Title of experiment:

2’s Complement of a 4-Bit number

Theory:

2’s complement of a binary number helps us in converting unsigned number to signed numbers. This is important because computers use 2’s complement to identify integers. They are also important because arithmetic operations can be carried out on signed bits.

To find the 2’s complement of any number, we simply invert all the digits and add 1 to the Least Significant Bit (LSB).

Example-

Finding 2’s complement of 101010.

1. We invert all the digits.

   => 010101

2. We add 1 to LSB.

   => 010101+1 = 010110

Hence, 2’s complement of 101010 is 010110.

Truth table of 2’s complement of 4-bit number:

Decimal	Binary				2’s complement			
	A	B	C	D	W	X	Y	Z
0	0	0	0	0	0	0	0	0
1	0	0	0	1	1	1	1	1
2	0	0	1	0	1	1	1	0
3	0	0	1	1	1	1	0	1
4	0	1	0	0	1	1	0	0
5	0	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	0
7	0	1	1	1	1	0	0	1
8	1	0	0	0	1	0	0	0
9	1	0	0	1	0	1	1	1
10	1	0	1	0	1	1	1	0
11	1	0	1	1	0	1	0	1
12	1	1	0	0	0	1	0	0
13	1	1	0	1	0	0	1	1
14	1	1	1	0	0	0	1	1
15	1	1	1	1	0	0	0	1

Schematic Diagram:

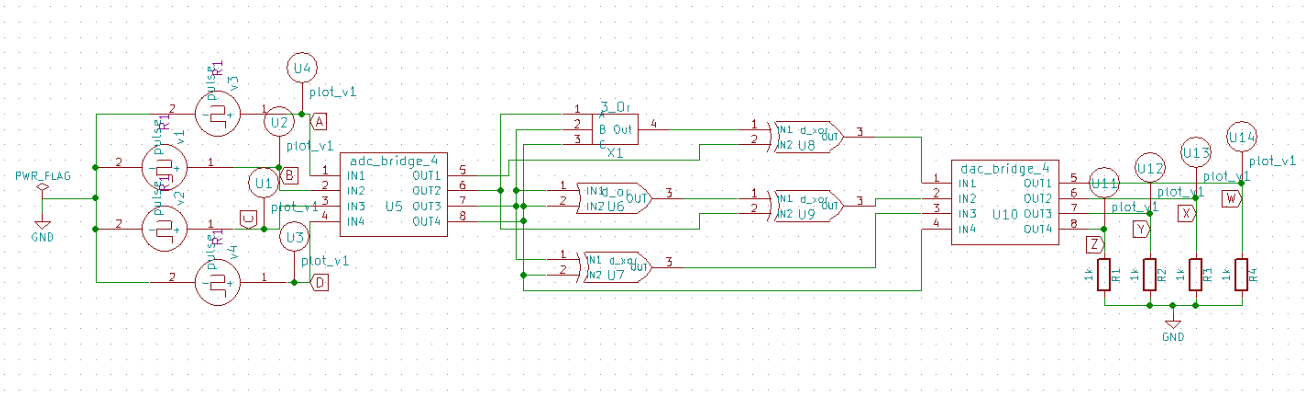

Figure 1: 2's complement of binary number

Sub-Circuit:

A sub-circuit for 3 input OR gate has been made and used in the main circuit.

