# Circuit Simulation Project

https://esim.fossee.in/circuit-simulation-project

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# Design of 4 Bit Magnitude Comparator using only logic gates

Theory:

This paper represents the design of 4 bit magnitude comparator using esim. 4 bit magnitude comparator is used to compare the two digital inputs with 4 bits each say A=A3A2A1A0 and B=B3B2B1B0, it gives the output whether the A is equal to B (A=B) or A is greater than B (A>B) or A is less than B (A<B) based on the input changes.

Lets see the cases for each A>B,A<B and A=B

**A=B:**

- If A3=B3, A2=B2, A1=B1, A0=B0 then the output would be A is equal to B (A=B)

The logical expression for A=B:

**For A=B is (A3 EXNOR B3).(A2 EXNOR B2).(A1 EXNOR B1).(A0 EXNOR B0)**

**Considering X3=(A3 EXNOR B3)**

**X2=(A2 EXNOR B2)**

**X1=(A1 EXNOR B1)**

**X0=(A0 EXNOR B0)**

**A>B:**

- If A3>B3 irrespective of other bits of A and B we can say that A is greater than B (A>B)
- If A3=B3 then starts comparing the value of A2 and B2 if A2>B2 we can say that A is greater than B (A>B).

- If A3=B3 and A2=B2 then starts comparing the value of A1 and B1 if A1>B1 we can say that A is greater than B (A>B).
- If A3=B3, A2=B2, A1=B1 then starts comparing the value of A0 and B0 if A0>B0 we can say that A is greater than B (A>B).

The logical expression for A>B is

**For A>B: (X3X2X1A0B0')+ (X3X2A1B1')+ (X3A2B2')+(A3B3')**

**A<B:**

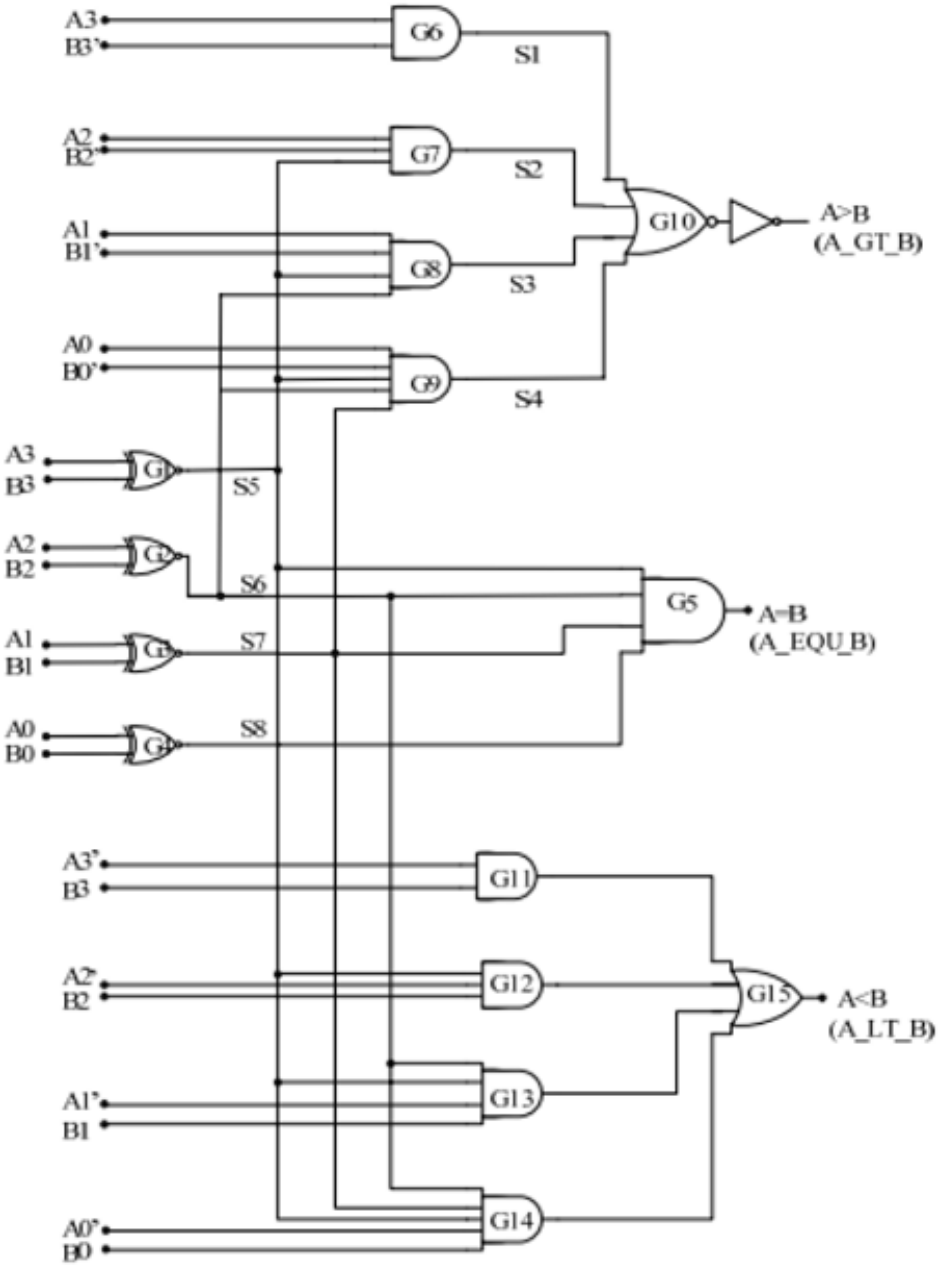
- If A3<B3 irrespective of other bits of A and B we can say that A is less than B (A<B)
- If A3=B3 then starts comparing the value of A2 and B2 if A2<B2 we can say that A is less than B (A<B).
- If A3=B3 and A2=B2 then starts comparing the value of A1 and B1 if A1<B1 we can say that A is less than B (A<B).
- If A3=B3, A2=B2, A1=B1 then starts comparing the value of A0 and B0 if A0<B0 we can say that A is less than B (A<B).

