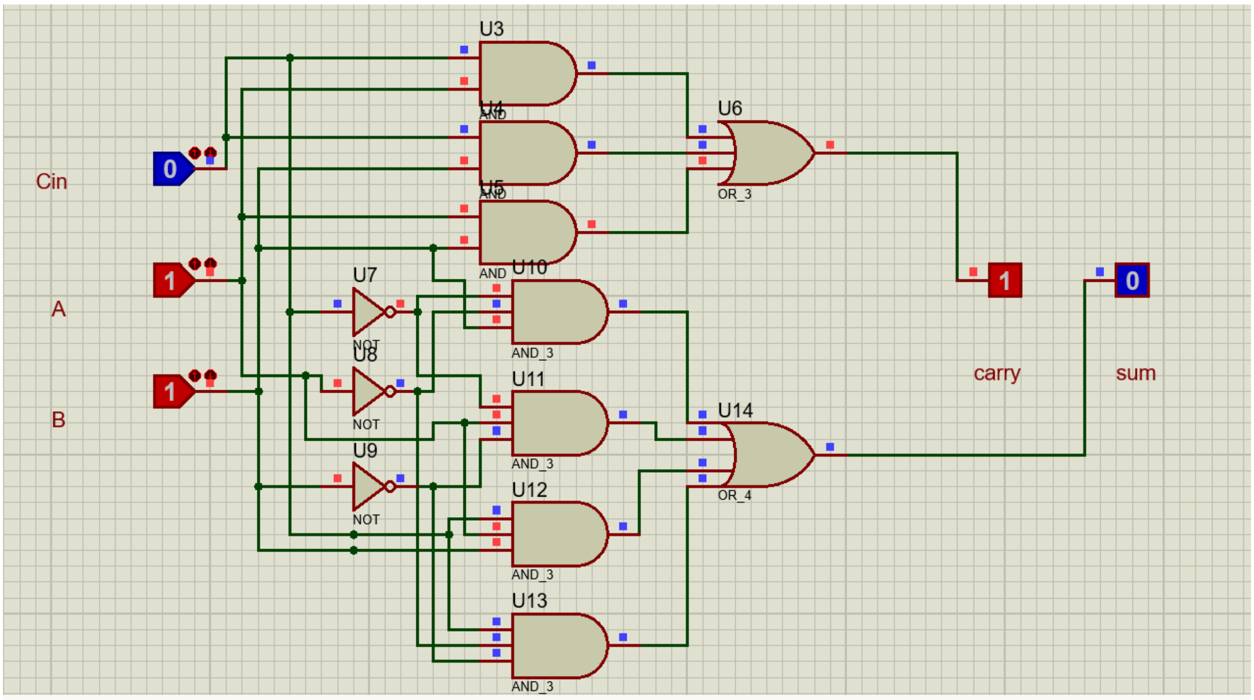
Circuit:

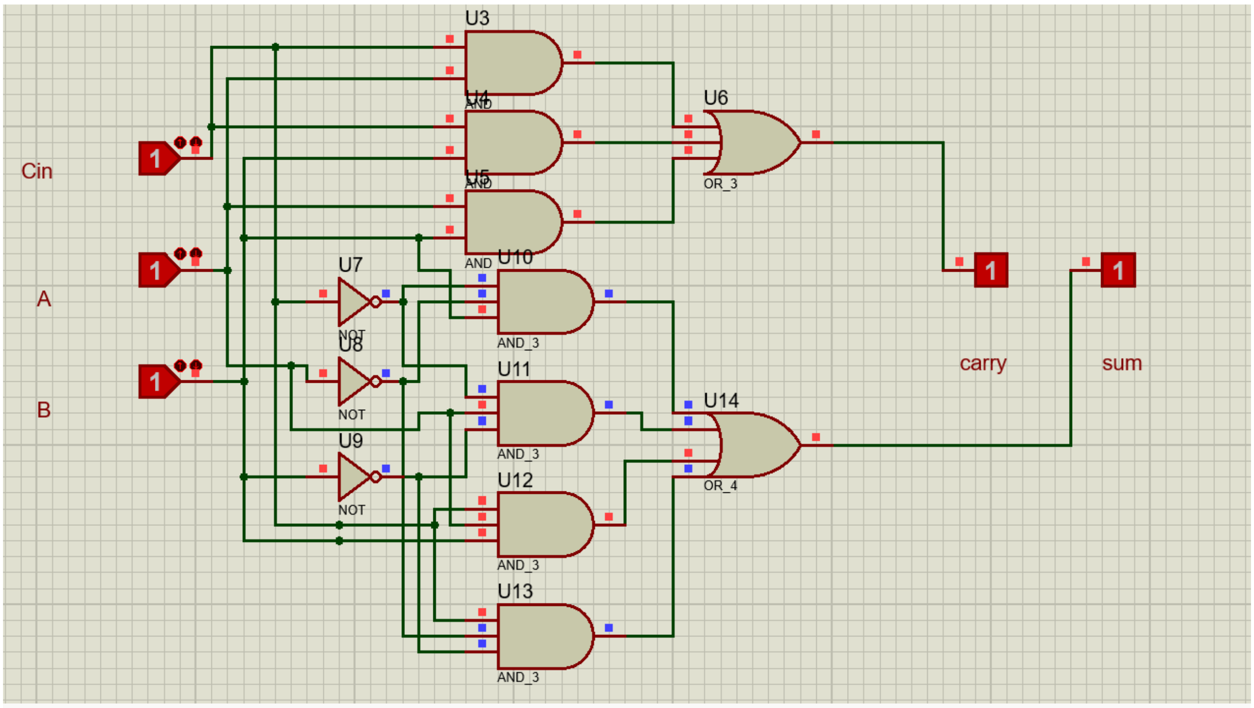


Working:


U3
U4
U5
U6
OR_3
Cin
A
B
U7
NOT
U8
NOT
U9
NOT
U10
AND_3
U11
AND_3
U12
AND_3
U13
AND_3
U14
OR_4
carry
sum
0
0
0
0
0


U3
U4
U5
U6
OR_3
Cin
A
B
U7
NOT
U8
NOT
U9
NOT
U10
AND_3
U11
AND_3
U12
AND_3
U13
AND_3
U14
OR_4
carry
sum
0
0
1
0
1





Task 2:

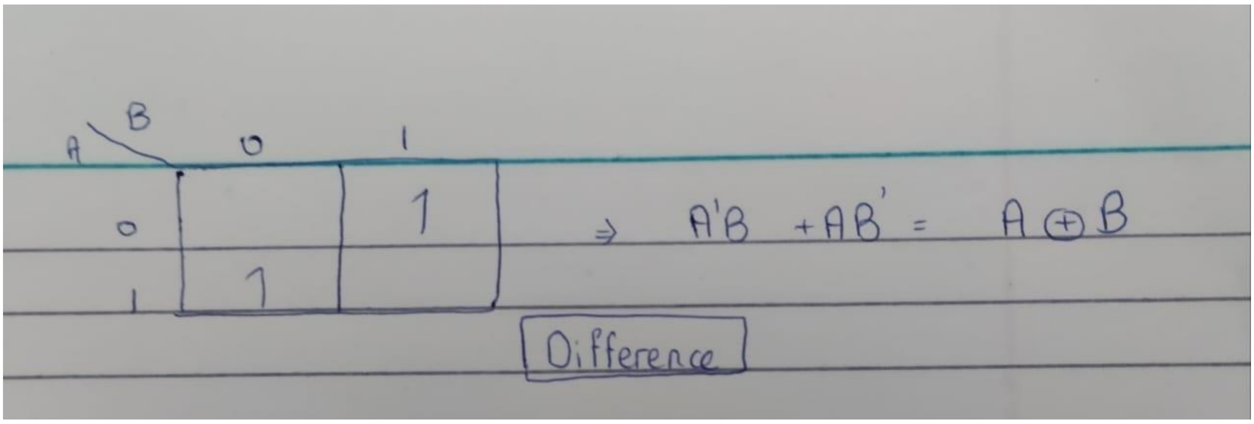
Implement half subtractor and full subtractor circuits. Find out their output equation using any techniques and draw their logical circuit. Form truth table and verify it.

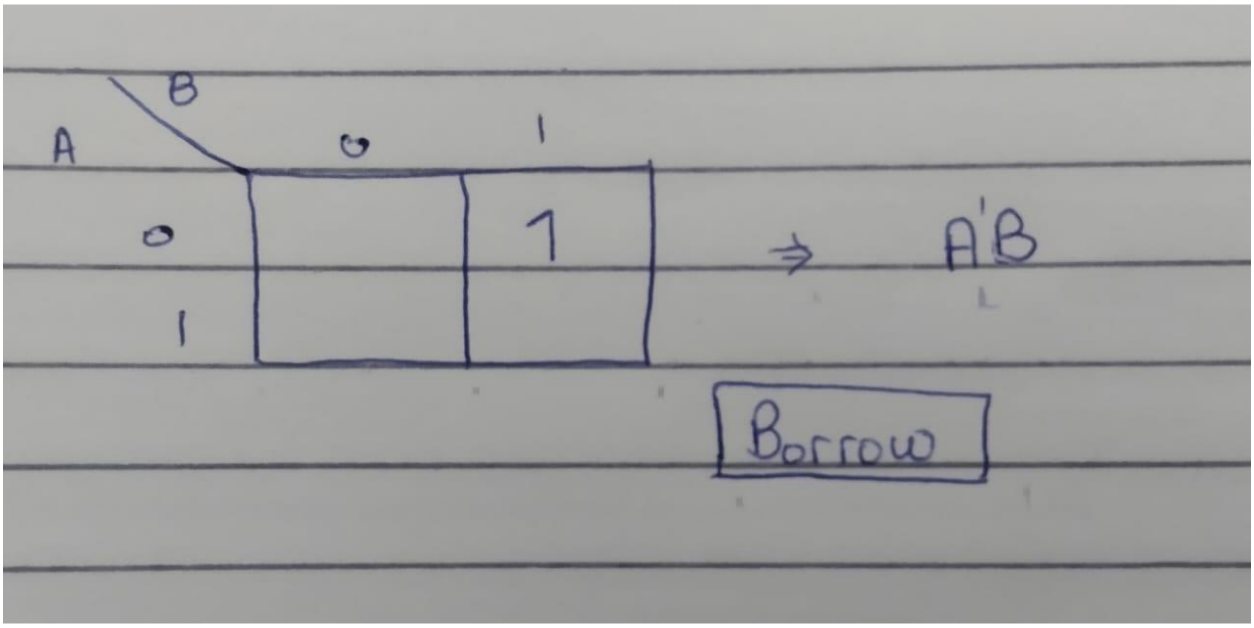
Half Subtractor

Truth Table:

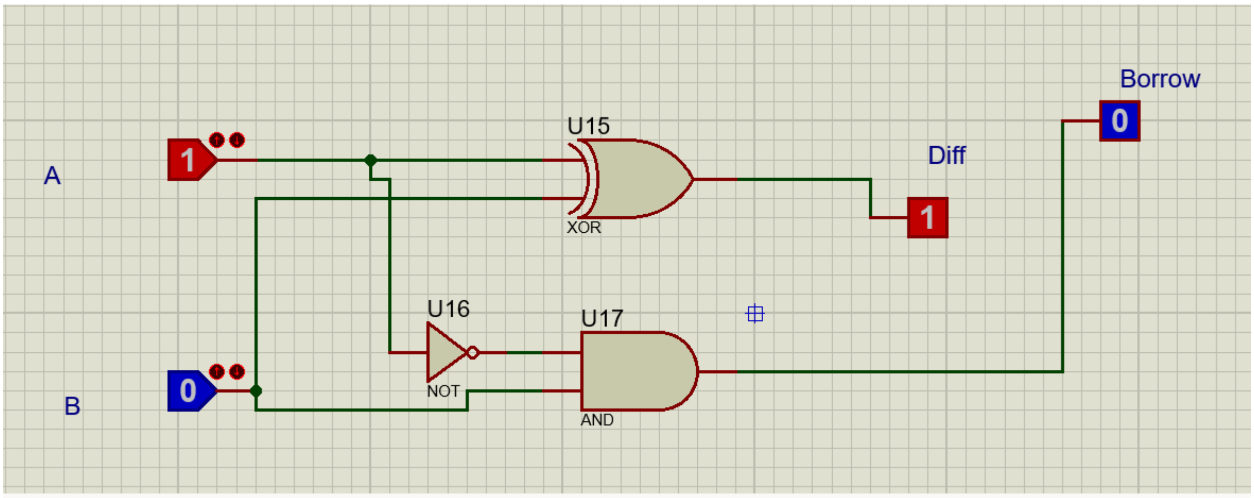
A	B	D	B_0
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Equation:

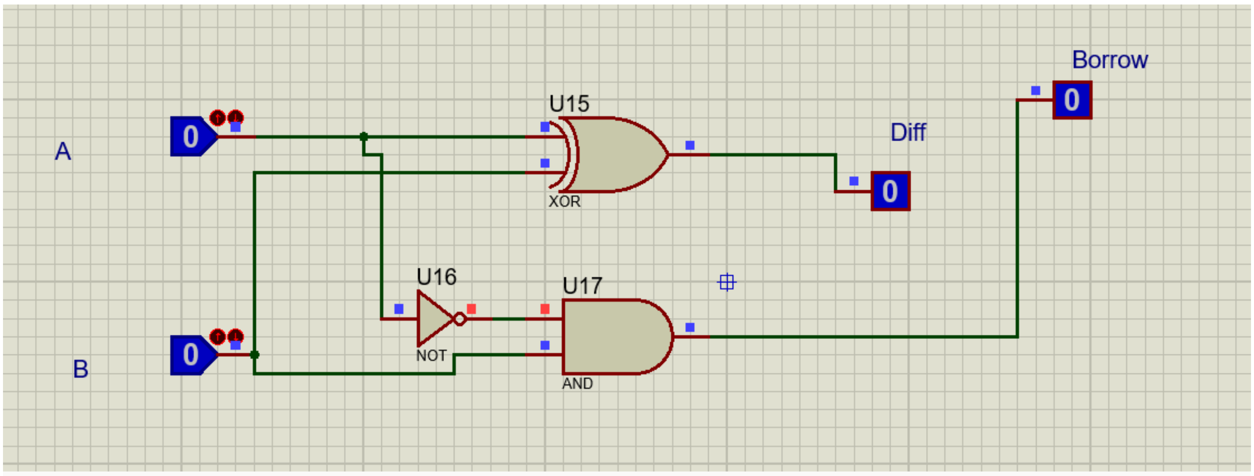


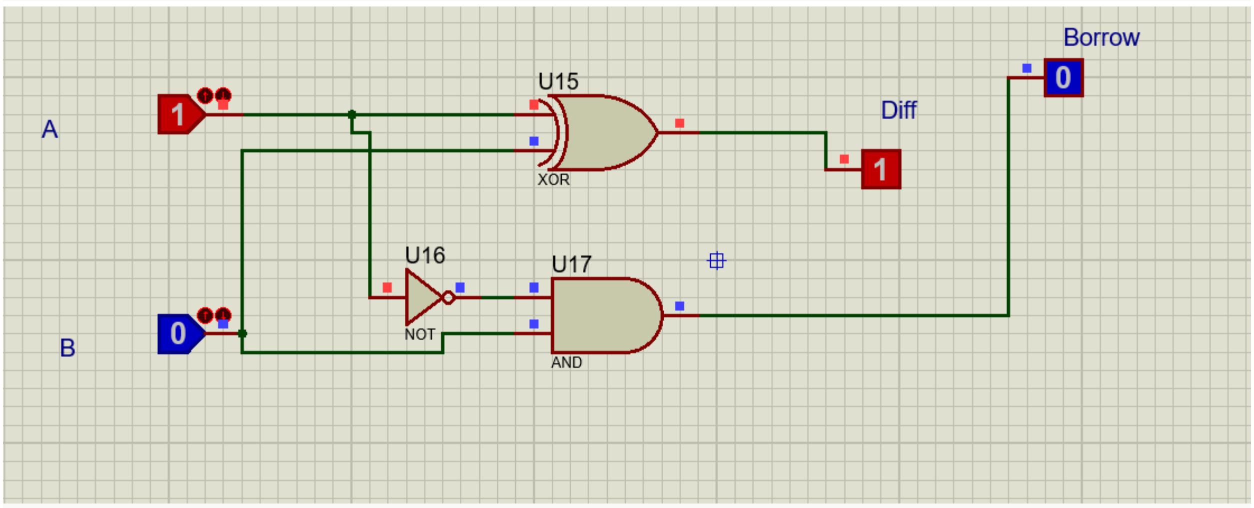


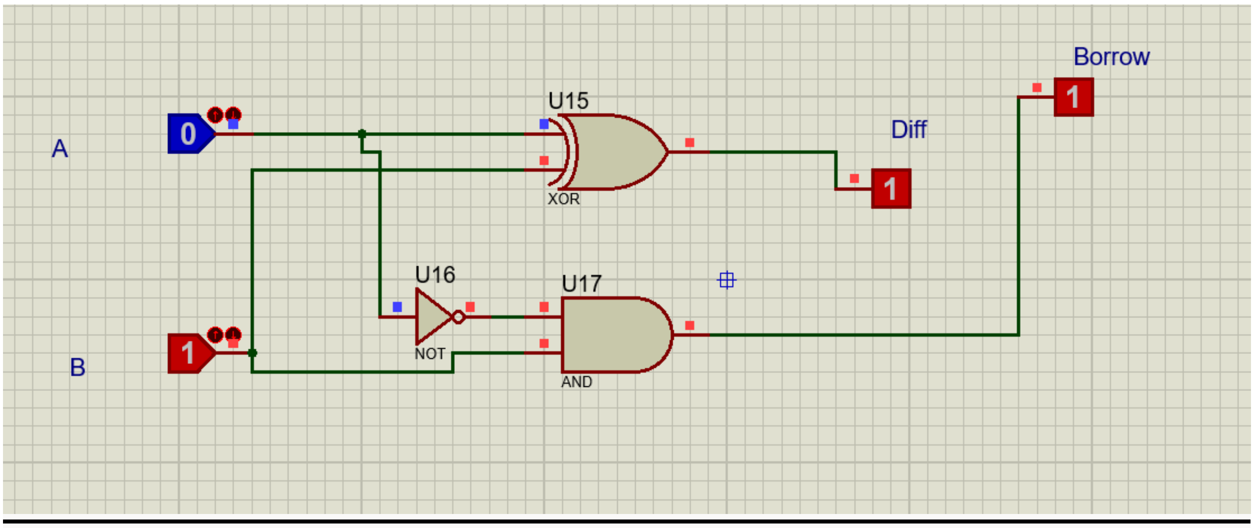
Circuit:



Working:





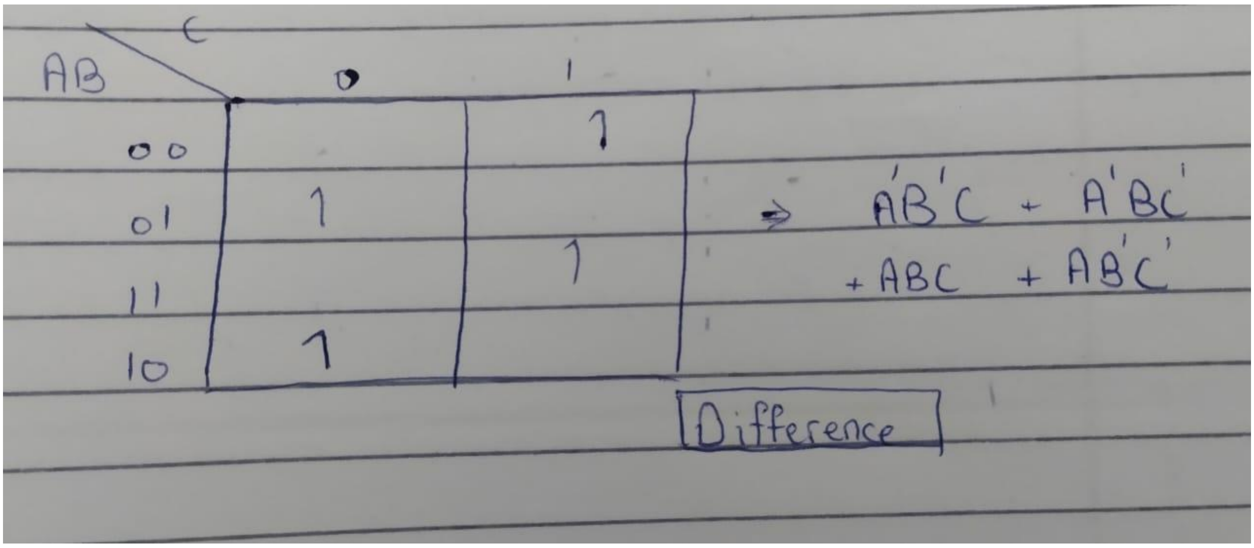


Full Subtractor

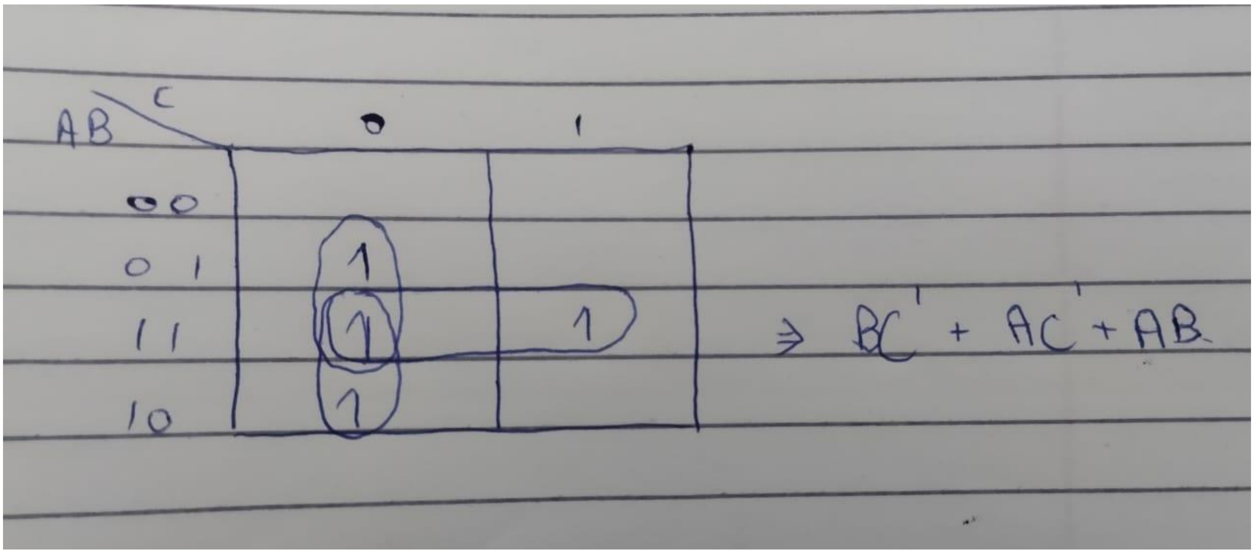
Truth Table:

X	Y	Z	Diff	Bor
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**

Equation:

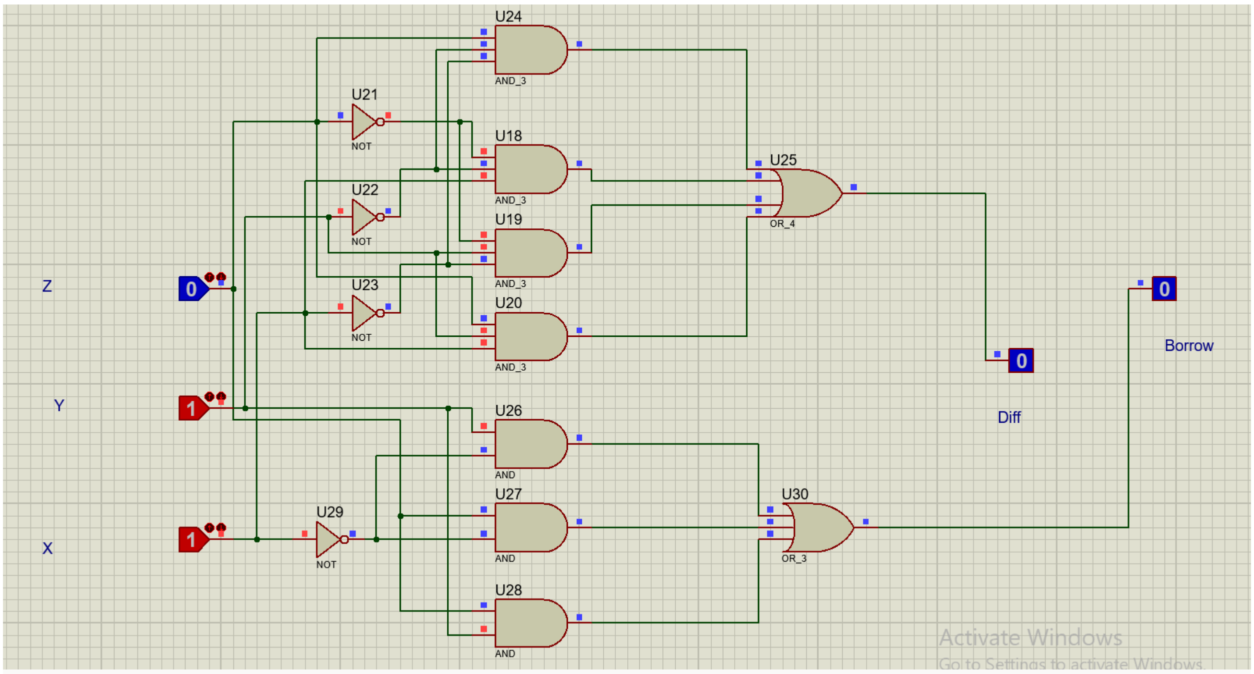


AB
C
0
1
00
01
11
10
1
1
1
1
⇒ A'B'C + A'BC' + ABC + AB'C'
Difference



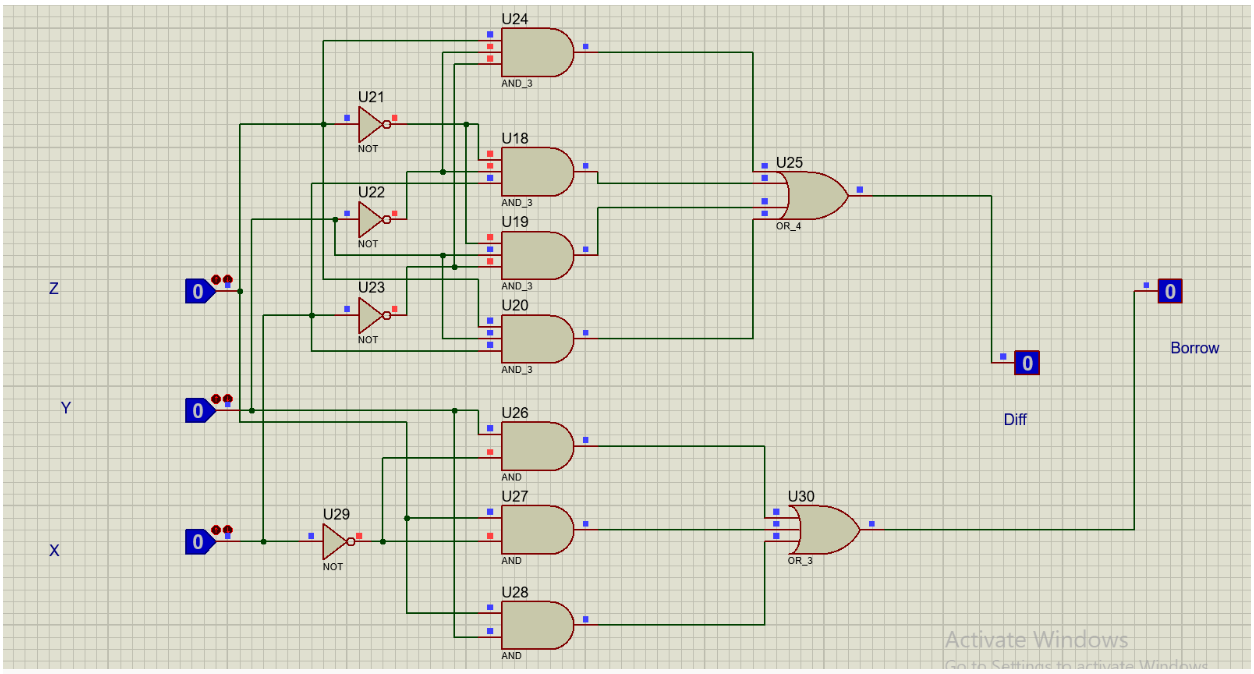
AB
C
0
1
00
01
11
10
1
1
1
1
⇒ BC' + AC' + AB

Circuit:

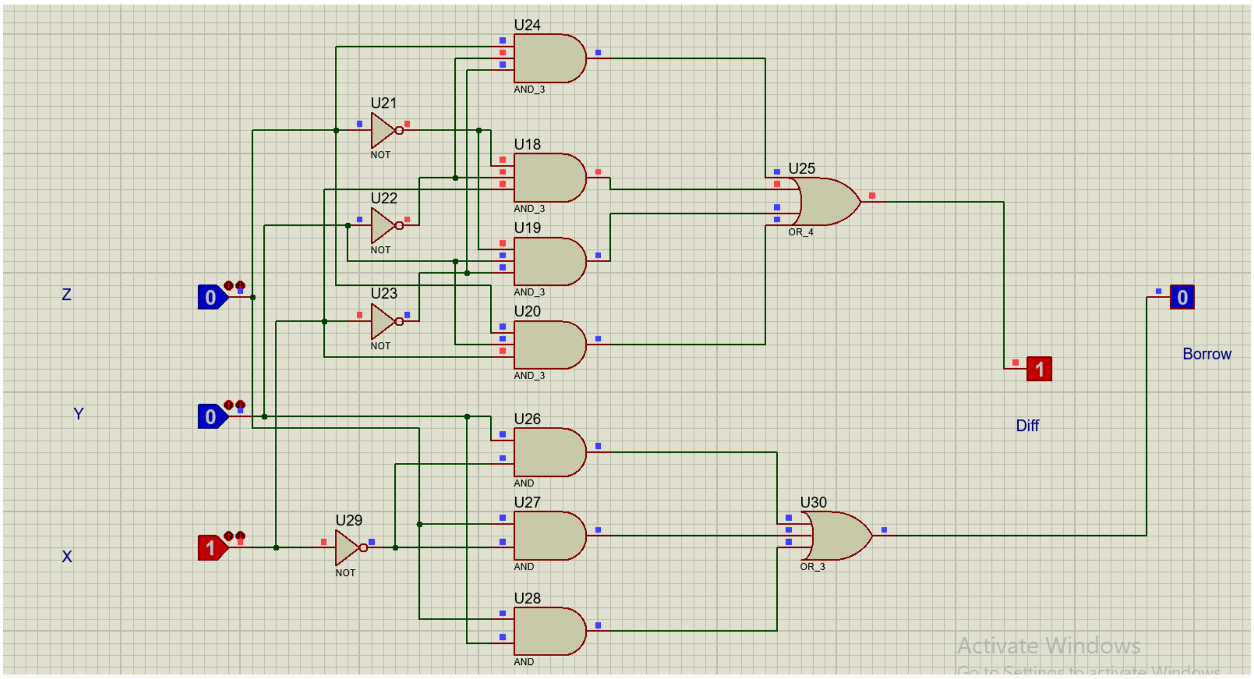


U24
AND_3
U21
NOT
U18
AND_3
U22
NOT
U19
AND_3
U23
NOT
U20
AND_3
U25
OR_4
Z
0
Y
1
X
1
U26
AND
U27
AND
U28
AND
U29
NOT
U30
OR_3
0
Diff
0
Borrow