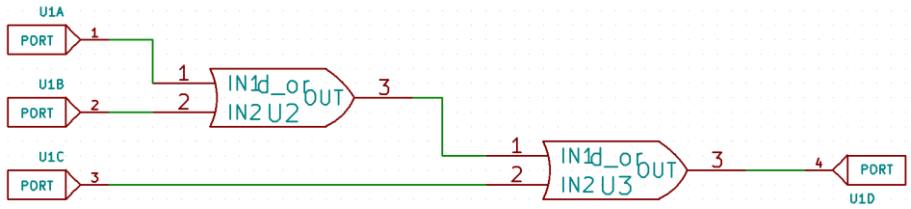

Figure 2.a: Circuit for 3 input OR gate

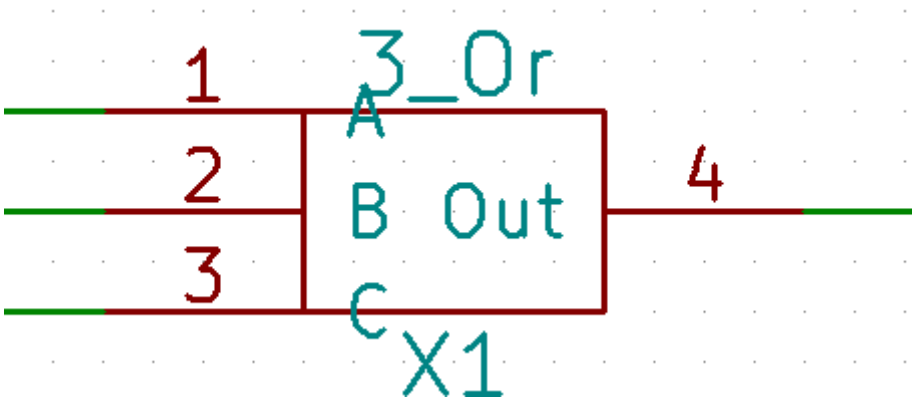

Figure 2.b: Component for 3 input OR gate used in main circuit

Simulation Plots:

1. NgSpice Plots:

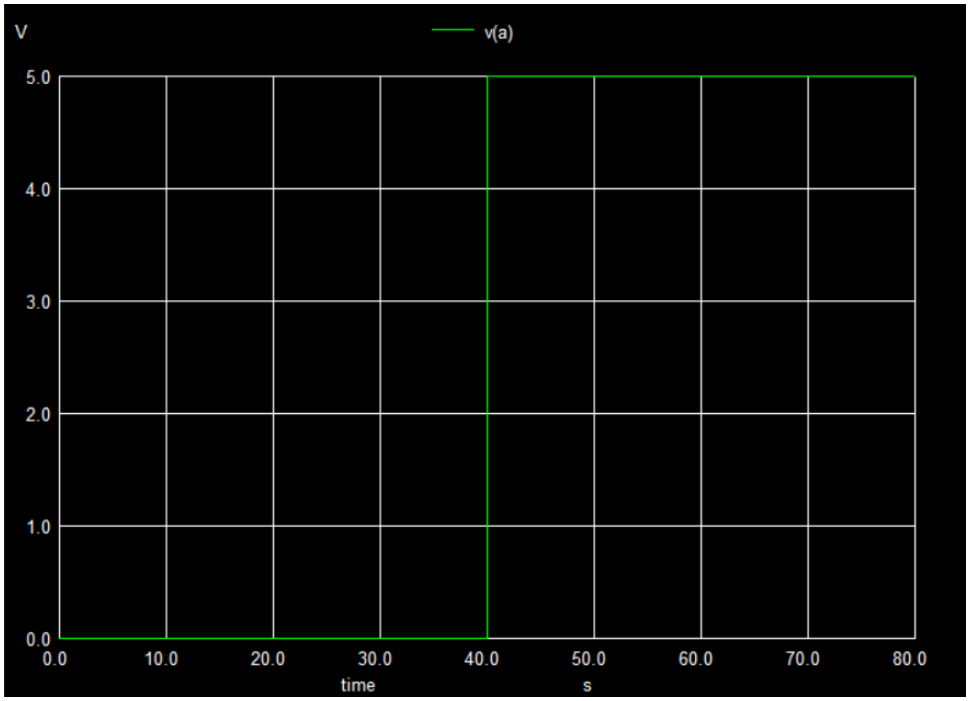

Figure 3.a: Input Plot (a)

