

## Circuit Simulation Project

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

Name of the participant: M.V.Rakesh gupta

### 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  $A=A_3A_2A_1A_0$  and  $B=B_3B_2B_1B_0$ , 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  $A_3=B_3, A_2=B_2, A_1=B_1, A_0=B_0$  then the output would be A is equal to B ( $A=B$ )

The logical expression for  $A=B$ :

**For  $A=B$  is  $(A_3 \text{ EXNOR } B_3).(A_2 \text{ EXNOR } B_2).(A_1 \text{ EXNOR } B_1).(A_0 \text{ EXNOR } B_0)$**

**Considering  $X_3=(A_3 \text{ EXNOR } B_3)$**

**$X_2=(A_2 \text{ EXNOR } B_2)$**

**$X_1=(A_1 \text{ EXNOR } B_1)$**

**$X_0=(A_0 \text{ EXNOR } B_0)$**

**A>B:**

- If  $A_3>B_3$  irrespective of other bits of A and B we can say that A is greater than B ( $A>B$ )
- If  $A_3=B_3$  then starts comparing the value of  $A_2$  and  $B_2$  if  $A_2>B_2$  we can say that A is greater than B ( $A>B$ ).

- If  $A_3=B_3$  and  $A_2=B_2$  then starts comparing the value of  $A_1$  and  $B_1$  if  $A_1>B_1$  we can say that  $A$  is greater than  $B$  ( $A>B$ ).
- If  $A_3=B_3$ ,  $A_2=B_2$ ,  $A_1=B_1$  then starts comparing the value of  $A_0$  and  $B_0$  if  $A_0>B_0$  we can say that  $A$  is greater than  $B$  ( $A>B$ ).

The logical expression for  $A>B$  is

$$\text{For } A>B: (X_3X_2X_1A_0B_0') + (X_3X_2A_1B_1') + (X_3A_2B_2') + (A_3B_3')$$

**A<B:**

- If  $A_3<B_3$  irrespective of other bits of  $A$  and  $B$  we can say that  $A$  is less than  $B$  ( $A<B$ )
- If  $A_3=B_3$  then starts comparing the value of  $A_2$  and  $B_2$  if  $A_2<B_2$  we can say that  $A$  is less than  $B$  ( $A<B$ ).
- If  $A_3=B_3$  and  $A_2=B_2$  then starts comparing the value of  $A_1$  and  $B_1$  if  $A_1<B_1$  we can say that  $A$  is less than  $B$  ( $A<B$ ).
- If  $A_3=B_3$ ,  $A_2=B_2$ ,  $A_1=B_1$  then starts comparing the value of  $A_0$  and  $B_0$  if  $A_0<B_0$  we can say that  $A$  is less than  $B$  ( $A<B$ ).

