TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS

LAB REPORT

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Submitted By:
Name: Suban Shrestha
Roll No: 076BCT082
Group: CD(D)

Submitted To:
Department of Electronics and Communications Enginnering

Half Adder, Half Subtractor, Full Adder, Full Subtractor

1 Objectives

1. To Study the half adder and full adder circuit and their truthtable.
2. To study the half subtractor and full Subtractor circuits and their truthtable.
3. To Realize half adder and half subtractor in a single circuit.
4. To Realize full adder and full subtractor in a single circuit.

2 Theory

2.1 Combinational Logic Circuit

Combinational Logic Circuits are made up from basic logic NAND, NOR , NOT or basic gates that are combined or connected together to produce more complicated desired results. Some examples of Combinational logic circuits are encoder, decoders, adders, multiplexers, etc. As combinational logic circuits are made up from individual logic gates only they can be considered as "decision making circuits" and combinational logic is about coming logic gates together to process two or more signals in order to produce at least one output signal accourding to the logical function of each logic gate.Common combinational circuits made up from the inidividual logic gates that carry out a desired application include adders, subtractors,multiplexers etc.

2.2 Half Adder

Half adder is a type of adder circuit that performs binary addition on its two inpus, and provides a sum and a carry value. This computation can be represented by XOR (for sum) and AND (for carry).

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table 1: Truth Table

Half Adder Block Diagram

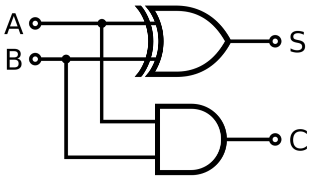


Figure 1: Circuit Diagram of Half Adder

Boolean Expression

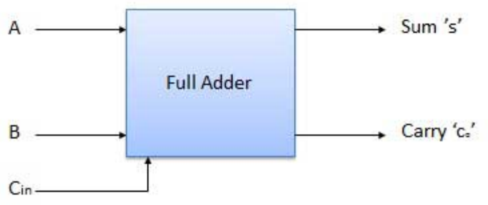
$$Sum = A \oplus B$$
$$Carry = A.B$$

2.3 Full Adder

Full adder is a type of adder circuit that performs binary addition on its three inpus, and provides a sum and a carry value. Full adders are can be made by using XOR, AND and OR gates. A full adder can also be made by using two half adders.

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

Table 2: Truth Table



Full Adder Block Diagram

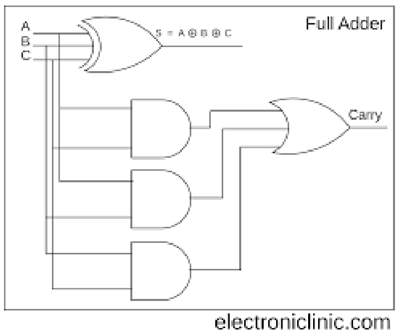


Figure 2: Circuit Diagram of Full Adder

Boolean Expression

$$\begin{aligned} Sum &= A'B'C + A'BC' + AB'C' + ABC \\ &= A'(B'C + BC') + A(B'C' + BC) \\ &= A'(B \oplus C) + A(B \oplus C)' \\ &= A \oplus B \oplus C \end{aligned} \tag{1}$$

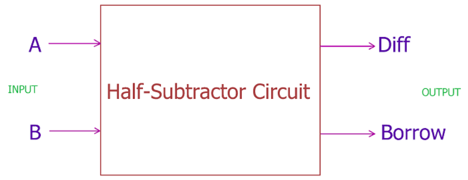
$$\begin{aligned} Carry &= A'BC + AB'C + ABC' + ABC \\ &= BC(A + A') + A(B'C + BC') \\ &= BC + AB'C + ABC' \end{aligned} \tag{2}$$

2.4 Half Subtractor

A half subtractor is a combinational circuit that subracts two bits and produces their difference. It also has an output to sepcify if a 1 has been borrowed.