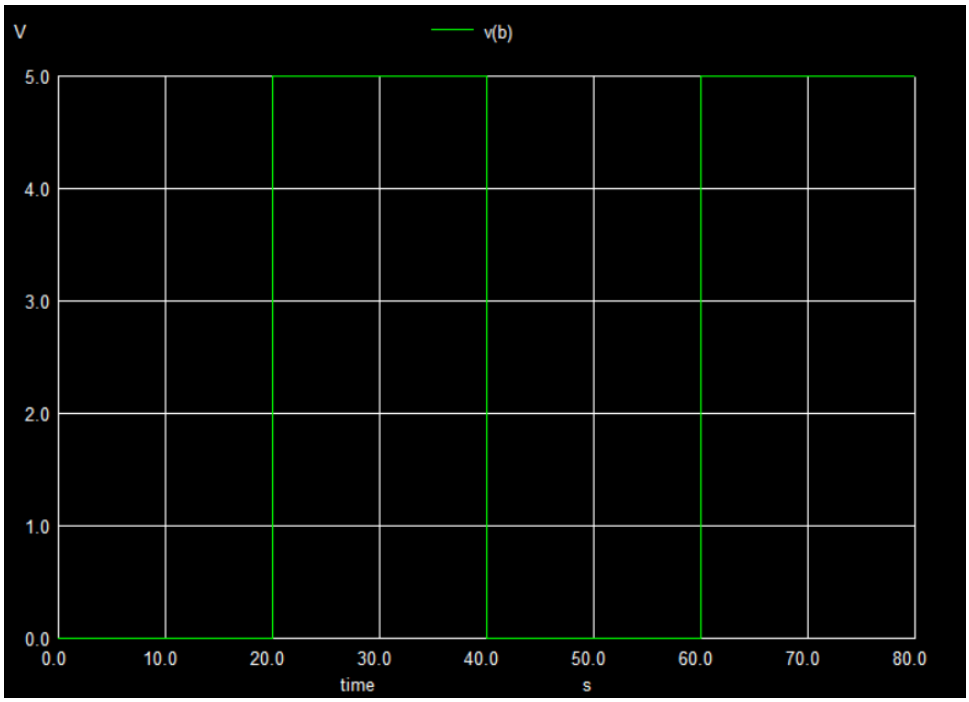

Figure 3.b: Input Plot (b)

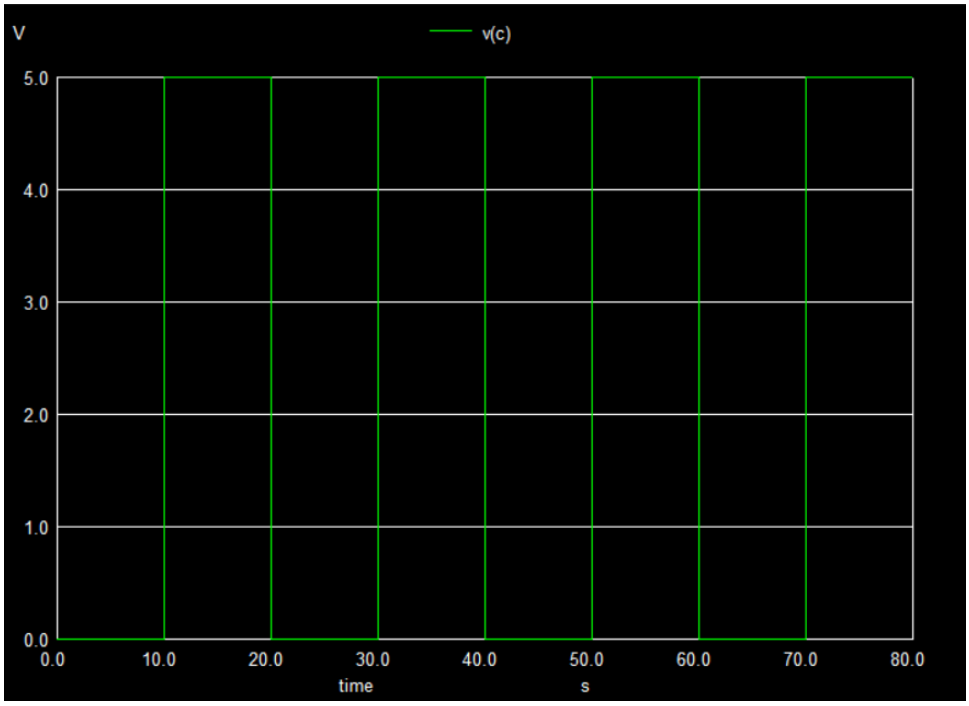

Figure 3.c: Input Plot (c)