The logical expression for A<B

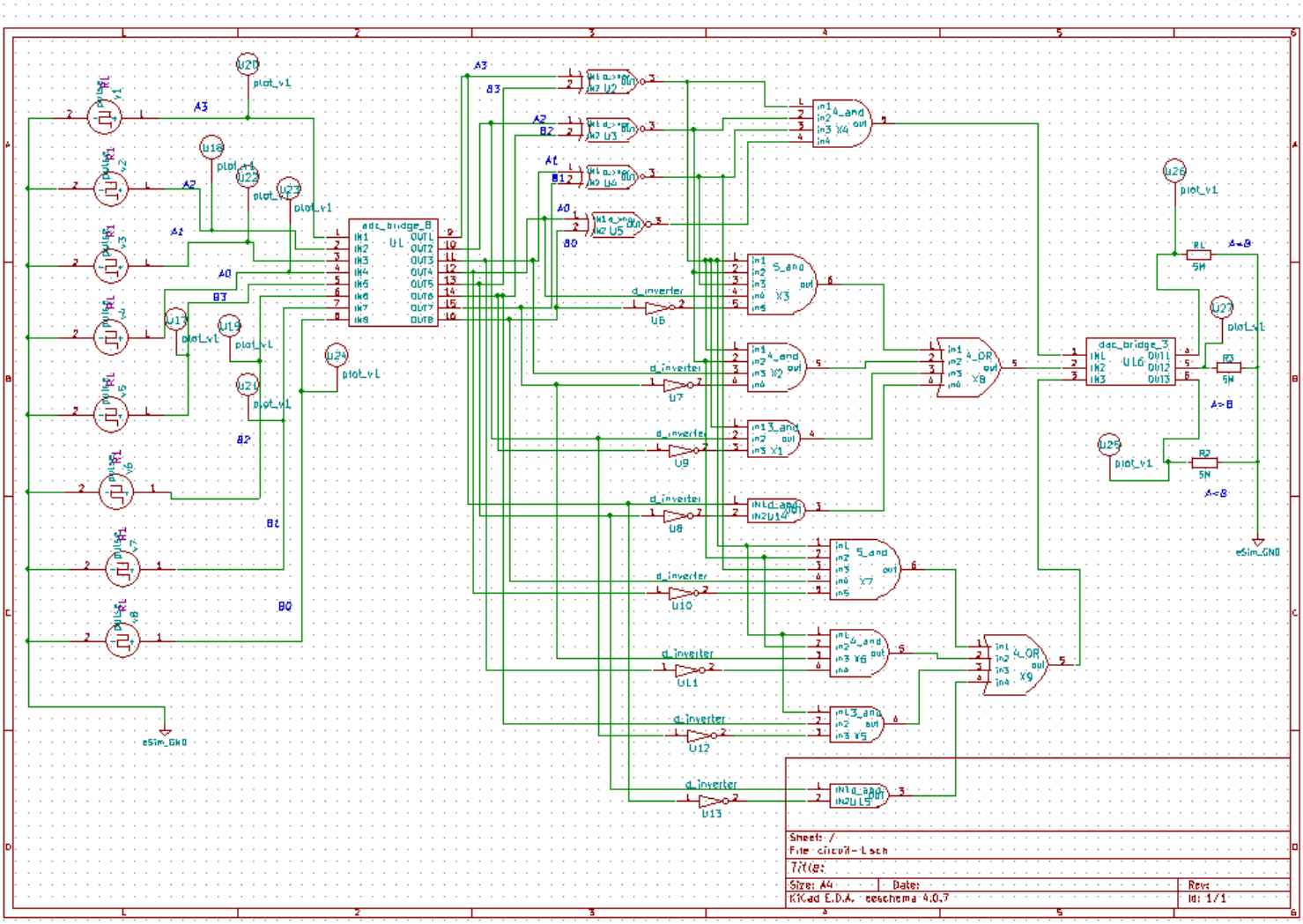
**For A<B: (X3X2X1A0'B0)+ (X3X2A1'B1)+ (X3A2'B2)+(A3'B3)**