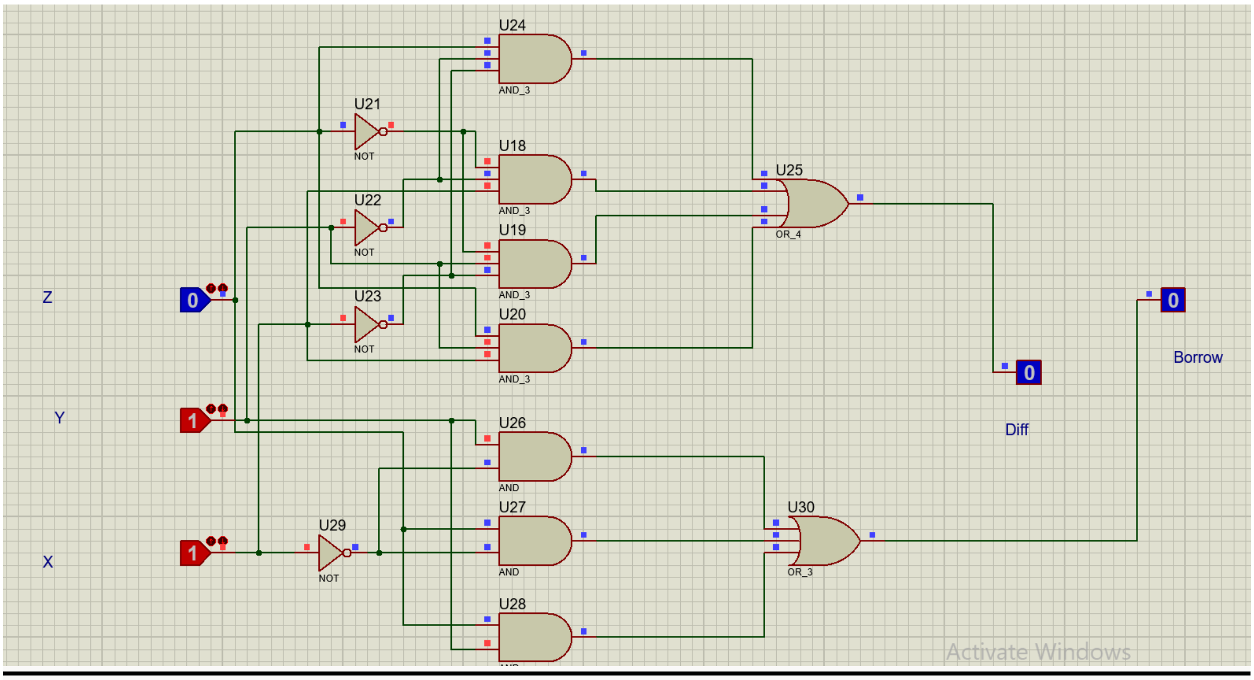
Working:



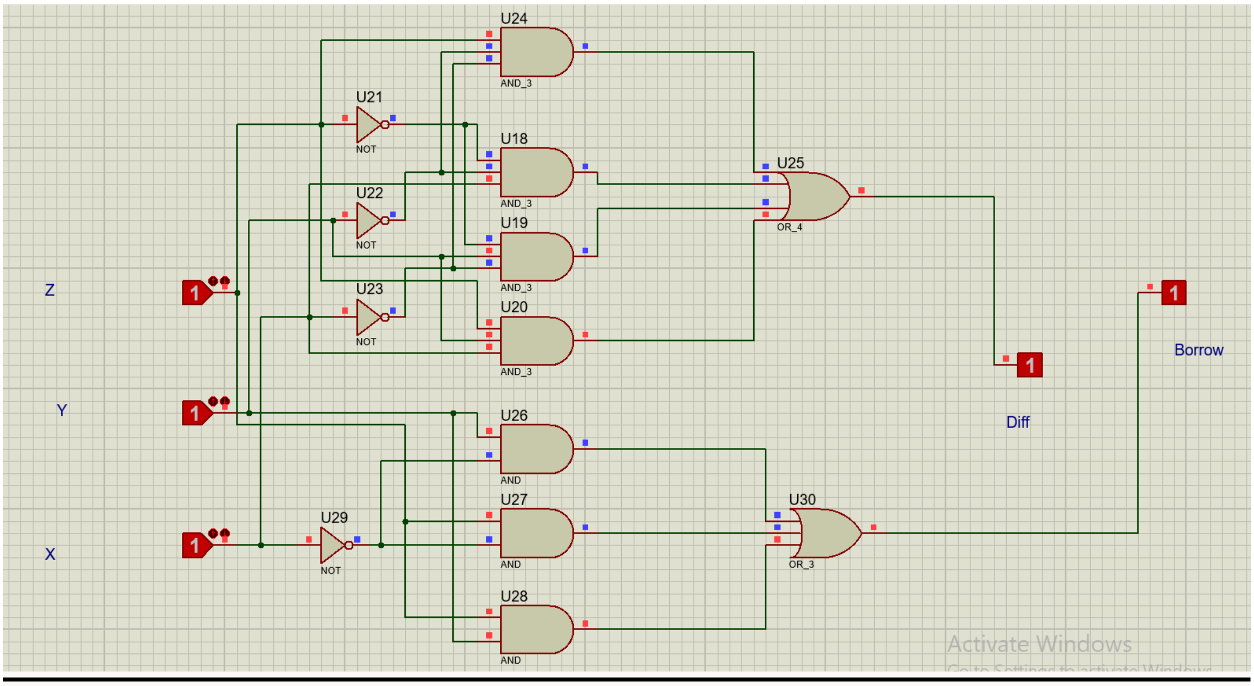
U24
AND_3
U21
NOT
U18
AND_3
U25
OR_4
U22
NOT
U19
AND_3
Z
0
U23
NOT
U20
AND_3
0
Borrow
0
Y
0
Diff
U26
AND
U27
AND
U30
OR_3
U29
NOT
X
0
U28
AND
Activate Windows



U24
AND_3
U21
NOT
U18
AND_3
U25
OR_4
U22
NOT
U19
AND_3
Z
0
U23
NOT
U20
AND_3
0
Borrow
1
Y
0
Diff
U26
AND
U27
AND
U30
OR_3
U29
NOT
X
1
U28
AND
Activate Windows



U24
AND_3
U21
NOT
U18
AND_3
U22
NOT
U19
AND_3
U23
NOT
U20
AND_3
U25
OR_4
Z
0
Y
1
X
1
U26
AND
U27
AND
U28
U29
NOT
U30
OR_3
0
Diff
0
Borrow



U24
AND_3
U21
NOT
U18
AND_3
U22
NOT
U19
AND_3
U23
NOT
U20
AND_3
U25
OR_4
Z
1
Y
1
X
1
U26
AND
U27
AND
U28
AND
U29
NOT
U30
OR_3
1
Diff
1
Borrow

Task 3:

Implement 4-bit adder, you have to perform addition of following number for input A and B respectively.

6, 7

8, 3

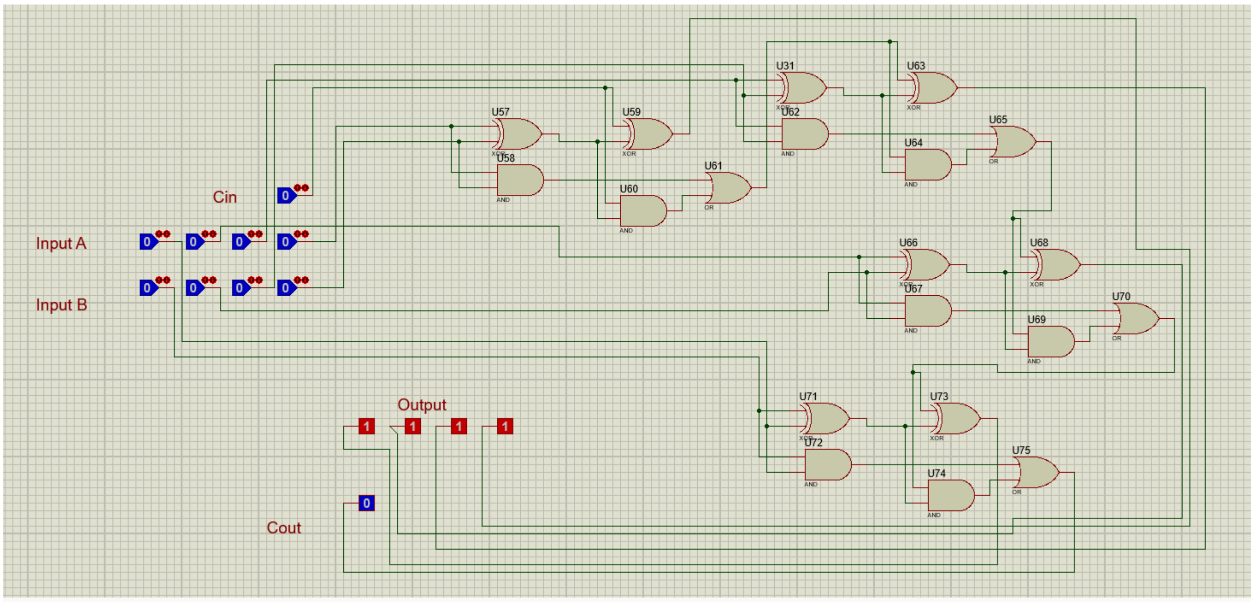
3, 9

11, 4

Without carry input and also with carry input.

And show carry out results as well.

Circuit:



Working:

1. **6 and 7:**

   6 = 0110

   7 = 0111

   6+7 = 13 = 1101

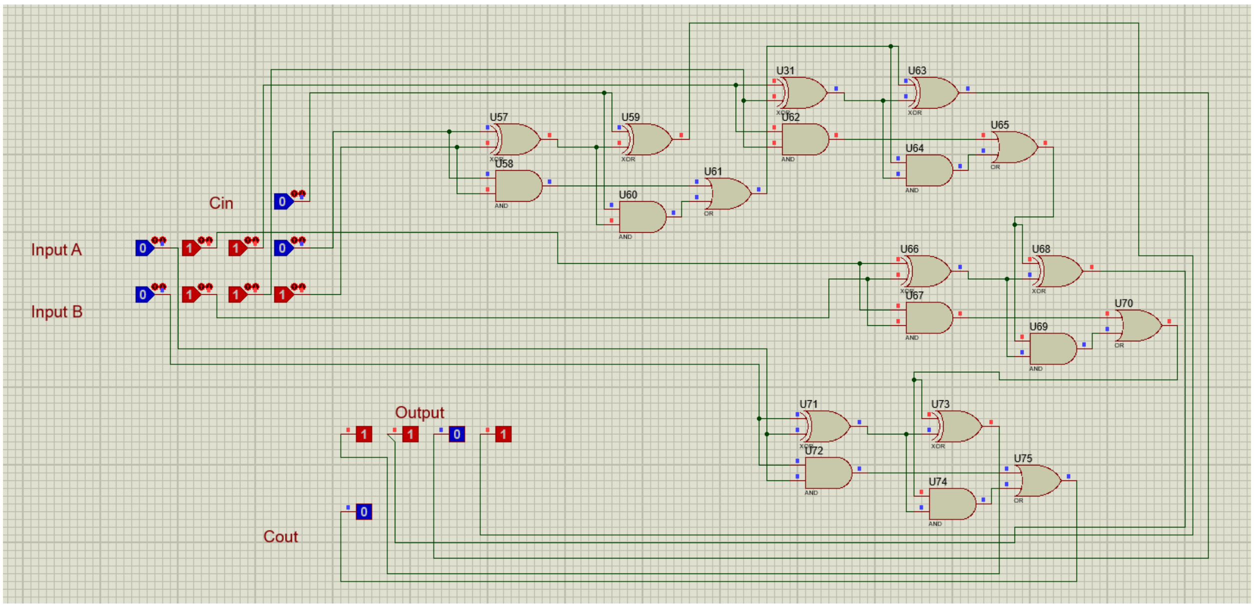


Figure 1: Without Carry bit

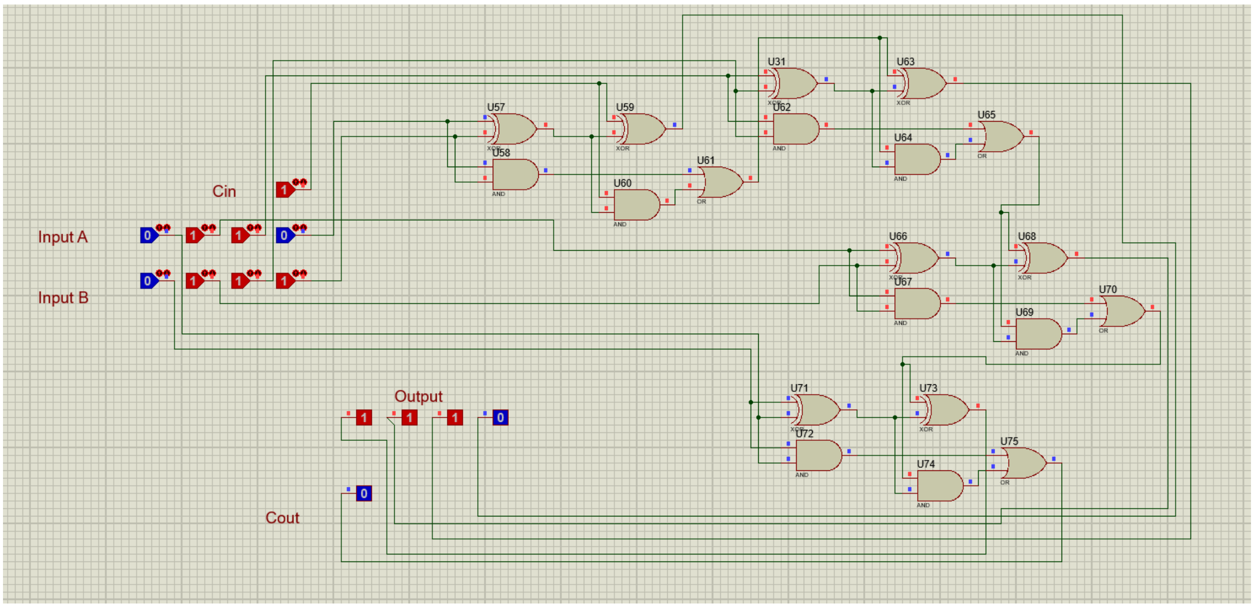


Figure 2: With Carry bit

2. 8 and 3:

8 = 1000

3 = 0011

8+3 = 11 = 1011

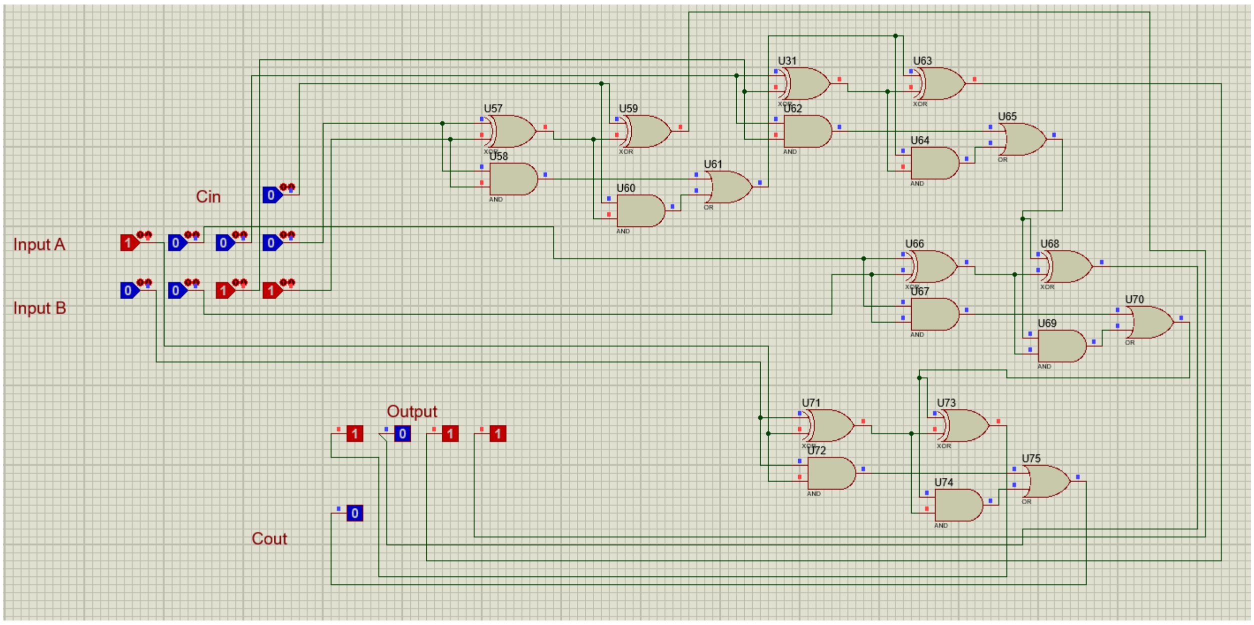


Figure 3: Without Carry bit

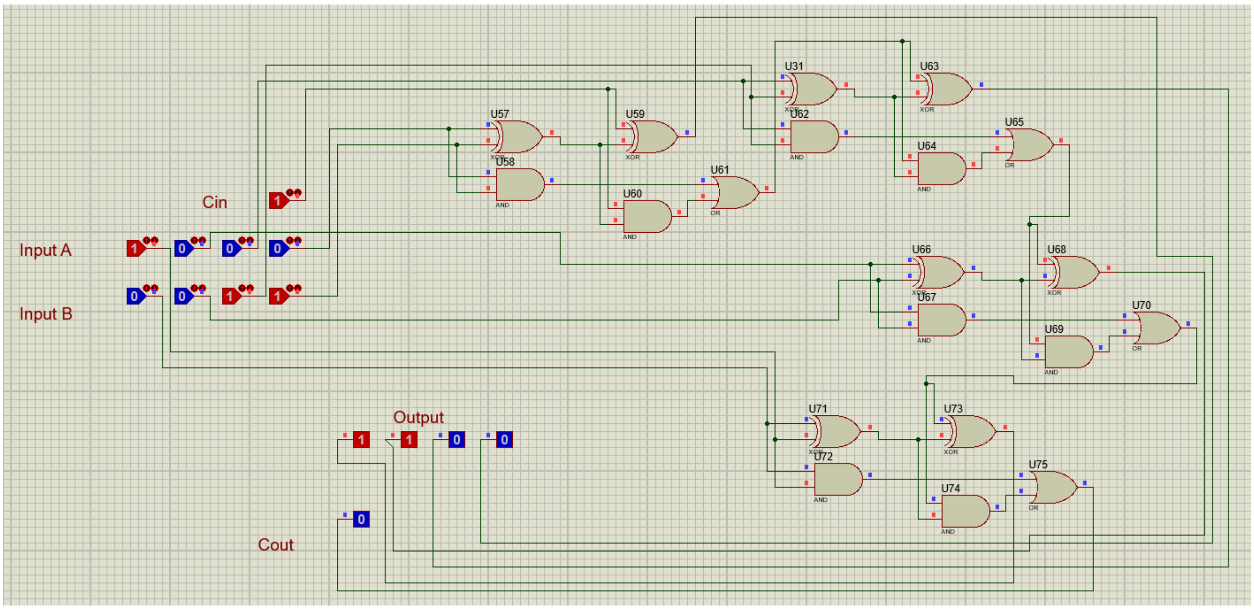


Figure 4: With carry bit

3. 3 and 9:

3 = 0011

9 = 1001

3+9 = 12 = 1100

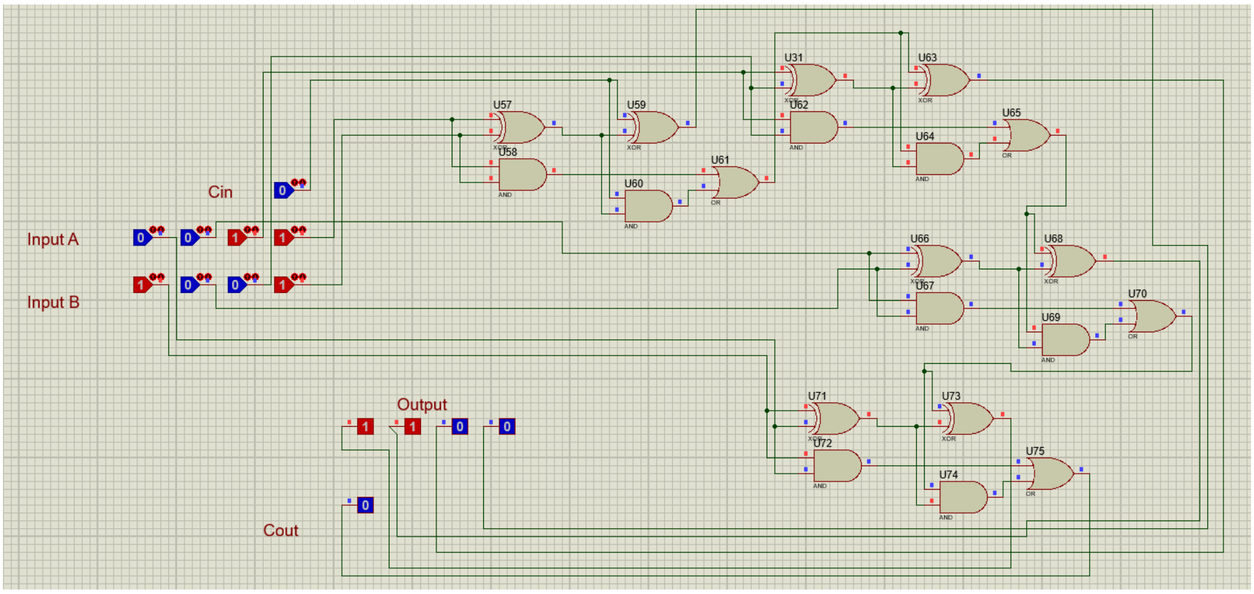


Figure 5: Without carry bit

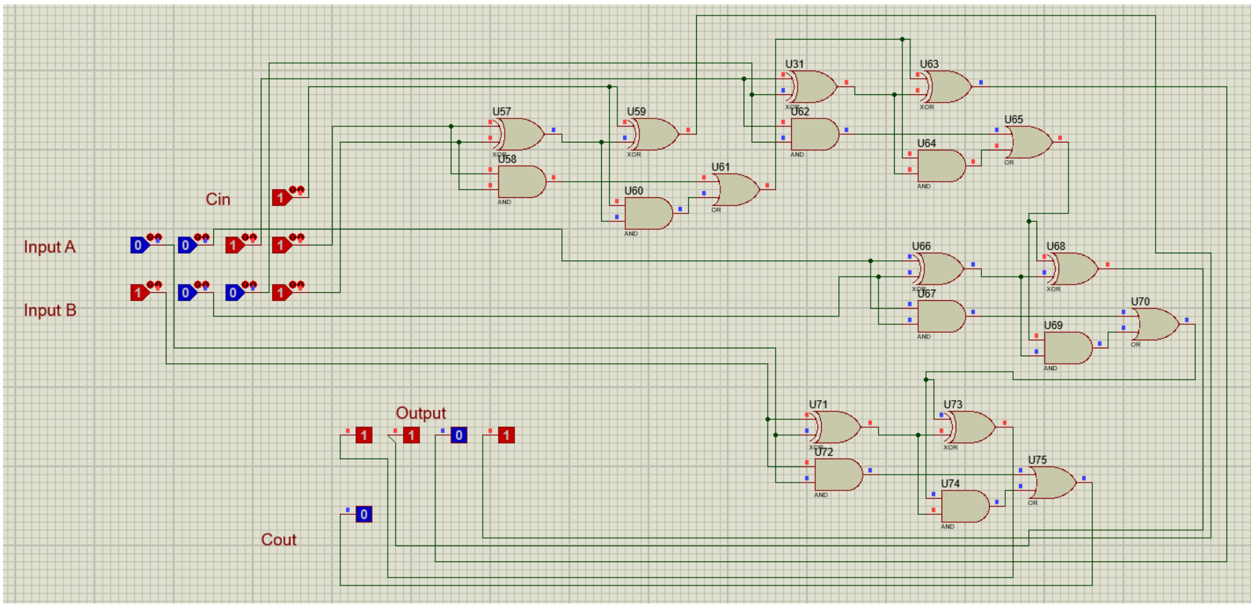


Figure 6: With carry bit

4. 11 and 4:

11 = 1011

4 = 0100

11+4 = 15 = 1111

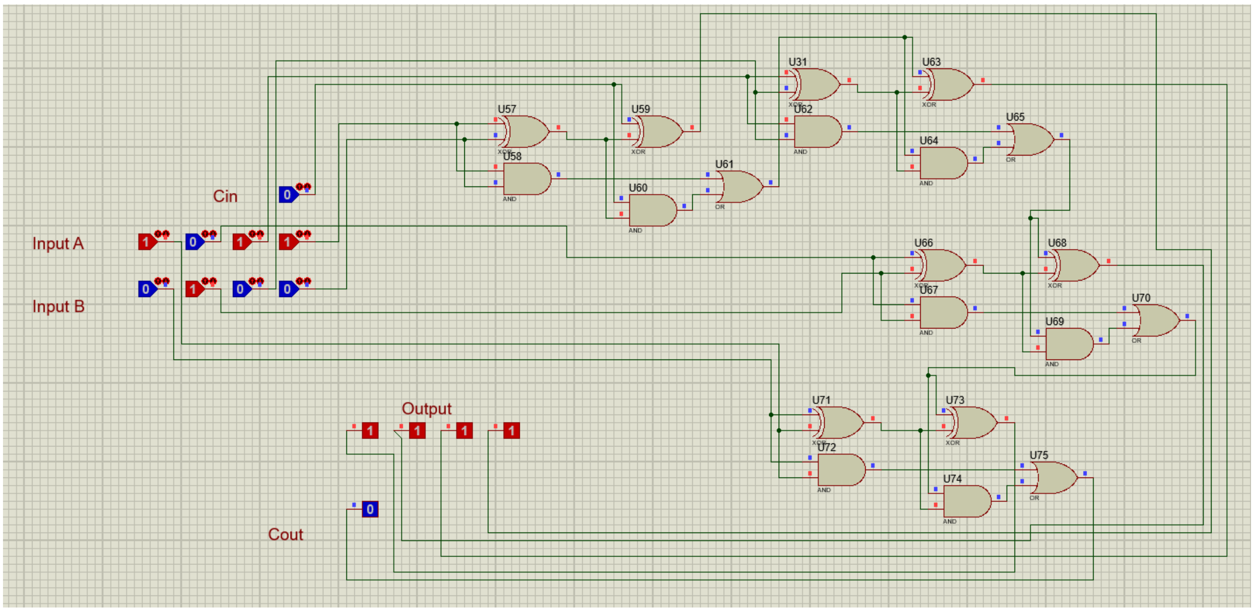


Figure 7: Without carry bit

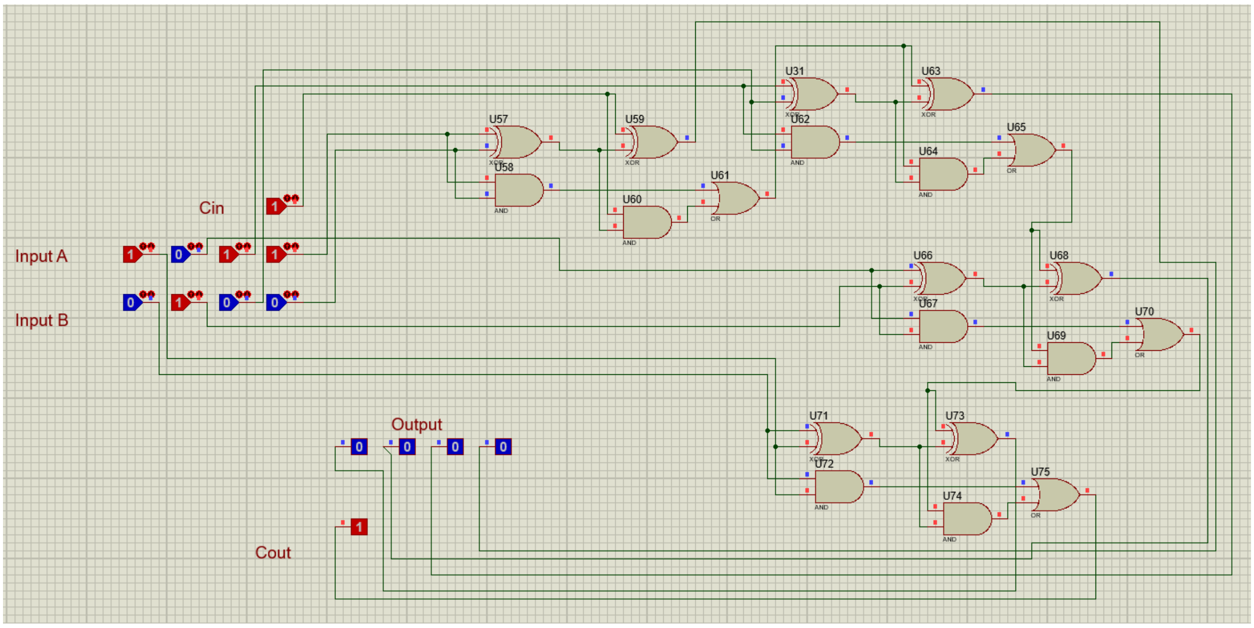


Figure 8: With carry bit

Task 4:

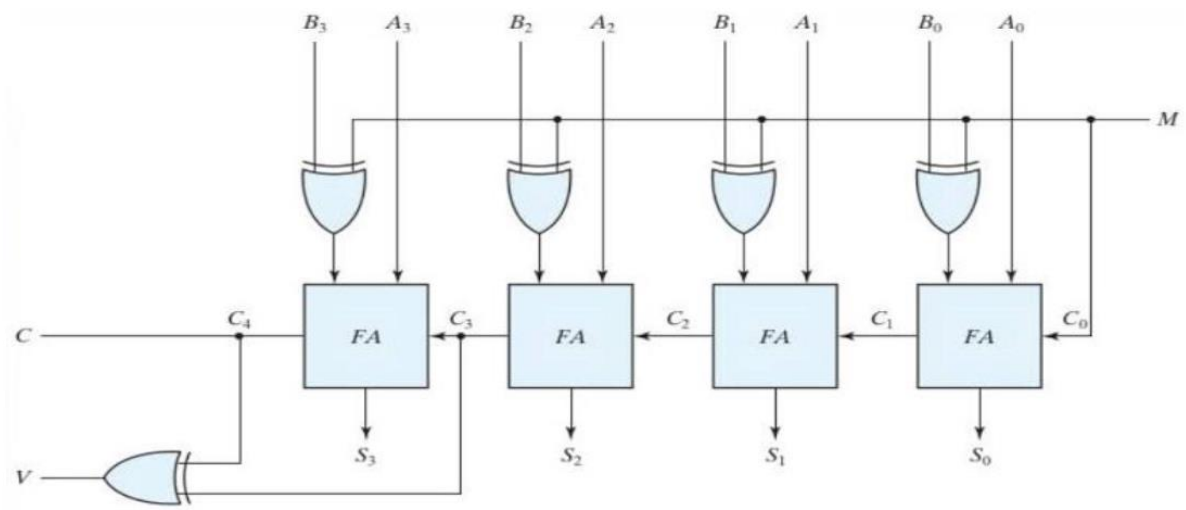
Implement 4-bit adder subtractor circuit and verify results. You have to verify the following combinations.