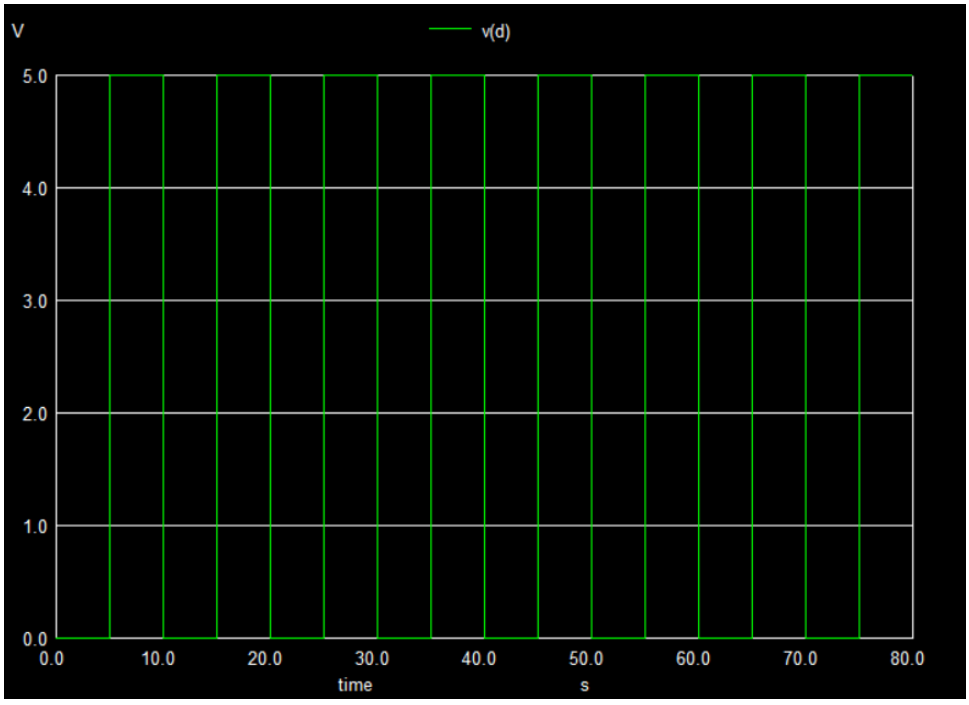

Figure 3.d: Input Plot (d)

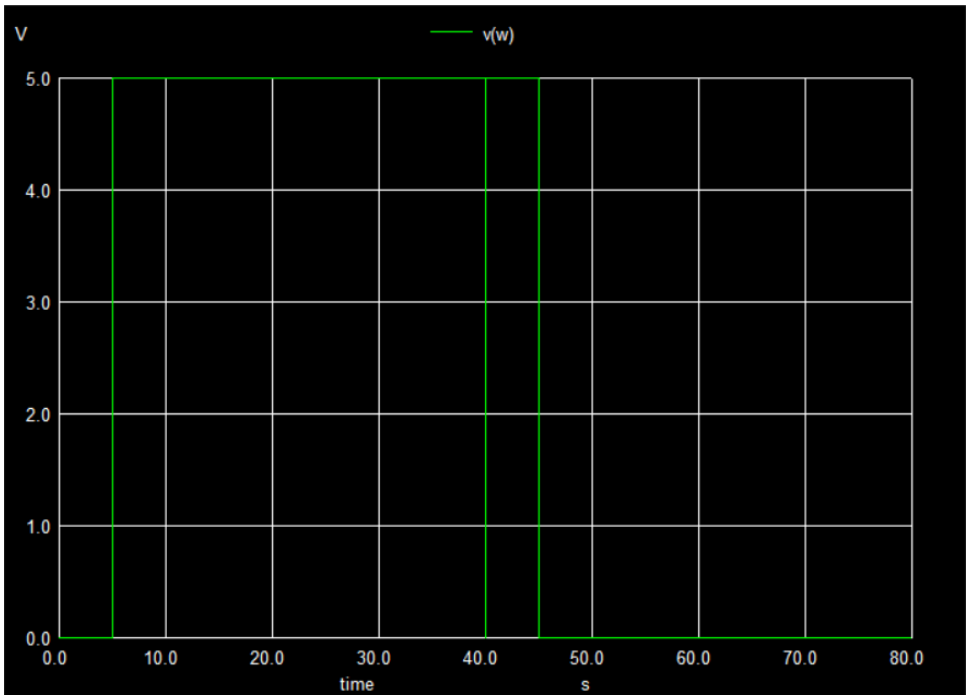

Figure 3.e: Output Plot (w)