| COMPARING INPUTS | | | | OUTPUT | | |
|---|---|---|---|---|---|---|
| **A3, B3** | **A2, B2** | **A1, B1** | **A0, B0** | **A > B** | **A < B** | **A = B** |
| A3 > B3 | X | X | X | H | L | L |
| A3 < B3 | X | X | X | L | H | L |
| A3 = B3 | A2 >B2 | X | X | H | L | L |
| A3 = B3 | A2 < B2 | X | X | L | H | L |
| A3 = B3 | A2 = B2 | A1 > B1 | X | H | L | L |
| A3 = B3 | A2 = B2 | A1 < B1 | X | L | H | L |
| A3 = B3 | A2 = B2 | A1 = B1 | A0 > B0 | H | L | L |
| A3 = B3 | A2 = B2 | A1 = B1 | A0 < B0 | L | H | L |
| A3 = B3 | A2 = B2 | A1 = B1 | A0 = B0 | H | L | L |
| A3 = B3 | A2 = B2 | A1 = B1 | A0 = B0 | L | H | L |
| A3 = B3 | A2 = B2 | A1 = B1 | A0 = B0 | L | L | H |
| H = High Voltage Level, L = Low Voltage, Level, X = Don't Care | | | | | | |

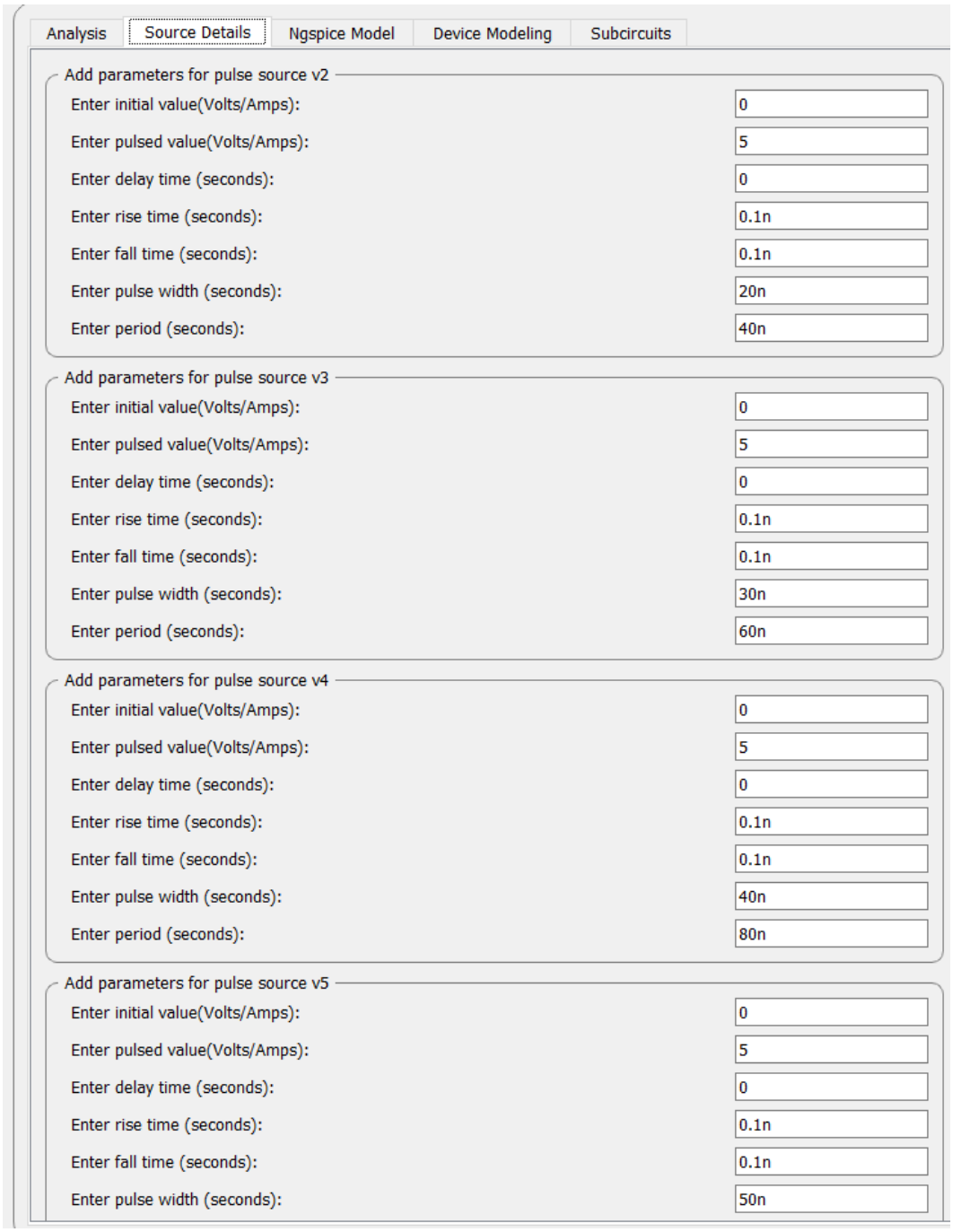
Circuit diagram:



Schematic Diagram:



# Source details:



Analysis | Source Details | Ngspice Model | Device Modeling | Subcircuits

Add parameters for pulse source v1

| | |
|---|---|
| Enter initial value(Volts/Amps): | 0 |
| Enter pulsed value(Volts/Amps): | 5 |
| Enter delay time (seconds): | 0 |
| Enter rise time (seconds): | 0.1n |
| Enter fall time (seconds): | 0.1n |
| Enter pulse width (seconds): | 10n |
| Enter period (seconds): | 20n |