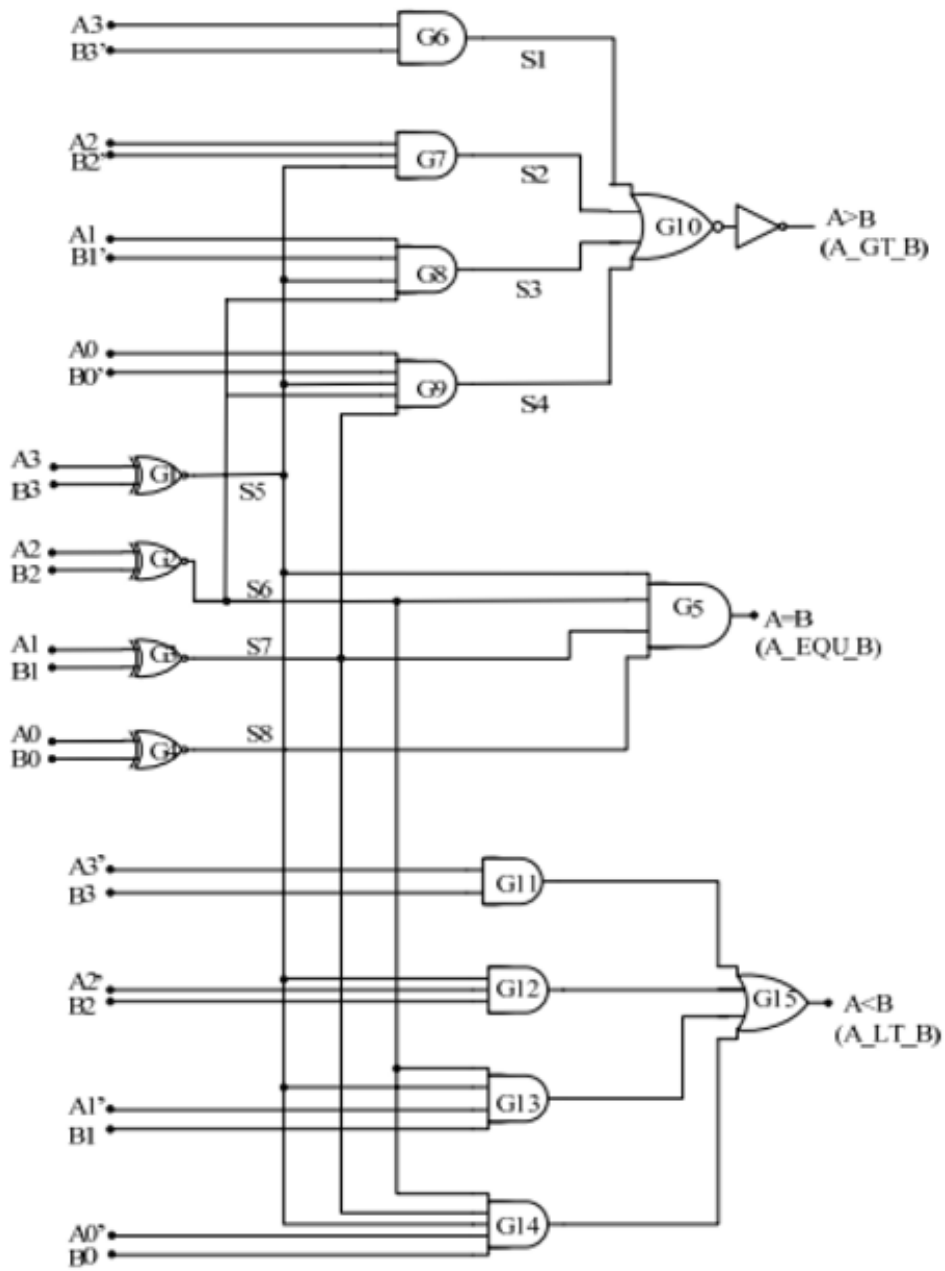
The logical expression for  $A<B$

$$\text{For } A<B: (X_3X_2X_1A_0'B_0) + (X_3X_2A_1'B_1) + (X_3A_2'B_2) + (A_3'B_3)$$