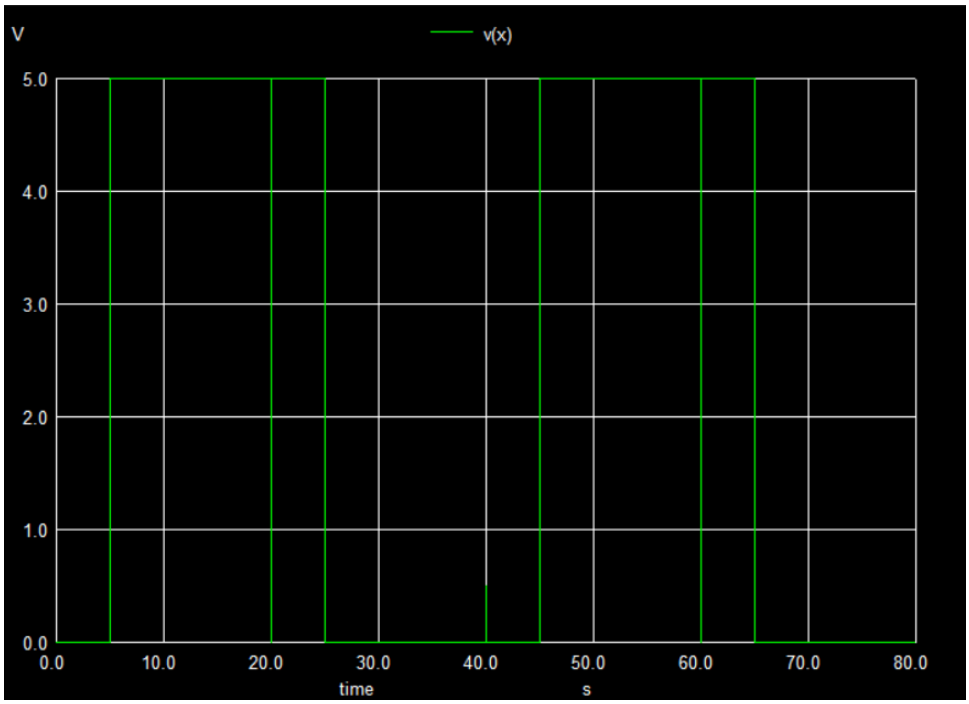

Figure 3.f: Output Plot (x)

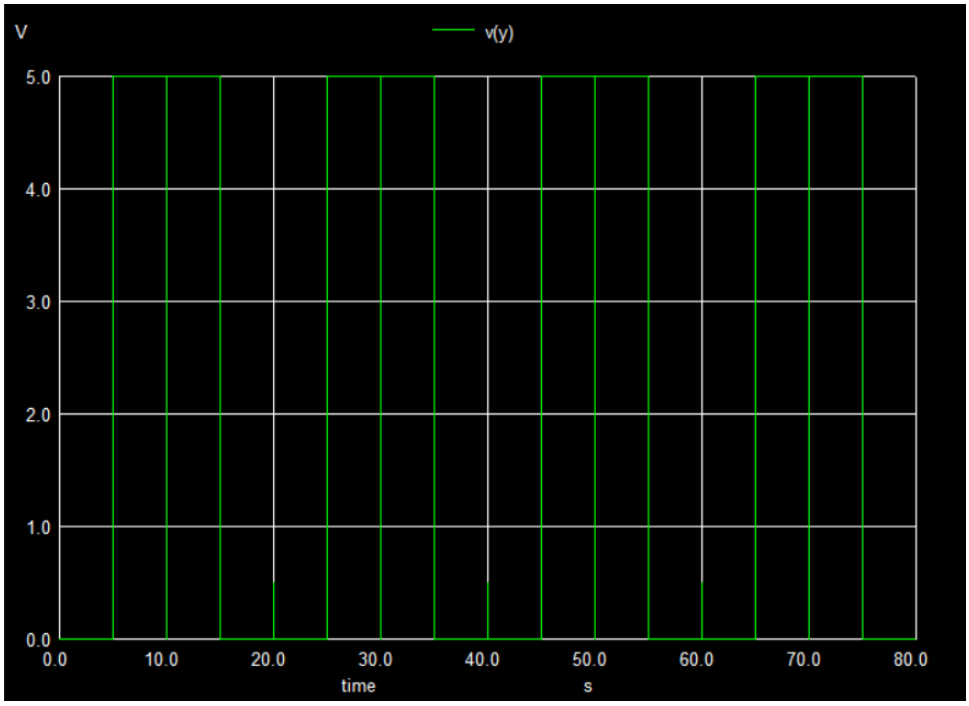

Figure 3.g: Output Plot (y)