A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Table 3: Truth Table



Half Subtractor Block Diagram

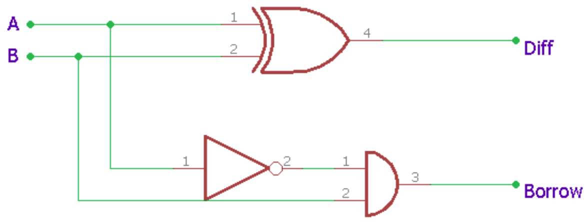


Figure 3: Circuit Diagram of Half Subtractor

Boolean Expression

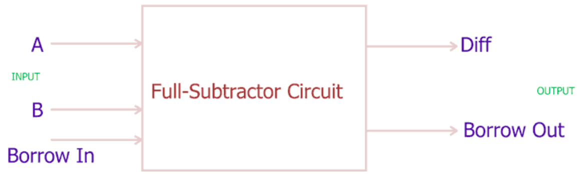
$$Sum = A \oplus B$$
$$Carry = A'.B$$

2.5 Full Subtractor

A full subtractor is a combinational circuit that performs a subtraction between two bits, taking into account that 1 may have been borrowed by a lower significant stage. This circuit has three inputs and two outputs.

A	B	B_{in}	Difference	B_{out}
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

Table 4: Truth Table



Full Subtractor Block Diagram

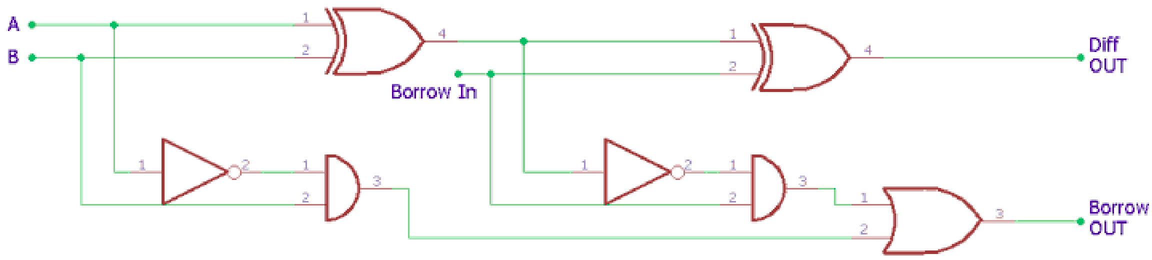


Figure 4: Circuit Diagram of Subtractor Adder

Boolean Expression

$$\begin{aligned} Difference &= A'B'B_{in} + A'BB'_{in} + AB'B'_{in} + ABB_{in} \\ &= B_{in}(A'B' + AB) + B'_{in}(AB' + A'B) \\ &= B_{in}(A \oplus B)' + B'_{in}(A \oplus B) \\ &= B_{in} \oplus A \oplus B \\ &= A \oplus B \oplus B_{in} \end{aligned} \tag{3}$$

$$\begin{aligned} B_{out} &= A'B'B_{in} + A'BB'_{in} + A'BB_{in} + ABB_{in} \\ &= A'B'B_{in} + A'BB'_{in} + A'BB_{in} + A'BB_{in} + A'BB_{in} + ABB_{in} \\ &= A'B_{in}(B + B') + A'B(B_{in} + B'_{in}) + BB_{in}(A + A') \\ &= A'B_{in} + A'B + BB_{in} \end{aligned} \tag{4}$$

2.6 Full adder using Half Adders

Full adder can be constructed by using half adders. It requires two full adders and a Or gate.
Boolean Expression

$$Sum = A \oplus B \oplus C \tag{5}$$

$$\begin{aligned} Carry &= A'BC + AB'C + ABC' + ABC \\ &= C(A'B + AB') + AB(C' + C) \\ &= C(A \oplus B) + AB \end{aligned} \tag{6}$$