0000, 0000

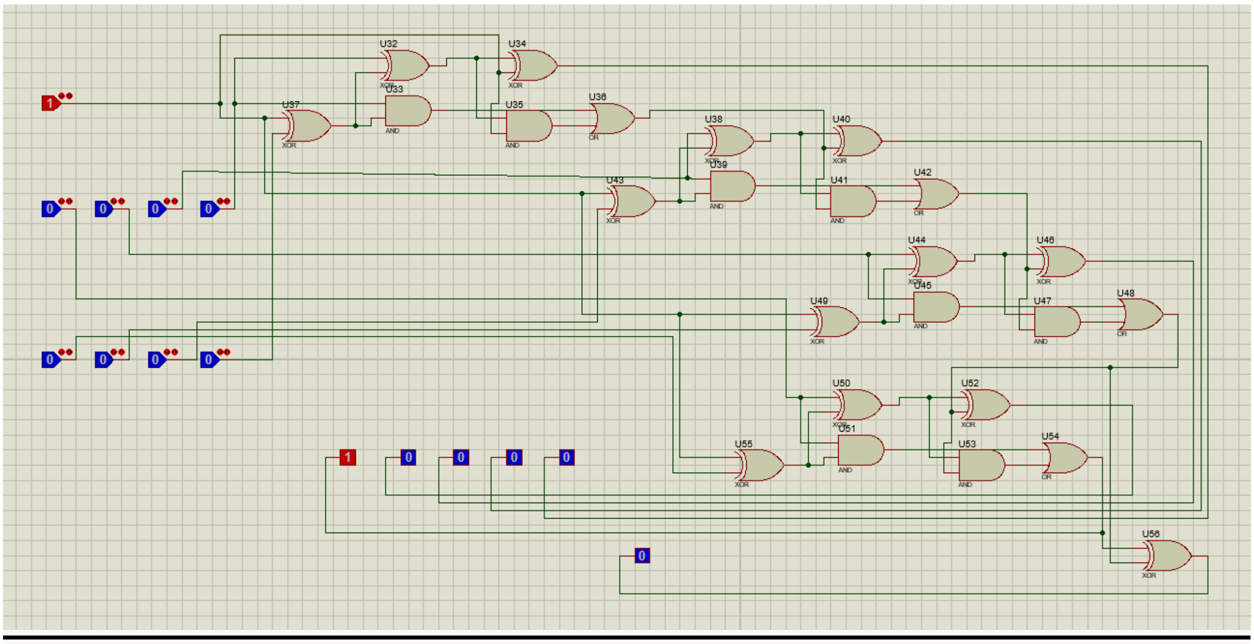
0001, 1000

0010, 0100
1111, 0110
With M = 0 and 1.

Adder Subtractor diagram:



Circuit:

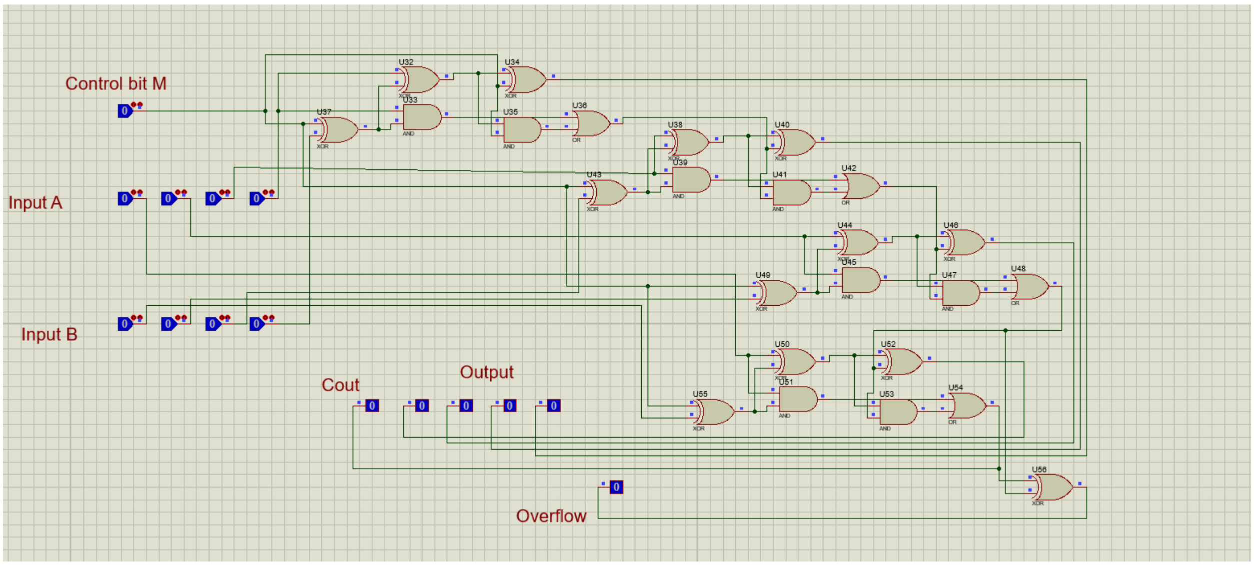


Working:

1. 0000, 0000:

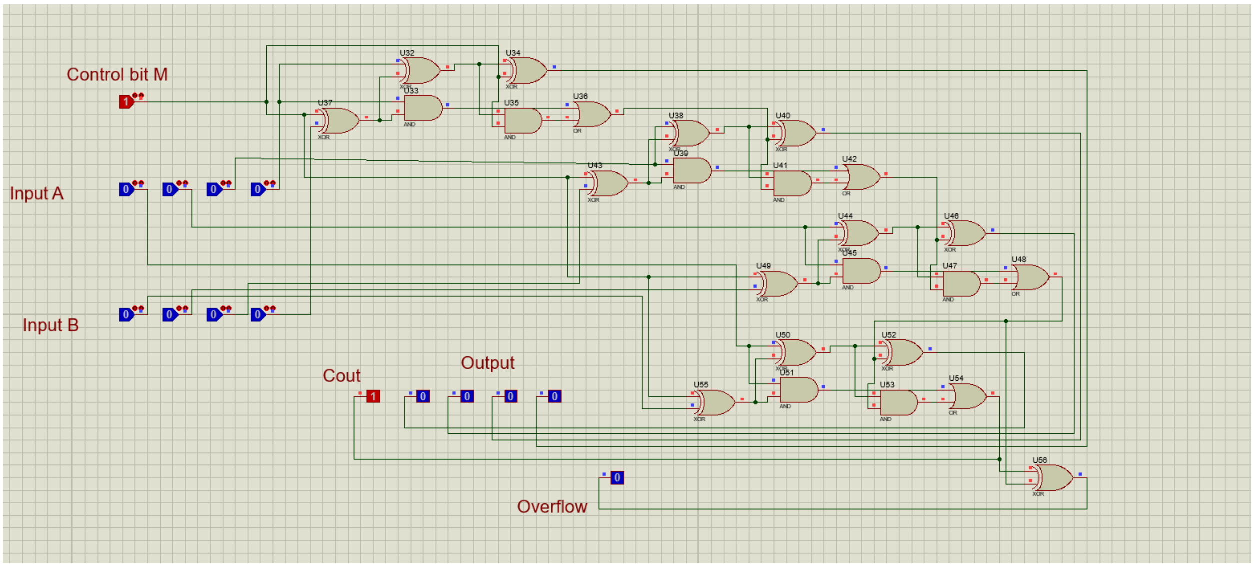
M=0 (Addition)

0000 + 0000 = 0000



M=1 (Subtraction)

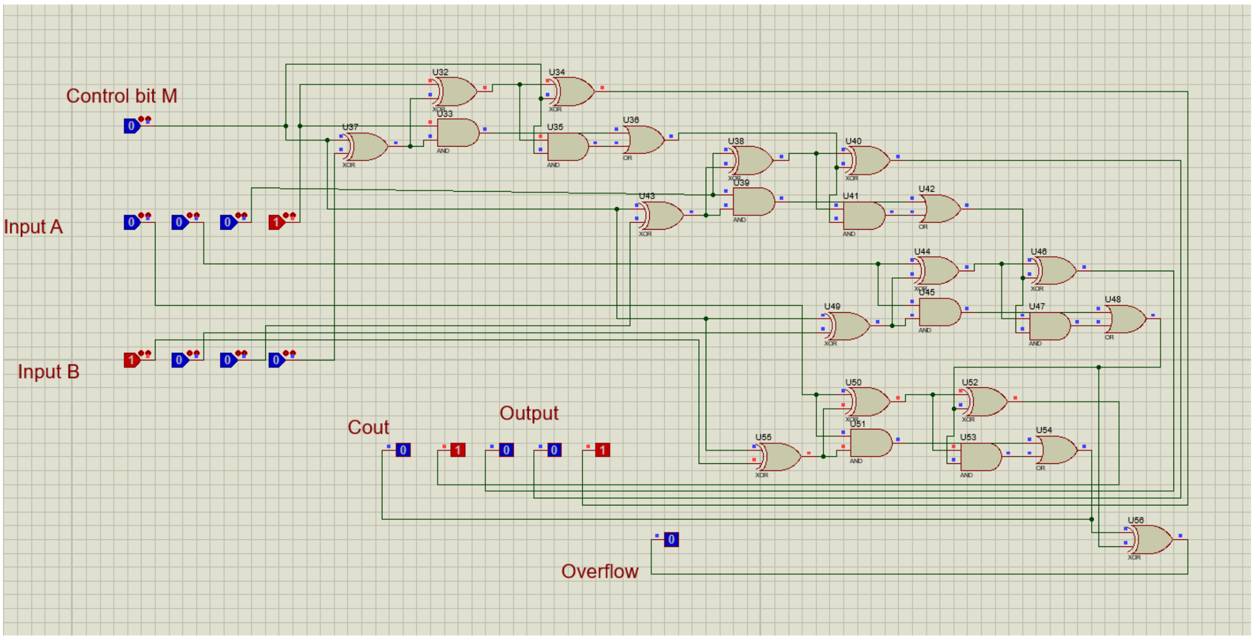
0000 – 0000 = 0000



2. 0001, 1000:

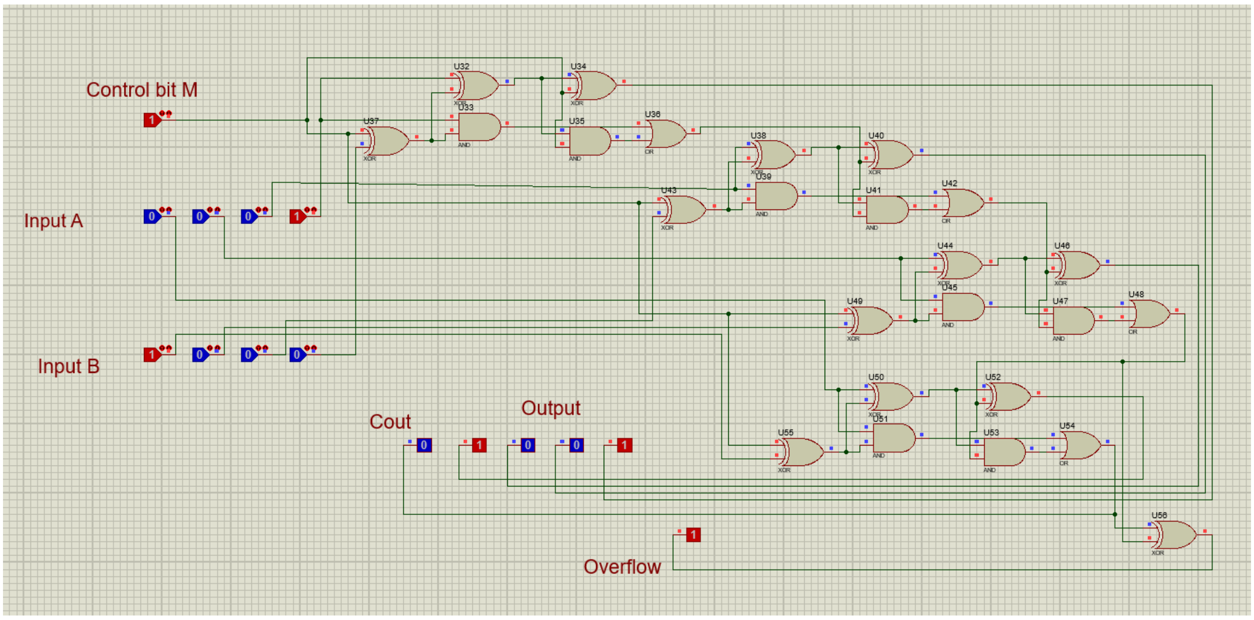
M=0 (Addition)