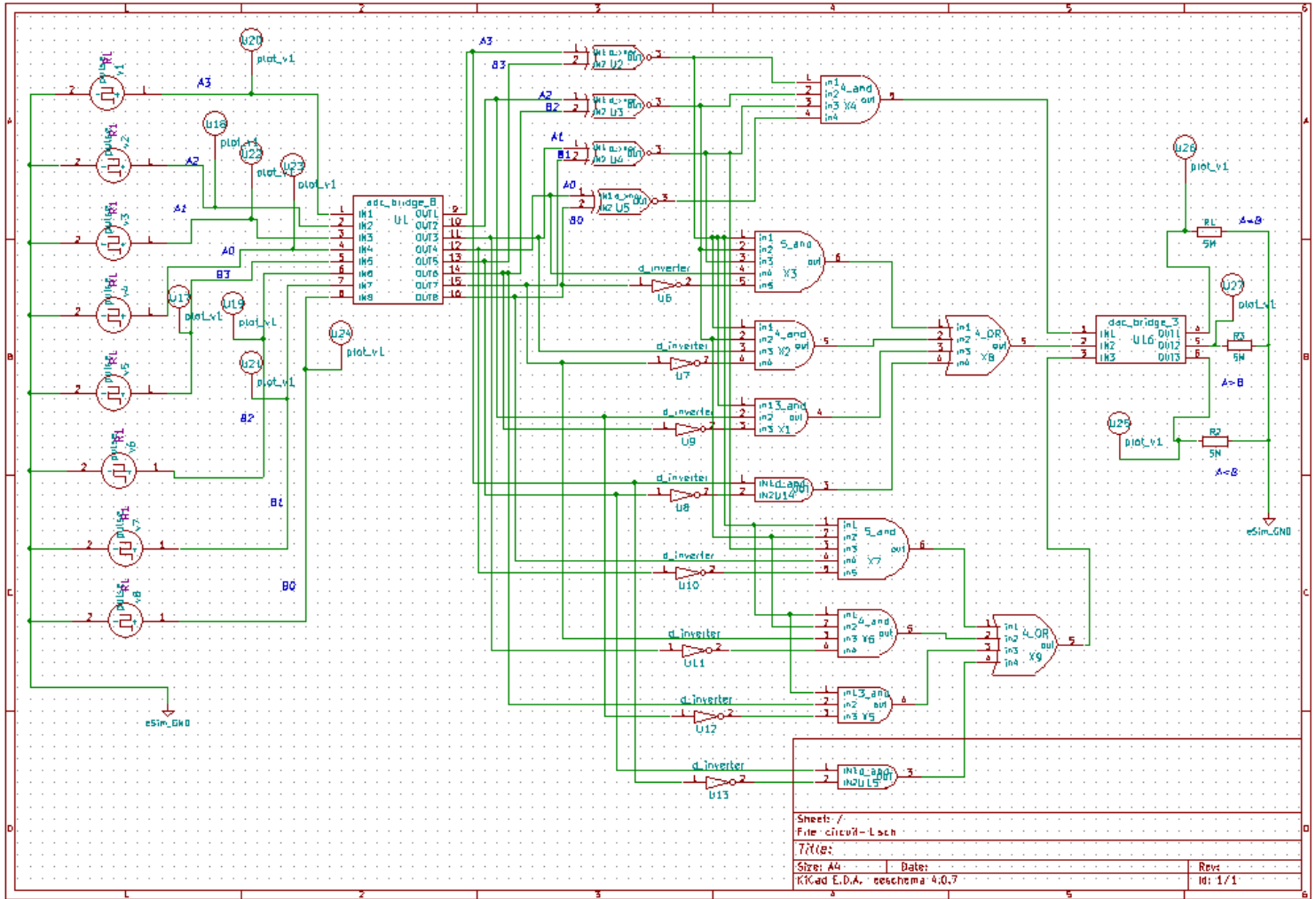
| COMPARING INPUTS |         |         |         | OUTPUT |       |       |
|------------------|---------|---------|---------|--------|-------|-------|
| A3, B3           | A2, B2  | A1, B1  | A0, B0  | A > B  | A < B | A = B |
| A3 > B3          | X       | X       | X       | H      | L     | L     |
| 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 v2 |                |               |                 |             |
| 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):       |                | 20n           |                 |             |
| Enter period (seconds):            |                | 40n           |                 |             |
| Add parameters for pulse source v3 |                |               |                 |             |
| 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):       |                | 30n           |                 |             |
| Enter period (seconds):            |                | 60n           |                 |             |
| Add parameters for pulse source v4 |                |               |                 |             |
| 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):       |                | 40n           |                 |             |
| Enter period (seconds):            |                | 80n           |                 |             |
| Add parameters for pulse source v5 |                |               |                 |             |
| 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):       |                | 50n           |                 |             |

Analysis

Source Details

Ngspice Model

Device Modeling

Subcircuits

Add parameters for pulse source v1

|                                  |                                   |
|----------------------------------|-----------------------------------|
| Enter initial value(Volts/Amps): | <input type="text" value="0"/>    |
| Enter pulsed value(Volts/Amps):  | <input type="text" value="5"/>    |
| Enter delay time (seconds):      | <input type="text" value="0"/>    |
| Enter rise time (seconds):       | <input type="text" value="0.1n"/> |
| Enter fall time (seconds):       | <input type="text" value="0.1n"/> |
| Enter pulse width (seconds):     | <input type="text" value="10n"/>  |
| Enter period (seconds):          | <input type="text" value="20n"/>  |

Add parameters for pulse source v6

|                                  |                                   |
|----------------------------------|-----------------------------------|
| Enter initial value(Volts/Amps): | <input type="text" value="0"/>    |
| Enter pulsed value(Volts/Amps):  | <input type="text" value="5"/>    |
| Enter delay time (seconds):      | <input type="text" value="0"/>    |
| Enter rise time (seconds):       | <input type="text" value="0.1n"/> |
| Enter fall time (seconds):       | <input type="text" value="0.1n"/> |
| Enter pulse width (seconds):     | <input type="text" value="60n"/>  |
| Enter period (seconds):          | <input type="text" value="120n"/> |

Add parameters for pulse source v7

|                                  |                                   |
|----------------------------------|-----------------------------------|
| Enter initial value(Volts/Amps): | <input type="text" value="0"/>    |
| Enter pulsed value(Volts/Amps):  | <input type="text" value="5"/>    |
| Enter delay time (seconds):      | <input type="text" value="0"/>    |
| Enter rise time (seconds):       | <input type="text" value="0.1n"/> |
| Enter fall time (seconds):       | <input type="text" value="0.1n"/> |
| Enter pulse width (seconds):     | <input type="text" value="70n"/>  |
| Enter period (seconds):          | <input type="text" value="140n"/> |