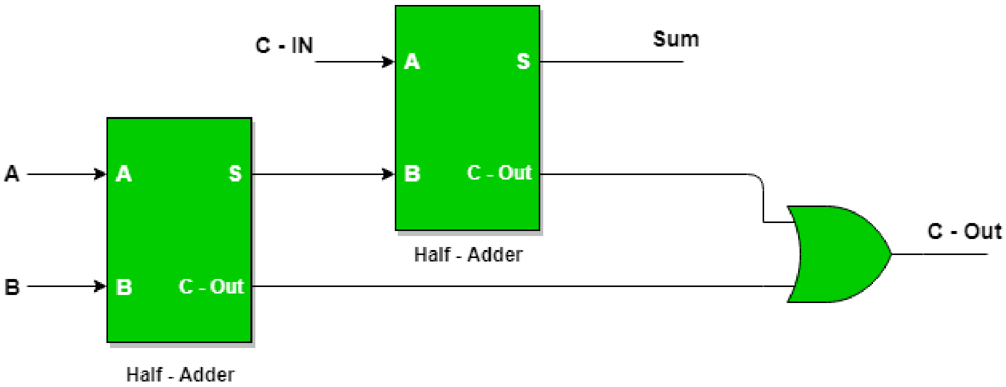


Figure 5: Block Diagram of Full Adder from Half Adders

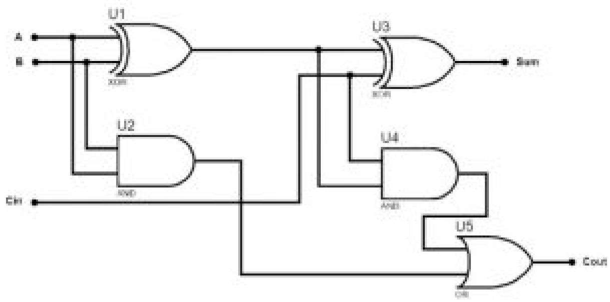


Figure 6: Circuit Diagram of Full Adder from half adders

2.7 Full Subtractor using Half Subtractor

Full subtractor can be constructed by using half subtractors. **Boolean Expression**

$$Sum = A \oplus B \oplus C \tag{7}$$

$$\begin{aligned} Carry &= A'B'B_{in} + A'BB_{in} + A'BB'_{in} + ABB_{in} \\ &= A'B(B_{in} + B'_{in}) + B_{in}(A'B' + AB) \\ &= A'B + C(A \oplus B)' \end{aligned} \tag{8}$$