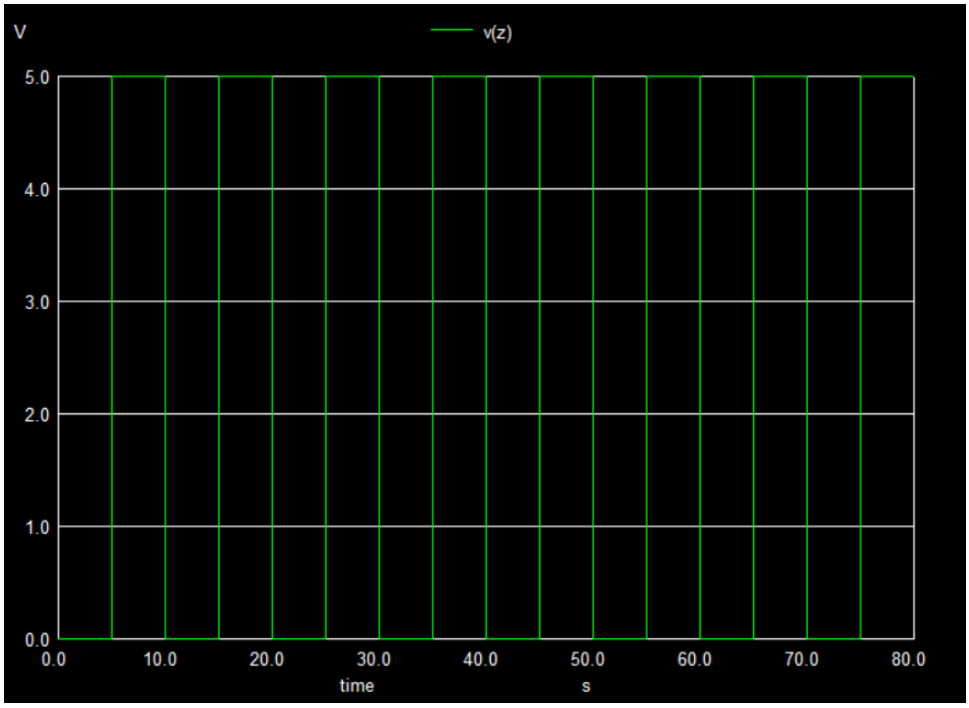

Figure 3.h: Output Plot (z)

2. Python Plots:

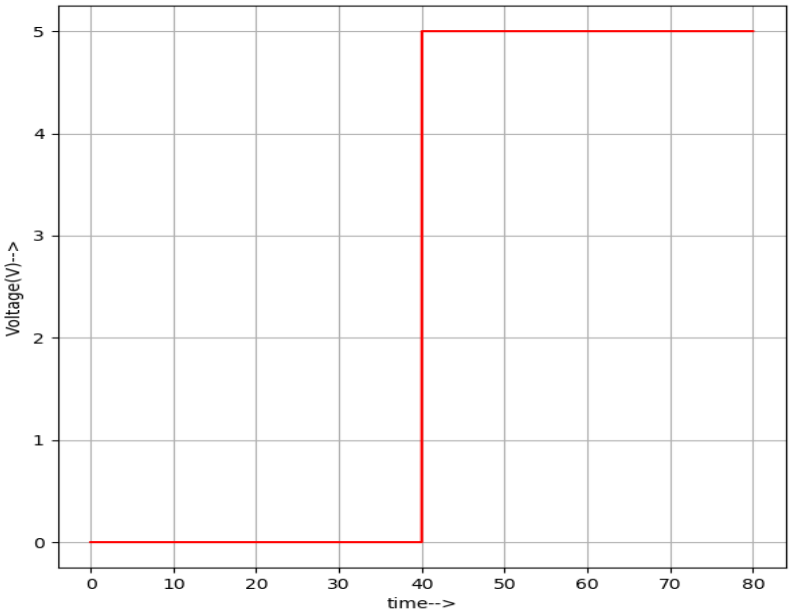

Figure 4.a: Input Plot (a)

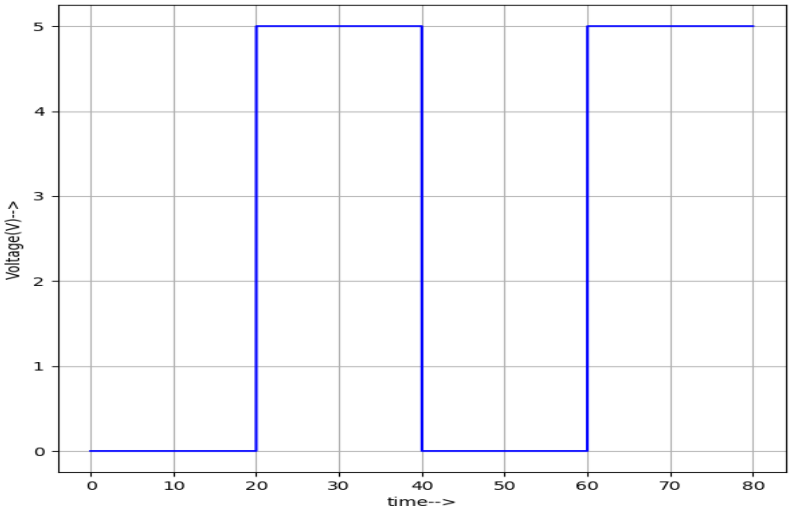

Figure 4.b: Input Plot (b)