Add parameters for pulse source v8

|                                  |                                   |
|----------------------------------|-----------------------------------|
| Enter initial value(Volts/Amps): | <input type="text" value="0"/>    |
| Enter pulsed value(Volts/Amps):  | <input type="text" value="5"/>    |
| Enter delay time (seconds):      | <input type="text" value="0"/>    |
| Enter rise time (seconds):       | <input type="text" value="0.1n"/> |
| Enter fall time (seconds):       | <input type="text" value="0.1n"/> |
| Enter pulse width (seconds):     | <input type="text" value="80n"/>  |
| Enter period (seconds):          | <input type="text" value="160n"/> |

# Transient analysis:

kicadToNgspice-21

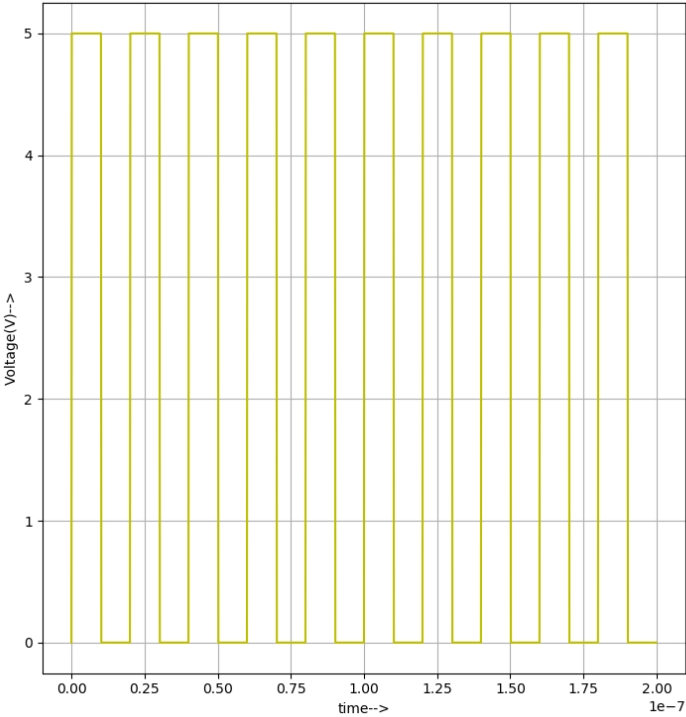
The image shows a software interface for configuring a simulation. At the top, there are several tabs: "Analysis", "Source Details", "Ngspice Model", "Device Modeling", and "Subcircuits". The "Analysis" tab is selected. Below the tabs, there is a section titled "Select Analysis Type" with three radio buttons: "AC", "DC", and "TRANSIENT". The "TRANSIENT" radio button is checked. Below this, there is a section titled "Transient Analysis" with three rows of input fields and dropdown menus:

| Parameter  | Value | Unit |
|------------|-------|------|
| Start Time | 0     | ns   |
| Step Time  | 20    | ns   |
| Stop Time  | 200   | ns   |

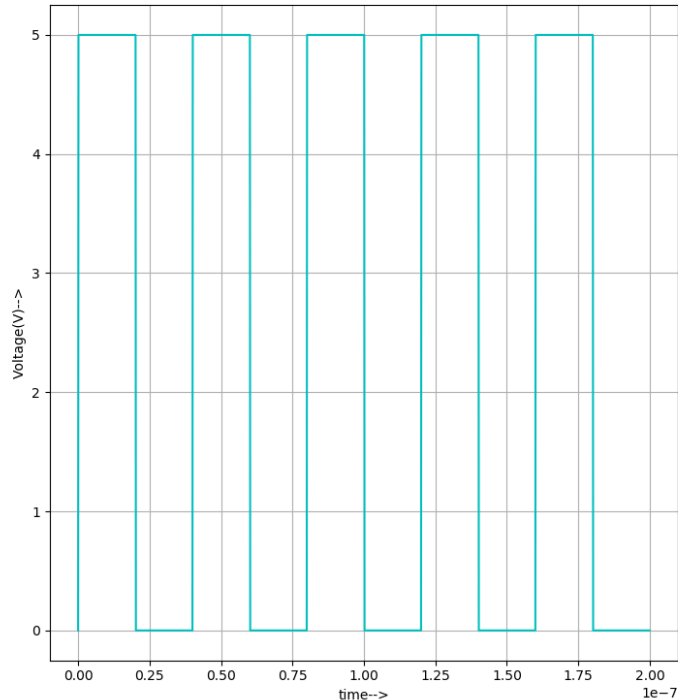
Simulation Results:

Plottings:

Input A3:

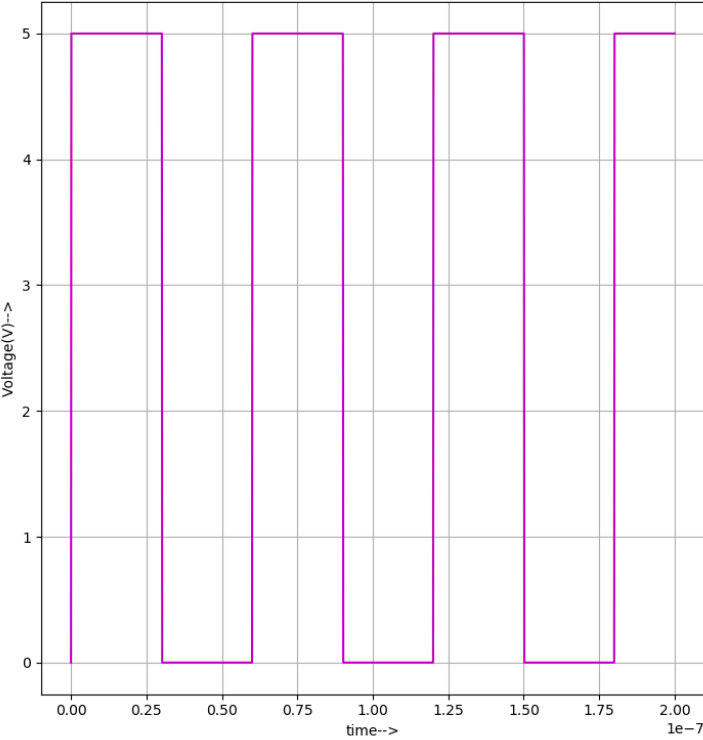


Input A2:

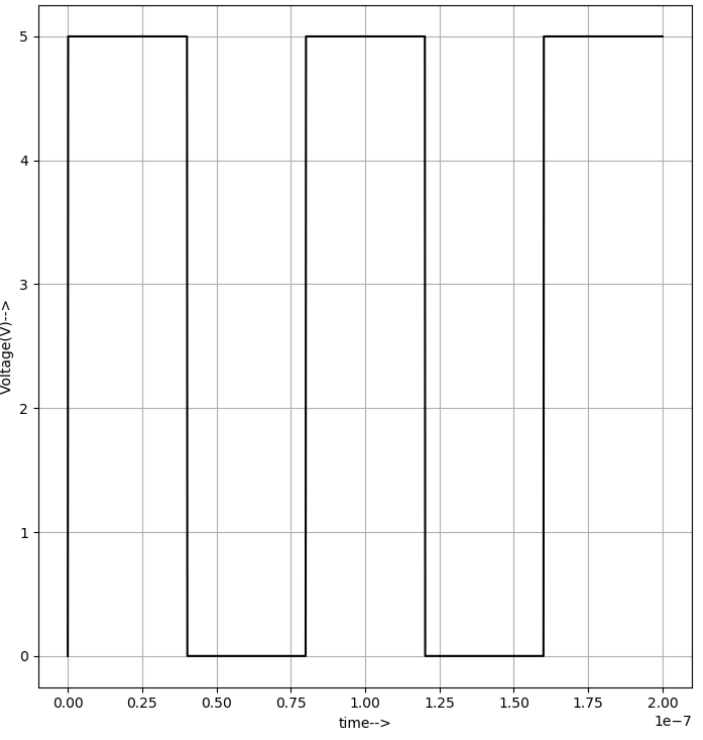




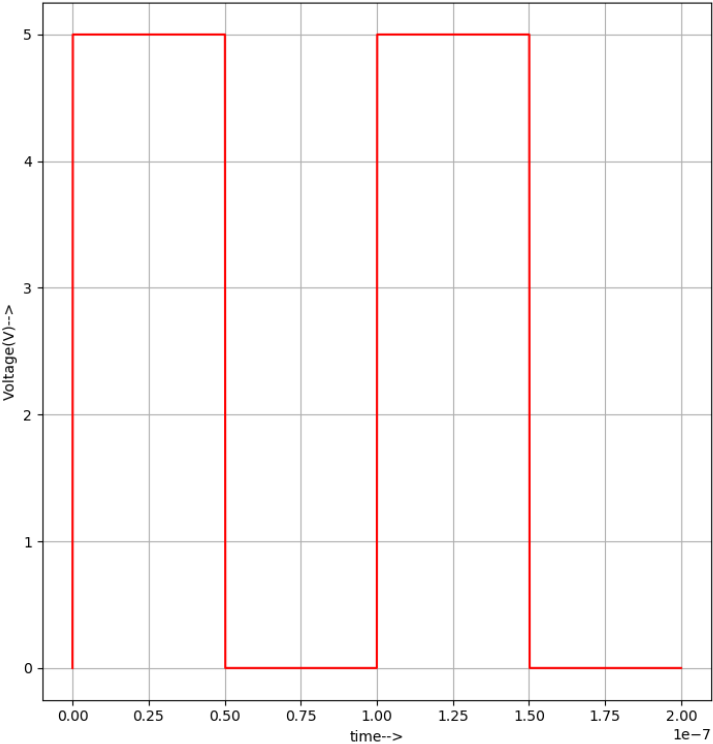
### Input A1:



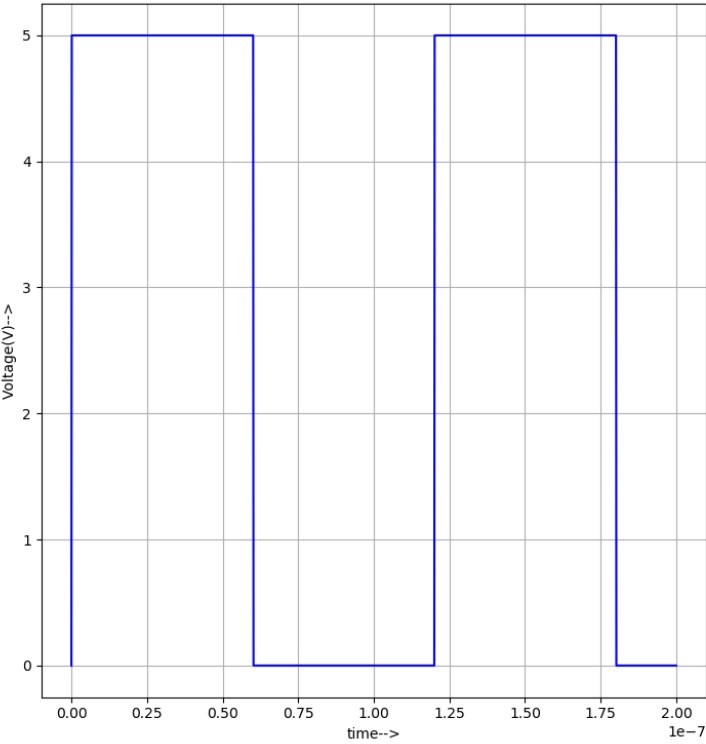
### Input A0:



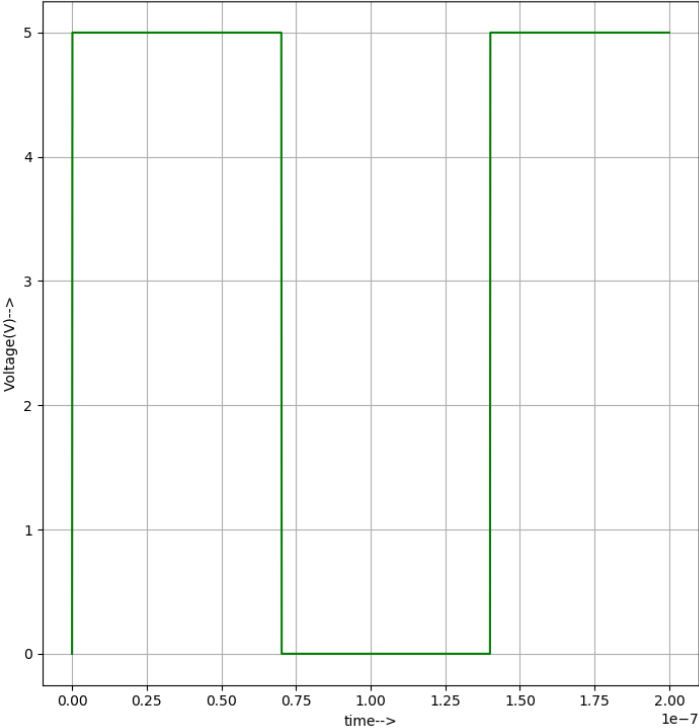
Input B3:



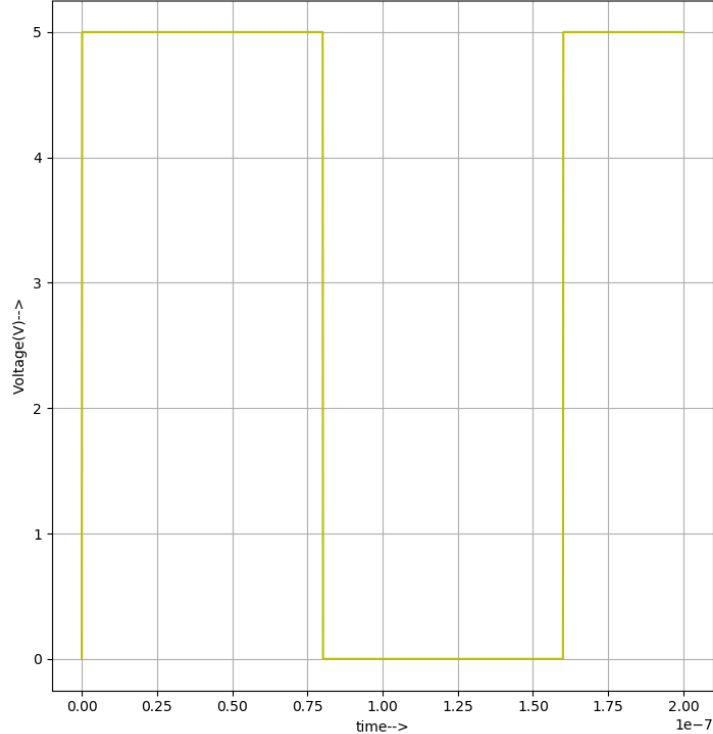
Input B2:



### Input B1:

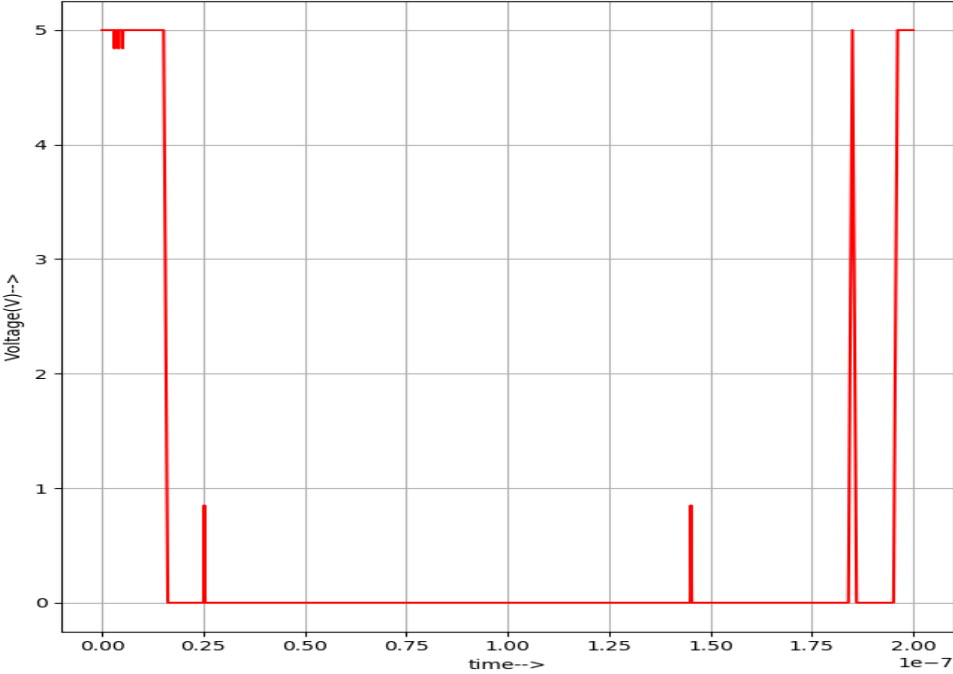


### Input B0:

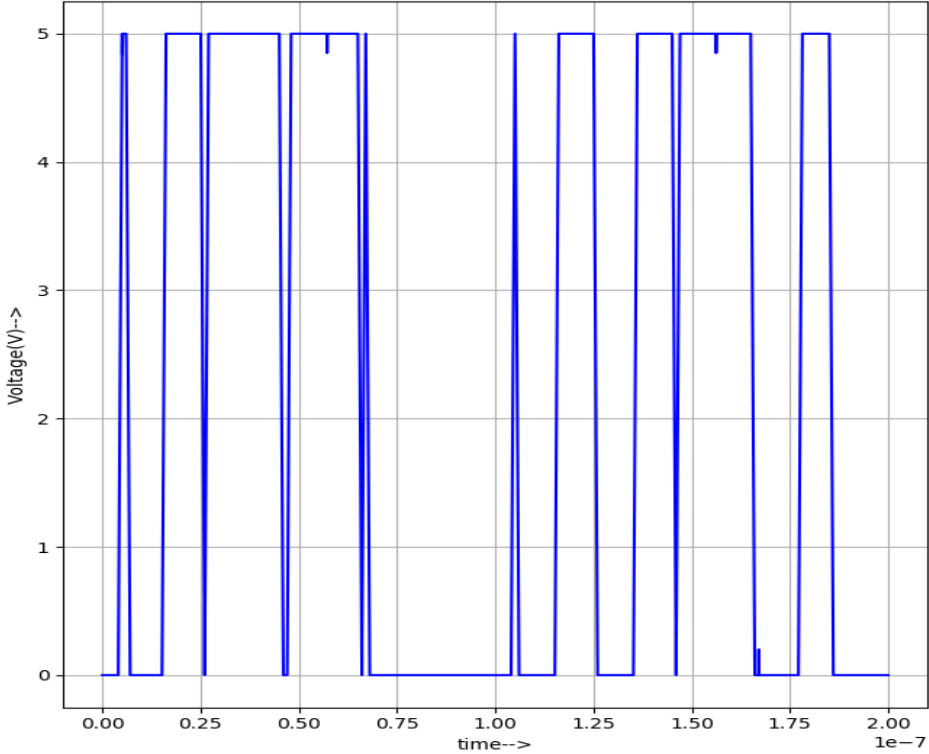


Output graphs:

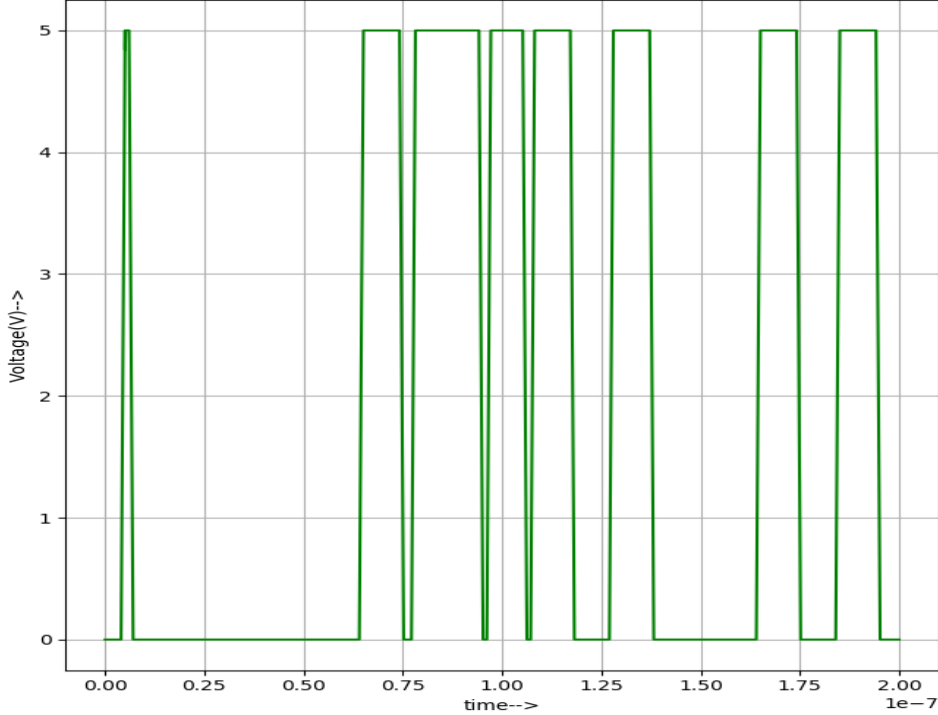
For A=B



For  $A < B$



For  $A > B$



## Conclusion:

Hence we compared the inputs  $A=A_3A_2A_1A_0$  and  $B=B_3B_2B_1B_0$  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/>