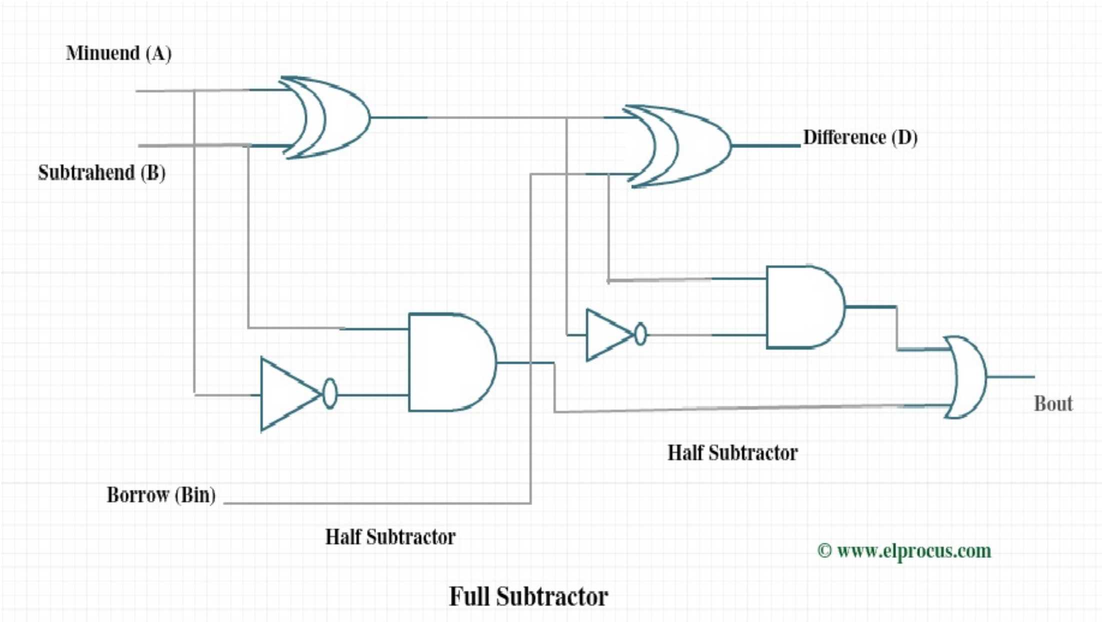


Figure 7: Circuit Diagram of Full subtractor from Half Subtractor

2.8 Realization of half adder and half subtractor in a single circuit

If we introduce a new input called switch or control state which chooses if the given two inputs will be added or subracted. We can Realize a half adder and a half subtractor in a single circuit. We can make it so that, When S=0, addition occours and when S=1, subtraction occours.

$$Sum/Difference = A \oplus B \tag{9}$$

$$\begin{aligned} Borrow/Carry &= C'AB + CA'B) \\ &= B(C'A + CA') \\ &= B(C \oplus A) \end{aligned} \tag{10}$$

S	A	B	Difference/Sum	Borrow/Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	0	0
1	0	1	1	1
1	1	0	1	0
1	1	1	0	0

Table 5: Truth Table

2.9 Realization of full adder and full subtractor in a single circuit

If we introduce a new input called switch or control state which chooses if the given two inputs will be added or subracted. We can Realize a full adder and a full subtractor in a single circuit. We can make it so that, When S=0, addition occours and when S=1, subtraction occours.

$$\begin{aligned} Sum/Difference &= AB'C + A'B'C + ABC + A'BC' \\ &= A'(B'C + BC') + A(B'C' + BC) \\ &= A'(B \oplus C) + A(B \oplus C)' \\ &= A \oplus B \oplus C \end{aligned} \tag{11}$$

$$\begin{aligned} Carry/Borrow &= BC + S'AC + S'AB + SA'C + SA'B \\ &= BC + S'AC + SA'C + S'AB + SA'B \\ &= BC + C(S'A + SA') + (S'A + SA') \\ &= BC + C(A \oplus S) + B(S \oplus A) \\ &= BC + (A \oplus B)(B + C) \end{aligned} \tag{12}$$

S	A	B	C	Difference/Sum	Borrow/Carry
0	0	0	0	0	0
0	0	0	1	1	0
0	0	1	0	1	0
0	0	1	1	0	1
0	1	0	0	1	0
0	1	0	1	0	1
0	1	1	0	0	1
0	1	1	1	1	1
1	0	0	0	0	0
1	0	0	1	1	1
1	0	1	0	1	1
1	0	1	1	0	1
1	1	0	0	1	0
1	1	0	1	0	0
1	1	1	0	0	0
1	1	1	1	1	1

Table 6: Truth Table

3 Lab

4 Half Adder

The following half adder circuit was made in proteus

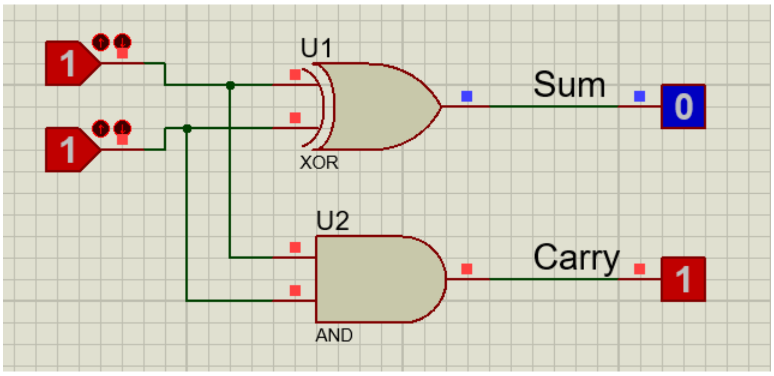


Figure 8: Half Adder circuit

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table 7: Truth Table

4.1 Full Adder

Full adder Circuit was simulated in proteus and truth table was verified.