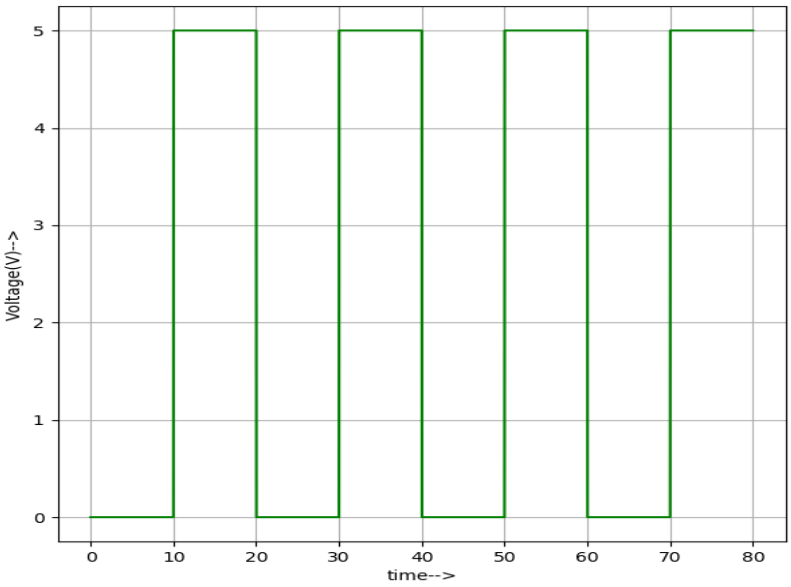

Figure 4.c: Input Plot (c)

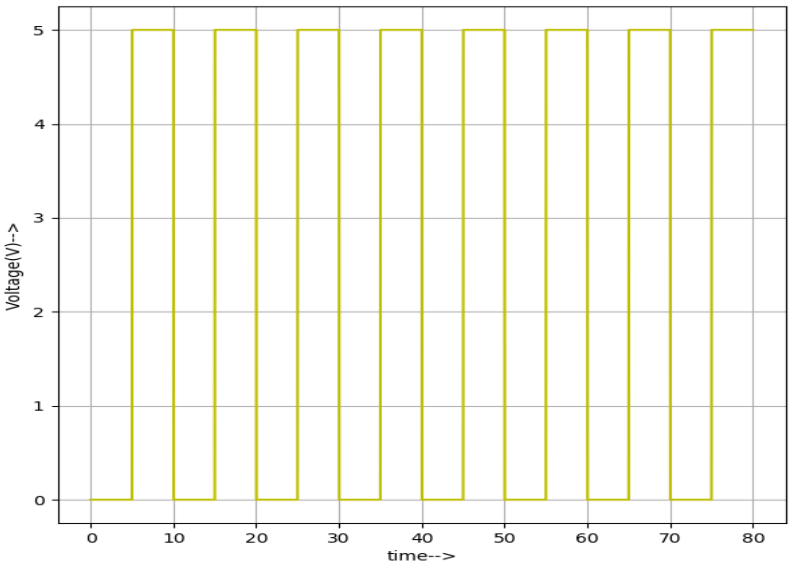

Figure 4.d: Input Plot (d)

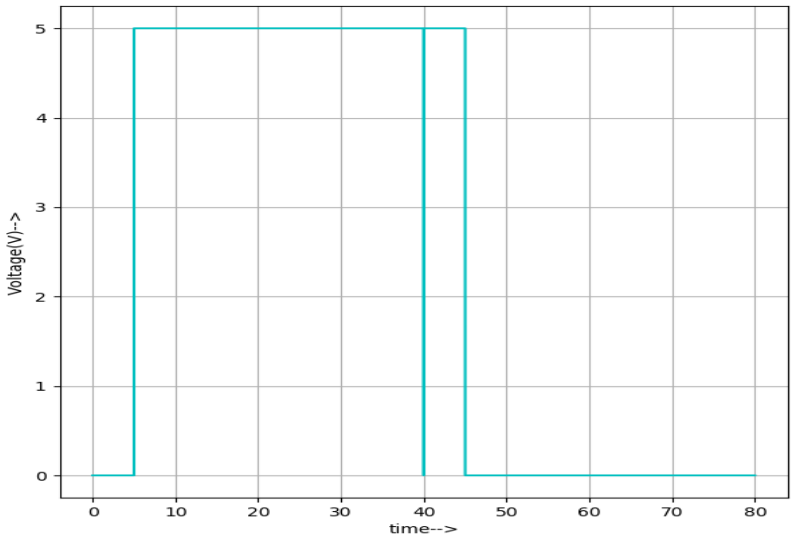

Figure 4.e: Output Plot (w)