Add parameters for pulse source v6

| | |
|---|---|
| Enter initial value(Volts/Amps): | 0 |
| Enter pulsed value(Volts/Amps): | 5 |
| Enter delay time (seconds): | 0 |
| Enter rise time (seconds): | 0.1n |
| Enter fall time (seconds): | 0.1n |
| Enter pulse width (seconds): | 60n |
| Enter period (seconds): | 120n |

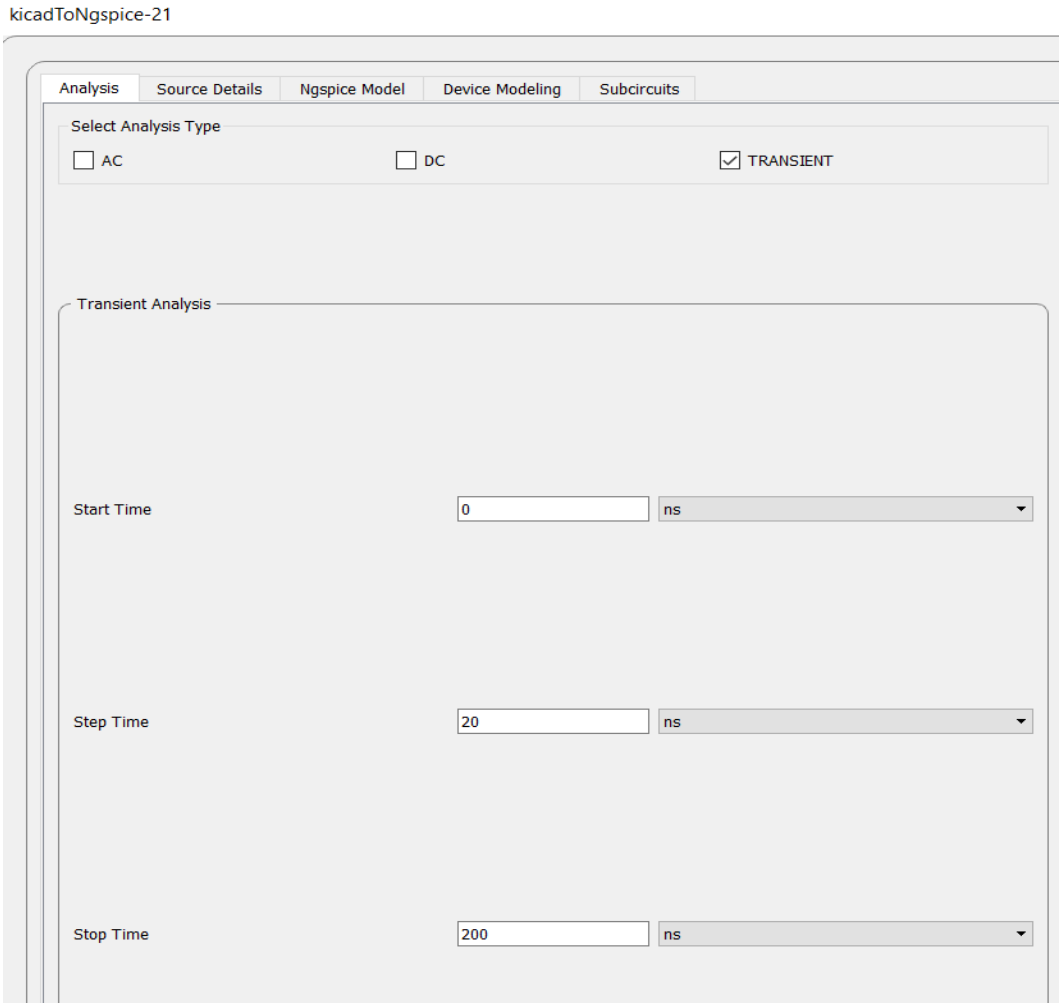
Add parameters for pulse source v7

| | |
|---|---|
| Enter initial value(Volts/Amps): | 0 |
| Enter pulsed value(Volts/Amps): | 5 |
| Enter delay time (seconds): | 0 |
| Enter rise time (seconds): | 0.1n |
| Enter fall time (seconds): | 0.1n |
| Enter pulse width (seconds): | 70n |
| Enter period (seconds): | 140n |

Add parameters for pulse source v8

| | |
|---|---|
| Enter initial value(Volts/Amps): | 0 |
| Enter pulsed value(Volts/Amps): | 5 |
| Enter delay time (seconds): | 0 |
| Enter rise time (seconds): | 0.1n |
| Enter fall time (seconds): | 0.1n |
| Enter pulse width (seconds): | 80n |
| Enter period (seconds): | 160n |