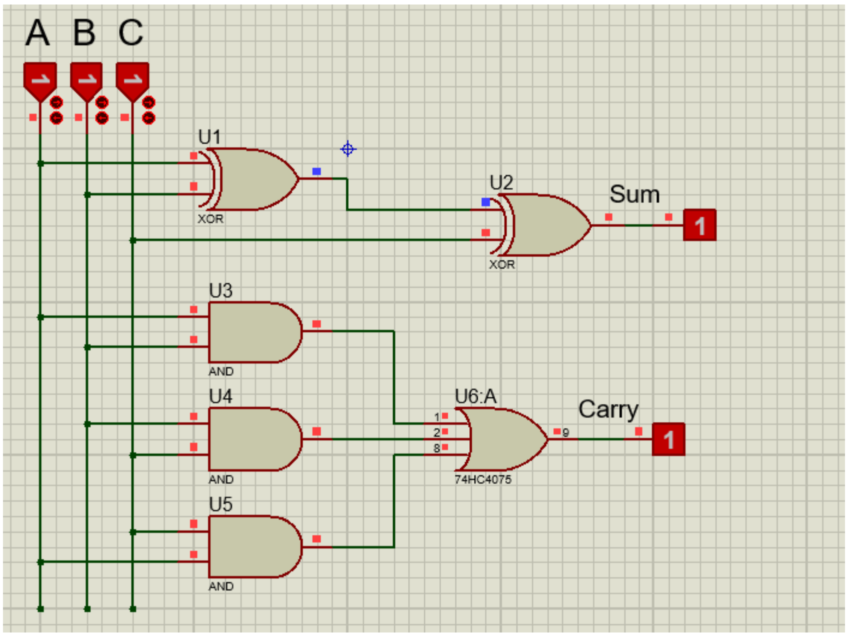


Figure 9: full adder circuit

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

Table 8: Truth Table

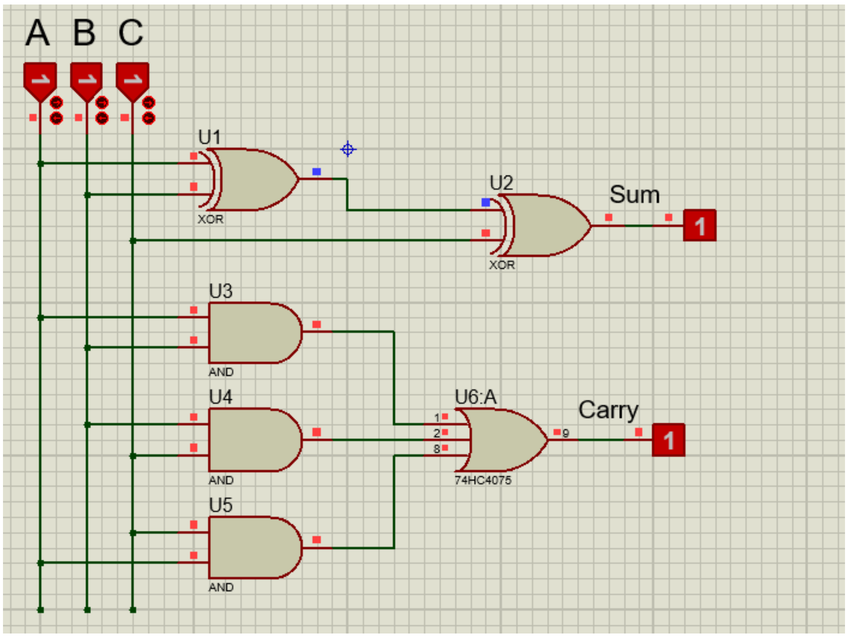


Figure 10: Full adder from half adders

4.2 Half Subtractor

Half Subtractor Circuit was built, and simulated in proteus and truth table was obtained.