0001 + 1000 = 1001



M=1 (Subtraction)

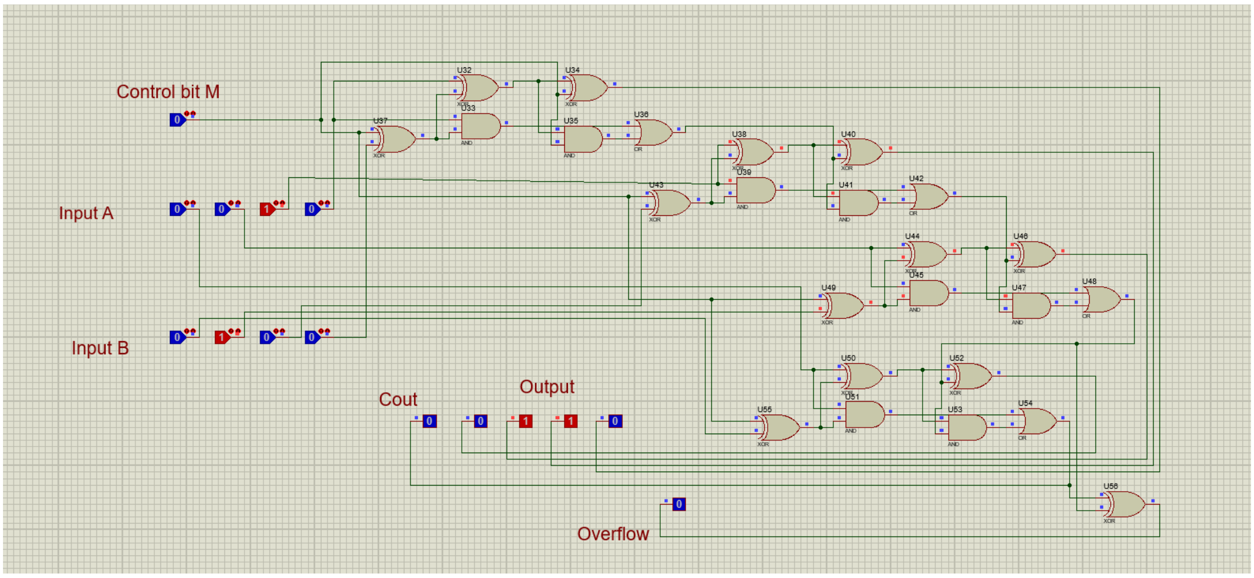
0001 – 1000 = 1001 with 1 borrow



3. 0010, 0100:

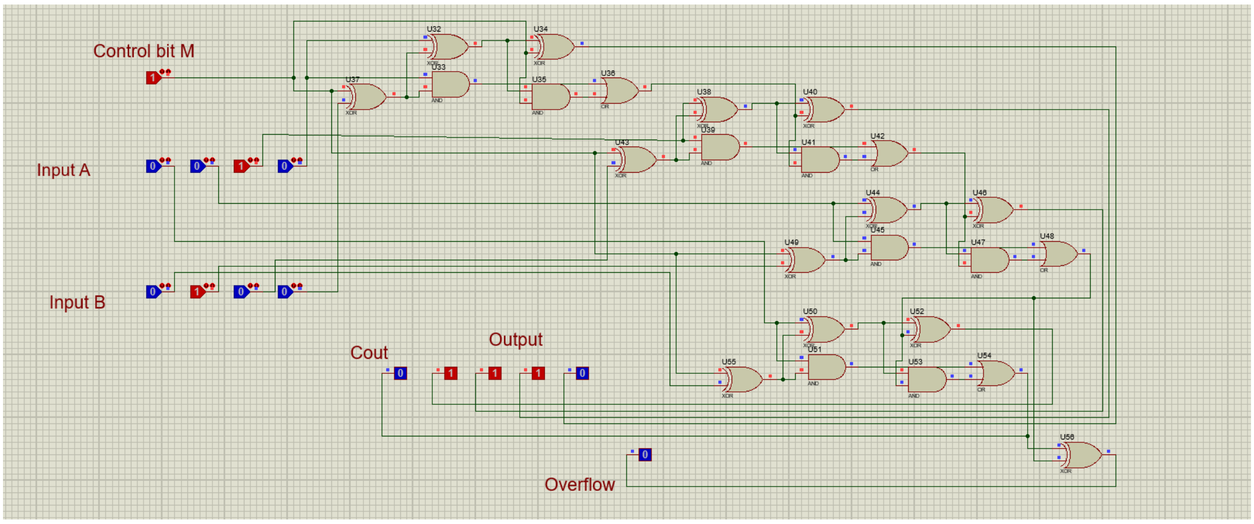
M=0 (Addition)

0010 + 0100 = 0110



M=1 (Subtraction)

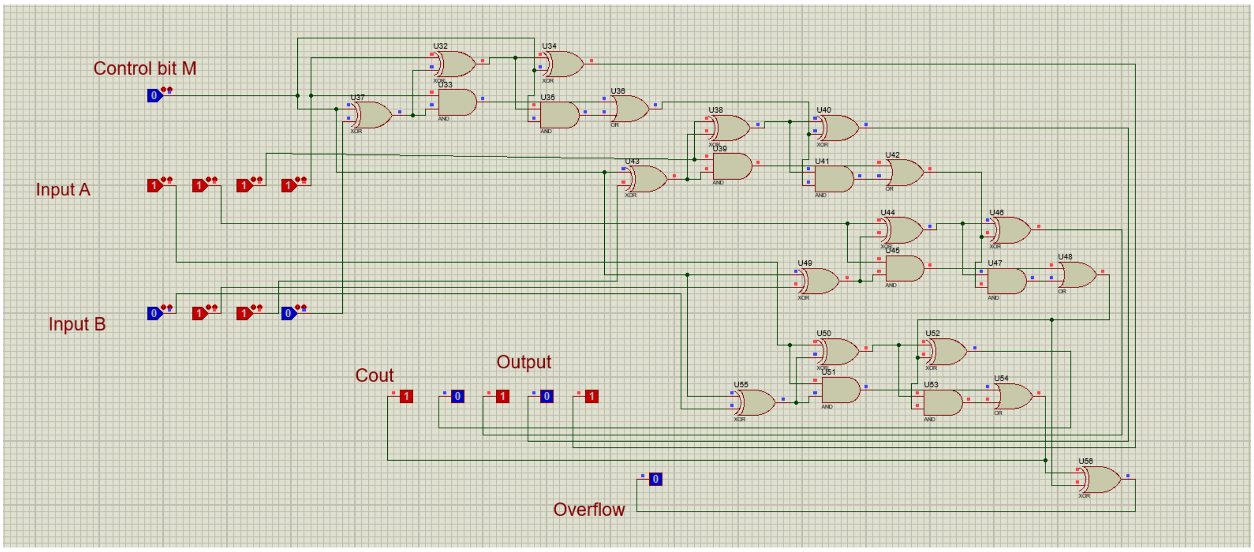
0010 – 0100 = 1110



4. 1111, 0110:

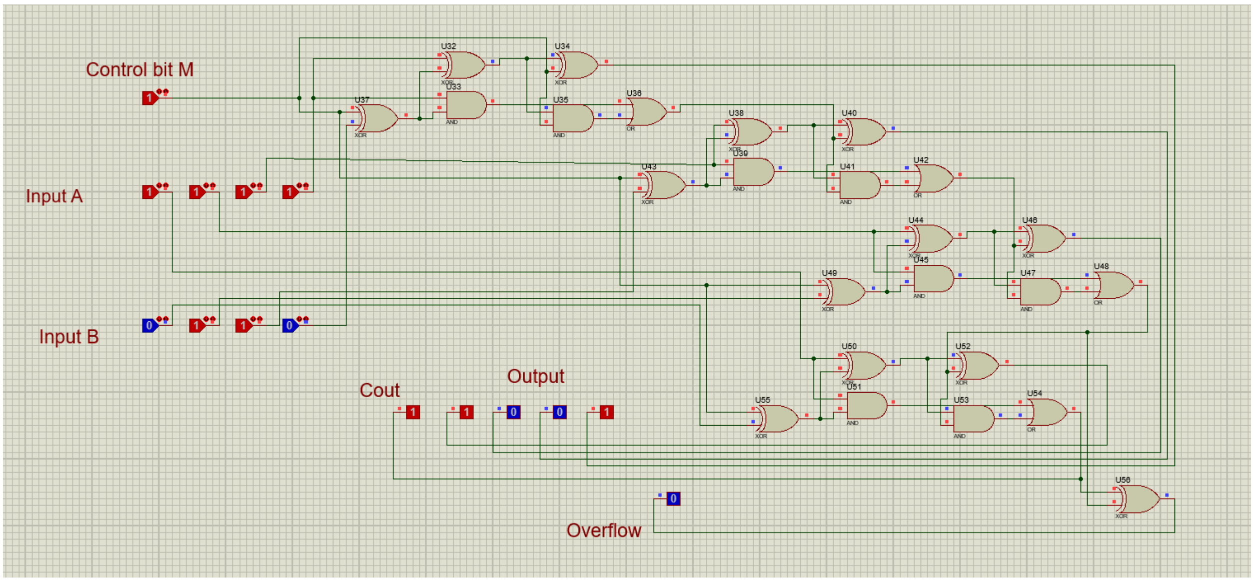
M=0 (Addition)

1111 + 0110 = 0101 with 1 carry



M=1 (Subtraction)

1111 – 0110 = 1001



Conclusion:

In this lab, we have learned how to construct the half adder and full adder circuits, their implementations and their truth tables. We have also learned the same for half and full subtractor circuits, and their implementation.
We have also learned to implement a full adder for any number of bits by making a combinatorial circuit using N number of full adders, to add N number of bits together.
We have also learned to make a Adder-Subtractor circuit, which uses a control bit to both add or subtract based on the control.