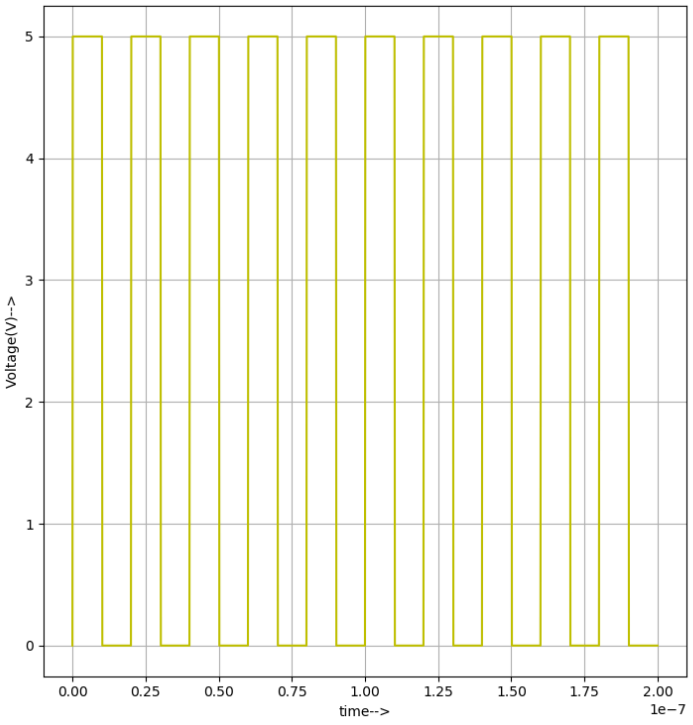
Transient analysis:



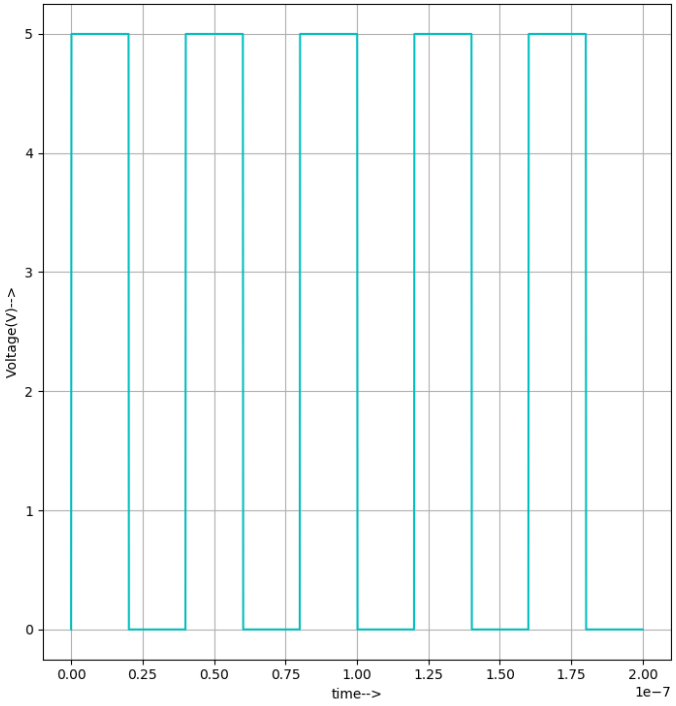

Simulation Results:

Plottings:

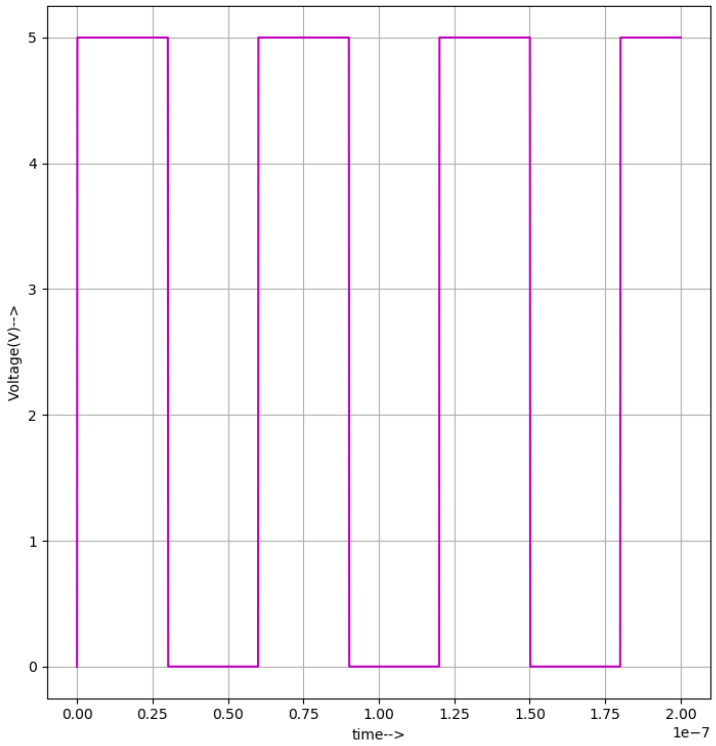
Input A3:



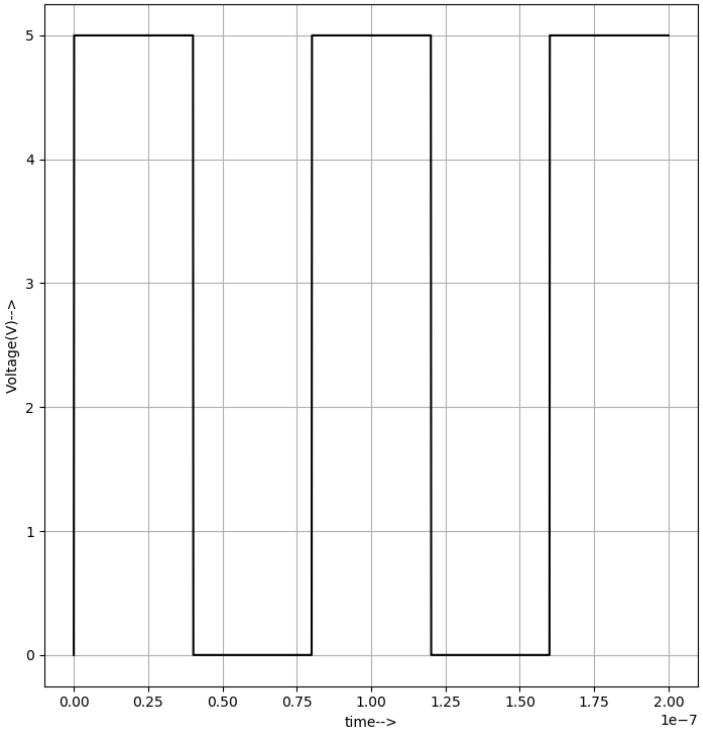

Input A2:



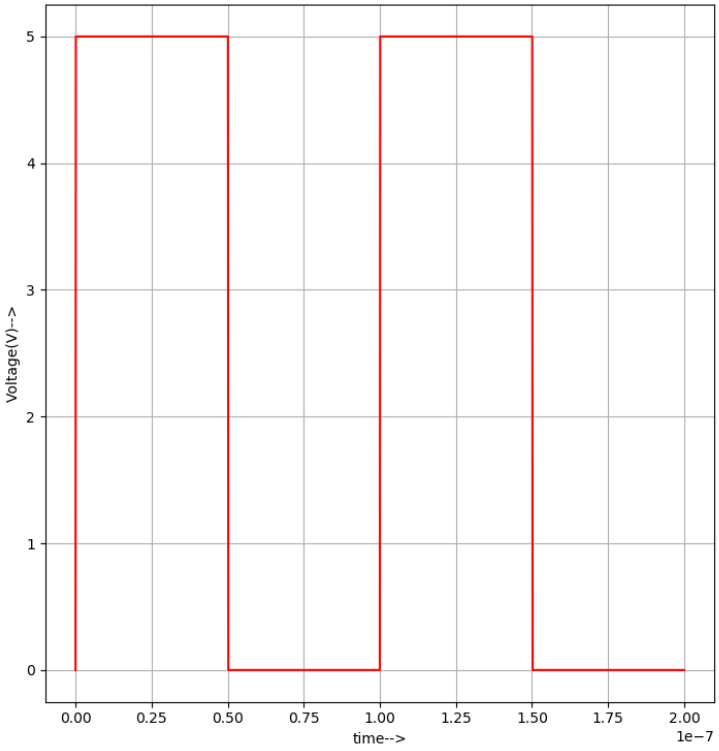
Input A1:



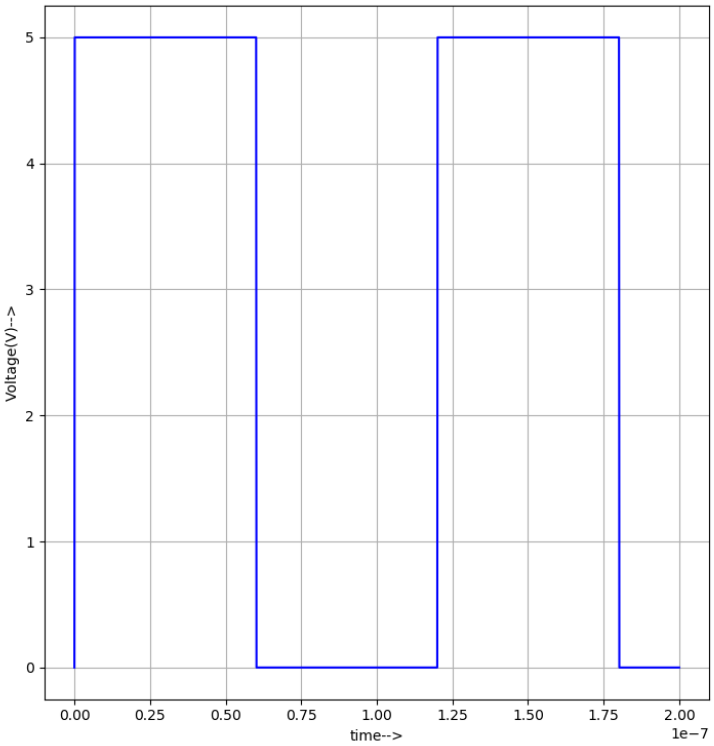

Input A0:



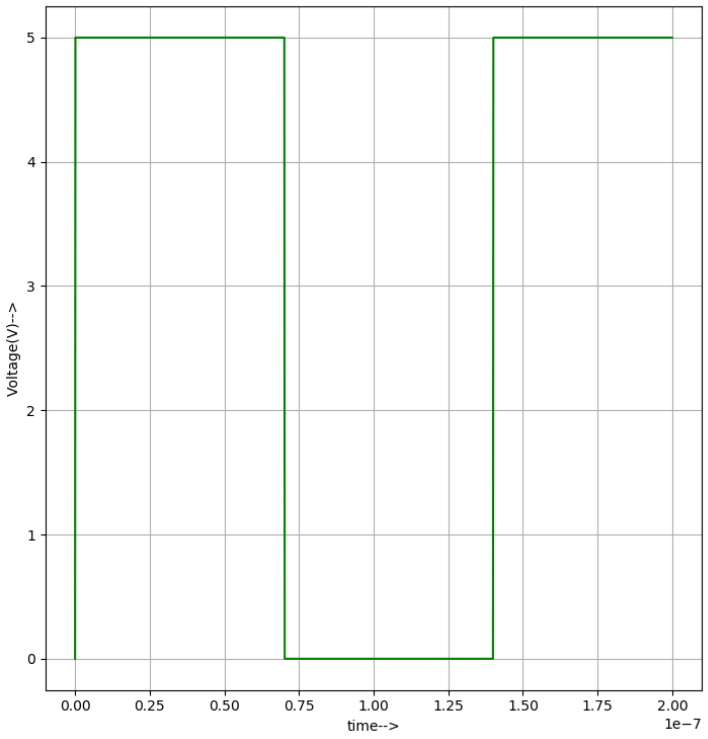
Input B3:



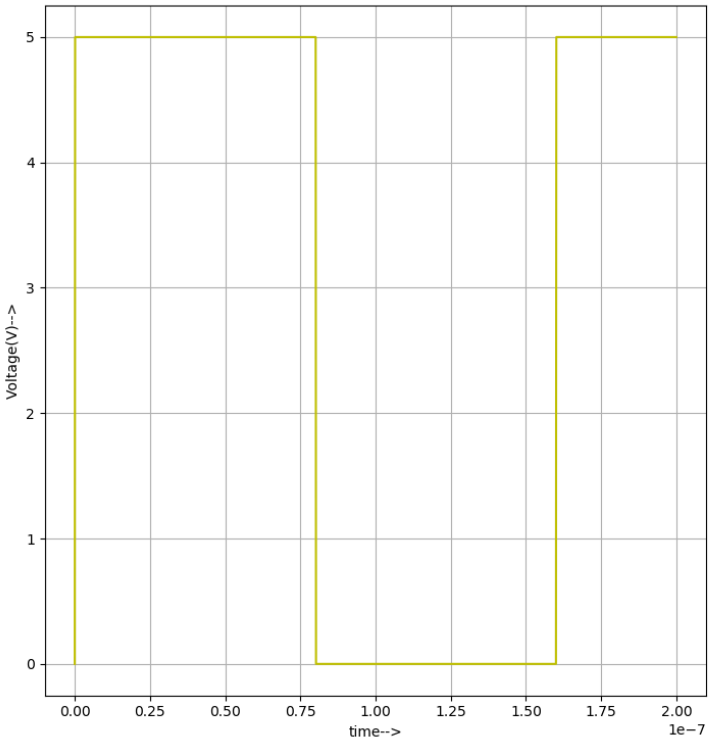

Input B2:



Input B1:

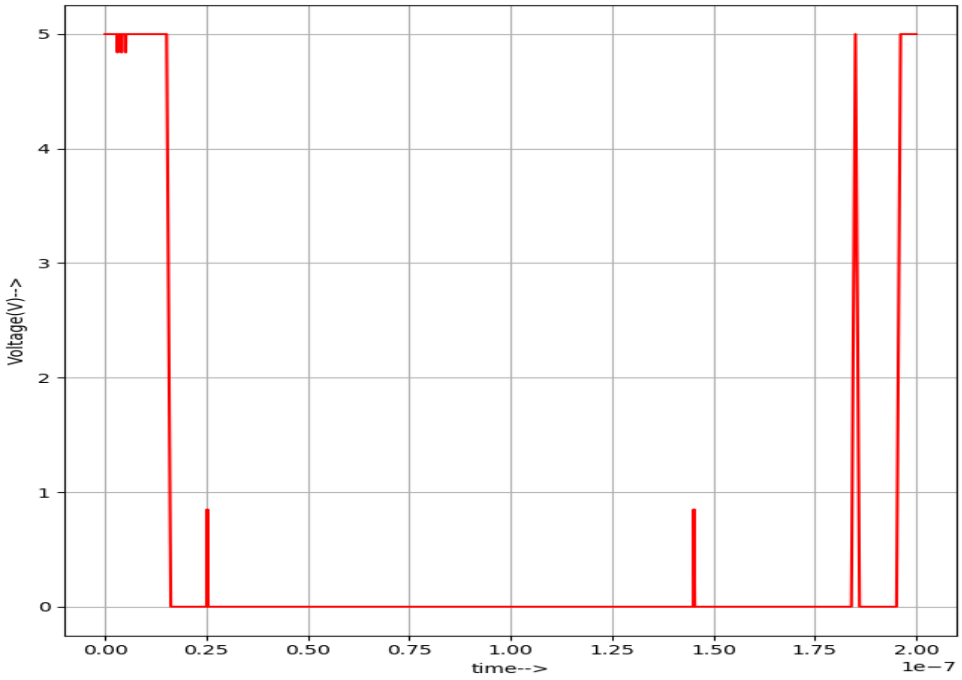



Input B0:

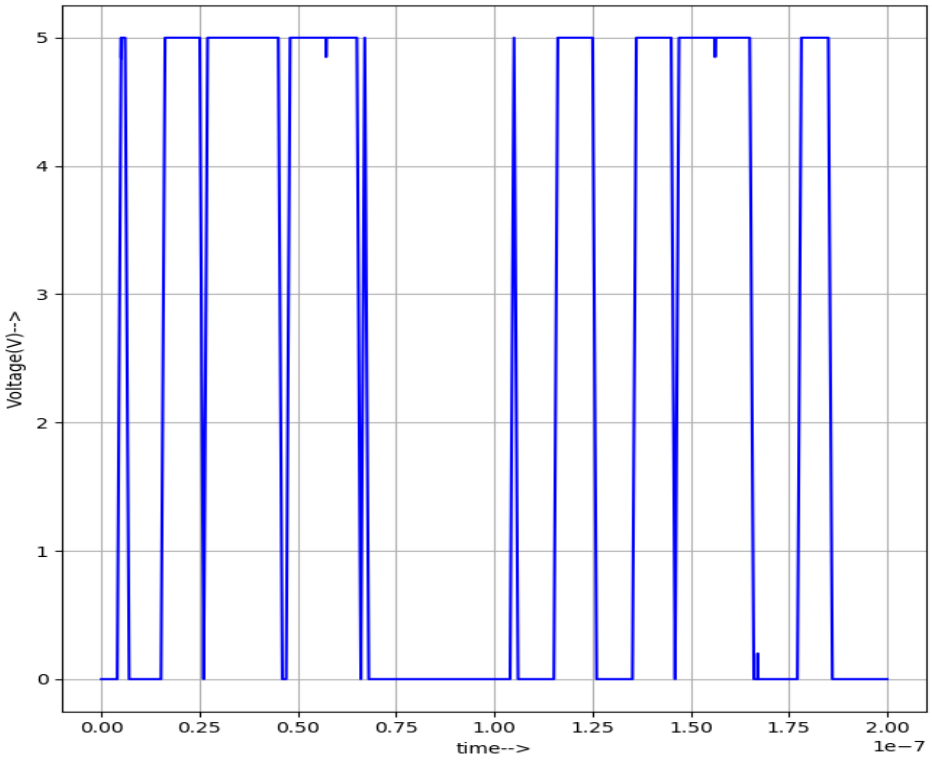


Output graphs:

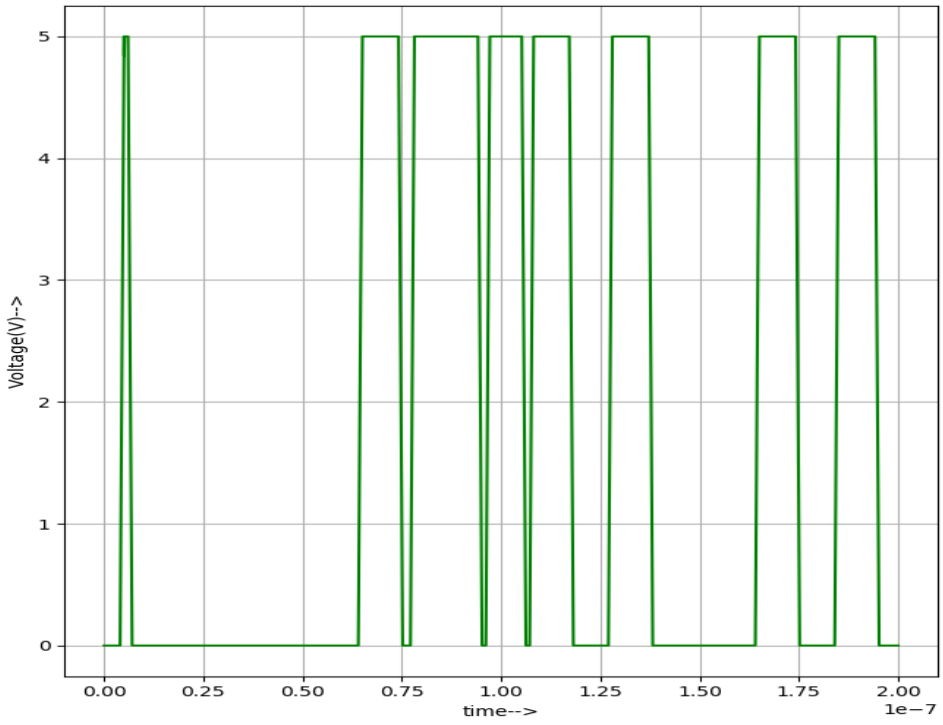
For A=B



For A<B


Voltage(V)-->
time-->
1e−7
0
1
2
3
4
5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

For A>B


Voltage(V)-->
time-->
1e−7
0
1
2
3
4
5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

## Conclusion:

Hence we compared the inputs A=A3A2A1A0 and B=B3B2B1B0 and determined whether A=B or A>B or A<B by plotting waveforms using magnitude comparator circuit in esim and hence verified

## Reference:

https://eevibes.com/digital-logic-design/how-to-design-a-4-bit-magnitude-comparator-circuit/