A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Table 9: Truth Table

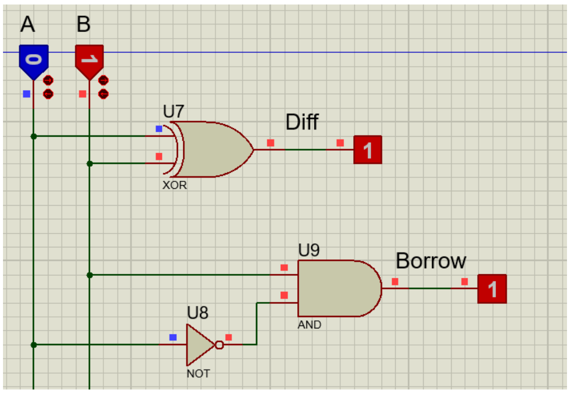


Figure 11: Half Subtractor

4.3 Full Subtractor

Half Subtractor Circuit was built, and simulated in proteus and truth table was obtained.

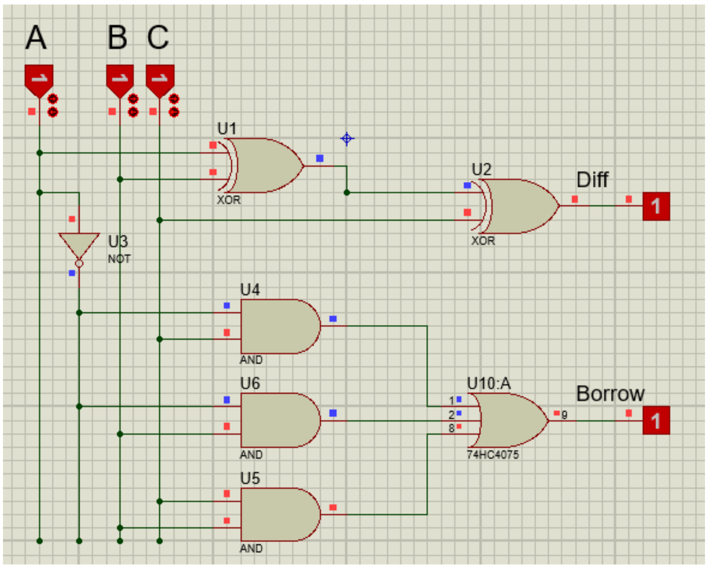


Figure 12: Full Subtractor

A	B	B_{in}	Difference	B_{out}
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

Table 10: Truth Table

4.4 Realization of half adder and half subtractor in a single circuit

If we introduce a new input called switch or control state which chooses if the given two inputs will be added or subracted. We can Realize a half adder and a half subtractor in a single circuit. We can make it so that, When S=0, addition occours and when S=1, subtraction occours.

$$Sum/Difference = A \oplus B \tag{13}$$

$$Carry/Borrow = B(S \oplus A) \tag{14}$$

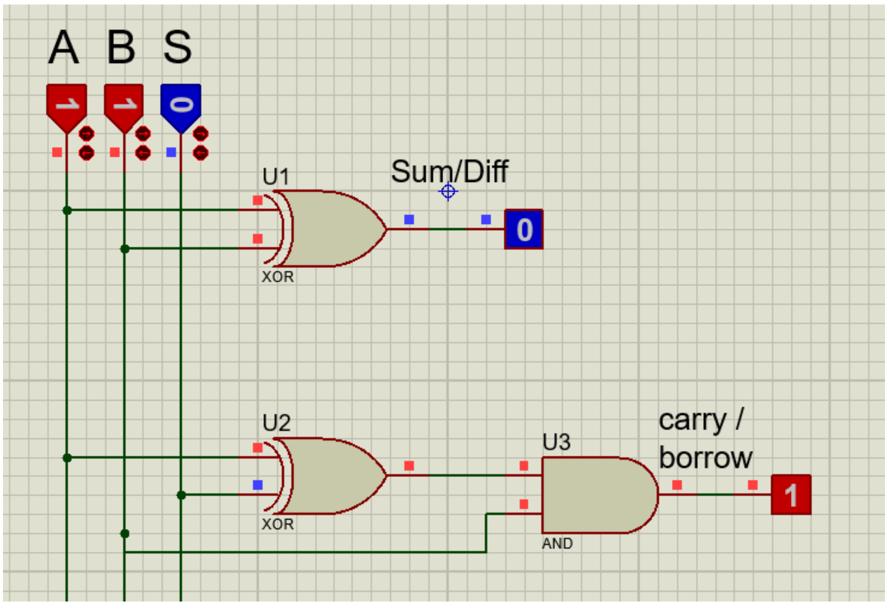


Figure 13: Half adder and Half subtractor in a single circuit

S	A	B	Difference/Sum	Borrow/Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	0	0
1	0	1	1	1
1	1	0	1	0
1	1	1	0	0