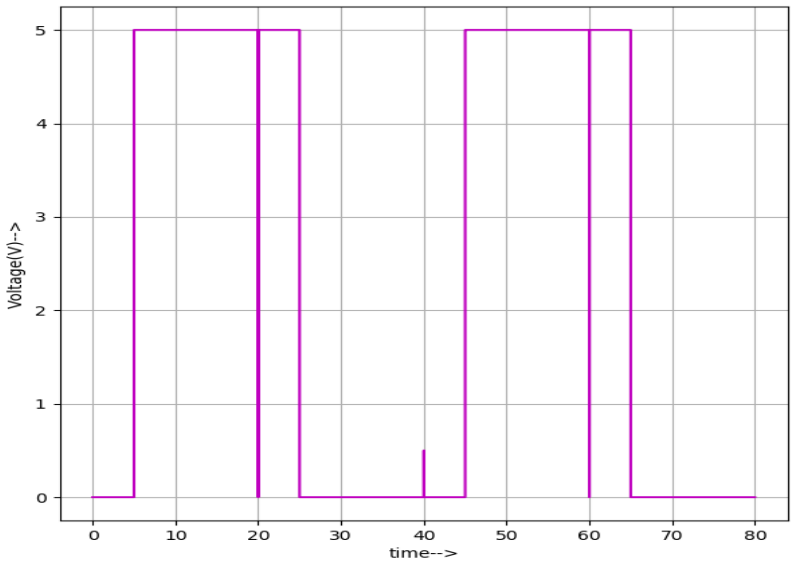

Figure 4.f: Output Plot (x)

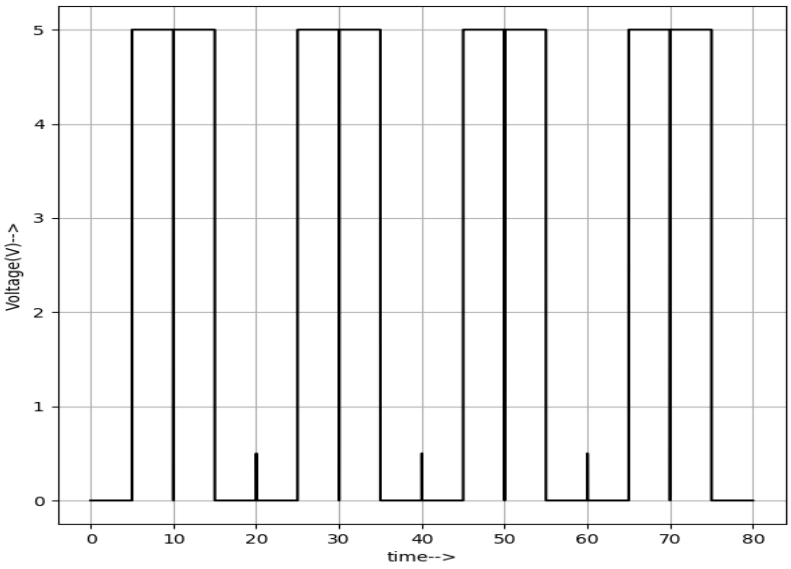

Figure 4.g: Output Plot (y)

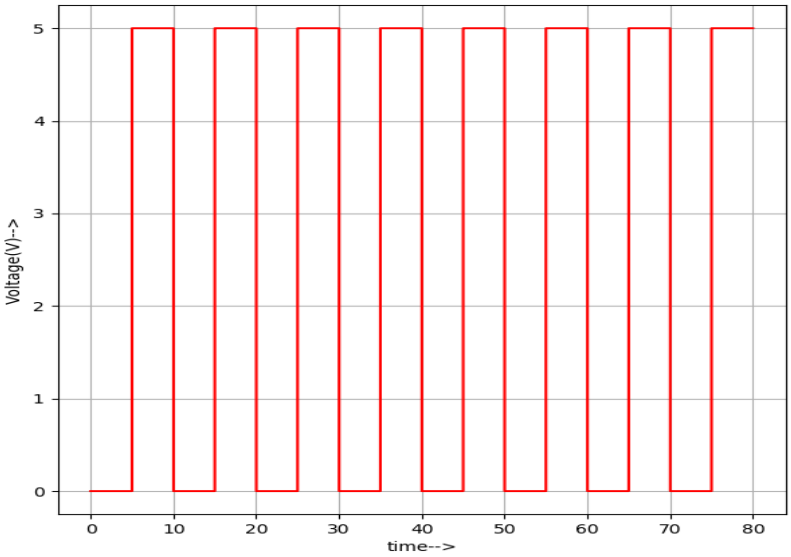

Figure 4.h: Output Plot (z)

Conclusion:

Using the circuit simulated, we have studied the logic and output of 2's complement circuit and it's practical use. The results simulated follow the truth table, thus validating the correctness of the circuit simulated.

References:

https://www.tutorialspoint.com/two-s-complement

https://www.semanticscholar.org/paper/4-bit-all-optical-binary-to-two%27s-complement-Bhattachryya-Gayen/d73de91484068bc6fec50059061e6dbb369da9fe