NE-3102: Electronics-II Laboratory

Roll ____________ Date ____________ Experiment No. ____________

Name of the experiment

Design (a) half adder, full adder and (b) half subtractor, full subtractor circuits using logic gates and test the circuits.

Contents

1 Objective

1. To implement half adder and full adder, half subtractor, and full subtractor circuits using logic gates (OR, AND, Ex-OR, etc.).
2. To test the circuits.

2 Theory

2.1 Half adder

The half adder circuit is required to add two input digits (for example, A and B) and generate a carry and sum. The half adder adds two binary digits called augend and addend and produces two outputs as sum and carry (XOR is applied to bate inputs to produce sum, and AND gate is applied to bate inputs to produce carry). It means half adder circuit can add only two digits.

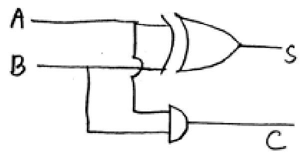

Figure 1: Half adder.

A	B	S	Cout
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table 1: Truth table for half adder.

$$\begin{gathered} S = \bar{A}B + A\bar{B} = A \oplus B \\ C_{out} = AB \end{gathered} \tag{1}$$

2.2 Full adder

A full adder logic circuit has three inputs, A, B, and Cin, which add the three input numbers and generate a carry and sum. The full adder adds three one-bit numbers, where two can retired to as output operands, and one can be retired to as bit carried is. And produces 2-bit output, and these can be referred to as output carry and sum. The difference between a half-adder and a full-adder is that full adder has three inputs and two outputs.

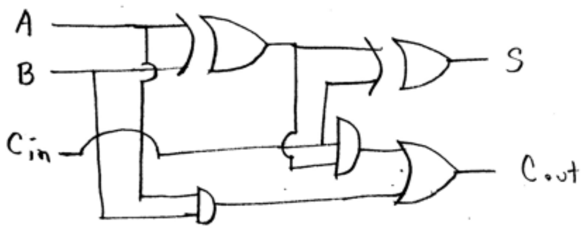

Figure 2: Full adder.

A	B	Cin	S	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

Table 2: Truth table for full adder.

$$\begin{aligned}
&S = \bar{A}B\bar{C}_{in} + A\bar{B}\bar{C}_{in} + \bar{A}\bar{B}C_{in} + ABC_{in}\\
&= \bar{C}_{in}(\bar{A}B + A\bar{B}) + C_{in}(\bar{A}\bar{B} + AB)\\
&= \bar{C}_{in}(A \oplus B) + (\overline{A \oplus B})\\
&= C_{in} \oplus (A \oplus B)\\
&C_{out} = AB\bar{C}_{in} + \bar{A}BC_{in} + A\bar{B}C_{in} + ABC_{in}\\
&= AB(\bar{C}_{in} + C_{in}) + C_{in}(\bar{A}B + A\bar{B})\\
&= AB + C_{in}(A \oplus B)
\end{aligned} \tag{2}$$

2.3 Half subtractor

The half subtractor is a combinational circuit which is used to perform subtraction of two bits.' It has two inputs, the minuend (A) and subtrahend (B), and two outputs, the difference diff and borrows out Bout. Borrows out signal is set when the subtractor needs to borrow from the next digit in a multi-digit subtraction.

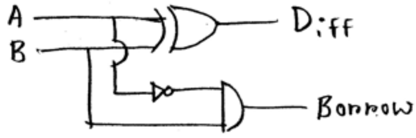

Figure 3: Half subtractor.

$$\begin{aligned}
&D = A\bar{B} + \bar{A}B = A \oplus B\\
&B_{out} = \bar{A}B
\end{aligned} \tag{3}$$

A	B	D	Bout
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Table 3: Truth table for half subtractor.

2.4 Full subtractor

A full subtractor is a combinational circuit that performs subtraction of two bits, one is minuend and the other is subtrahend, taking into account the borrow of the previous adjacent lower minuend bit. This circuit is a circuit that has three inputs and two outputs. The three inputs, A, B, and Bin, donate the minuend, subtrahend, and previous borrow.

The two outputs, D and Bout represent the difference and output borrows, respectively. Generally, the full subtractor is one of the most used and essential combinational logic circuits. It is a basic electronic device used to perform the subtraction of two binary numbers. Likewise, the full subtractor uses binary digits like 0,1 for subtraction.

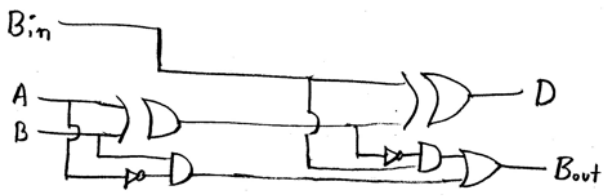

Figure 4: Full subtractor.

A	B	Bin	D	Bout
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 for full subtractor.

$$\begin{aligned}
&D = \bar{A}\bar{B}B_{in} + \bar{A}B\bar{B}_{in} + A\bar{B}\bar{B}_{in} + ABB_{in} \\
&= \bar{B}_{in}(\bar{A}B + A\bar{B}) + BB_{in}(\bar{A}\bar{B} + AB) \\
&= \bar{B}_{in}(A \oplus B) + B_{in}(\overline{A \oplus B}) \\
&= B_{in} \oplus (A \oplus B) \\
&B_{out} = \bar{A}\bar{B}B_{in} + \bar{A}B\bar{B}_{in} + \bar{A}BB_{in} + ABB_{in} \\
&= \bar{A}B(B_{in} + \bar{B}_{in}) + B_{in}(AB + \bar{A}\bar{B}) \\
&= \bar{A}B + B_{in}(\overline{A \oplus B})
\end{aligned} \tag{4}$$

3 Components and apparatus

1. Logic ICs
2. Passive components
3. Breadboard and connecting wires
4. Bench power supply

4 Circuit diagram/setup

5 Data collection and analysis

6 Result

7 Discussion

8 References

1. Tocci Ronald J, Neal W, Greg M. Digital Systems Principles and Applications.

Appendix