Table 11: Truth Table

4.5 Realization of full adder and full subtractor in a single circuit

If we introduce a new input called switch or control state which chooses if the given two inputs will be added or subracted. We can Realize a full adder and a full subtractor in a single circuit. We can make it so that, When S=0, addition occours and when S=1, subtraction occours.

$$Sum/Difference = A \oplus B \oplus C \tag{15}$$

$$Carry/Borrow = BC + (A \oplus S).(B + C) \tag{16}$$

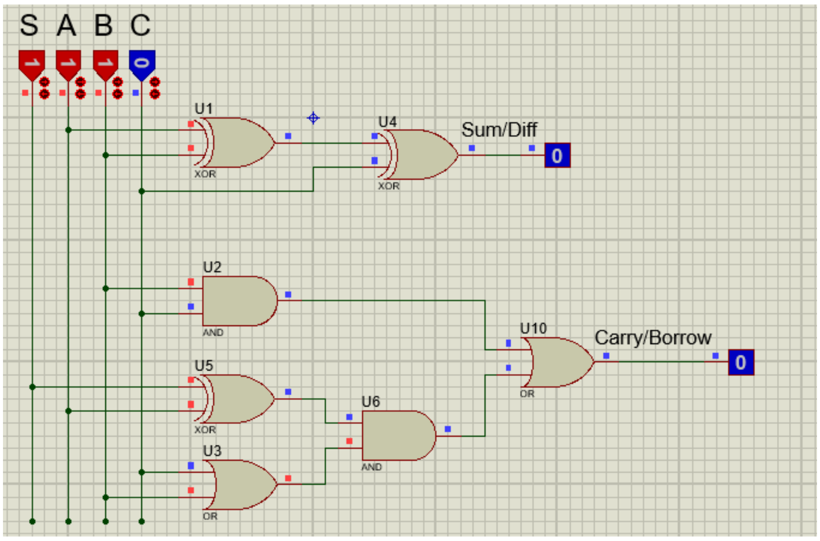


Figure 14: Full adder and Full subtractor in a single circuit

S	A	B	C	Difference/Sum	Borrow/Carry
0	0	0	0	0	0
0	0	0	1	1	0
0	0	1	0	1	0
0	0	1	1	0	1
0	1	0	0	1	0
0	1	0	1	0	1
0	1	1	0	0	1
0	1	1	1	1	1
1	0	0	0	0	0
1	0	0	1	1	1
1	0	1	0	1	1
1	0	1	1	0	1
1	1	0	0	1	0
1	1	0	1	0	0
1	1	1	0	0	0
1	1	1	1	1	1

Table 12: Truth Table

5 Discussion

Various digital circuits were constructed in the practical their truth tables wre obtained. The truth table of the circuits and Kmap was used to obtain a boolean expression for the circuit. With this their circuits were constructed. We got a better understanding the Combinational logic circuits. We were able to construct half adder, half subtractor, full adder, full subtractor circuits. We also learned that full adder circuit can be constructed using 2 half adders. Similarly a full subtractor circuit can be constructed using 2 half subtractors. We were also able to construct half adder and half subrractor in a single circuit, and similarly full andder and full subtractor in a single circuit. This was possible with the help of a switch(S) signal. The circuit would perform addition when S=0 and subtraction when S=1.

6 Conclusion

Thus, a through understanding of various combinational logic circuits was obtained. Kmap was used to obtain the boolean expresstion for half adder, half subtractor, full adder, full subtractor, half adder and half subtractor in single circuit, full adder and full subtractor in single circuit. These circuits were constructed and their behavour was deeply studied.