# EAST WEST UNIVERSITY

**Mini Project (P3)**
Course Code: **CSE345**
Course Title: **Digital Logic Design**
Section No: **05**

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**Project Title:** 4bit Comparator Circuit.

**Problem Statement:** Design a combinational logic circuit, that takes two 4 but binary numbers, A and B, as input and there will be three one bit outputs which will flag whether A>b or A<B or A=B.

## Problem Description:

As we can see in the problem statement, that we have to design and implement a combinational logic circuit that will compare 2 binary 4bit numbers; A and B which will tell us whether the number is equal, greater or less than the other number using three 1bit outputs.

## Designing a Comparator Circuit:

We have two 4bit binary inputs; A and B.

So, $A = A_3A_2A_1A_0$
And $B = B_3B_2B_1B_0$

A comparator will compare two numbers. That means A will be compared to B. So for binary numbers, we will compare 4bits of A with 4bits of B.

Taking that in mind, the condition, **A>B** is possible for the following four cases:

i. If $A_3 = 1$ and $B_3 = 0$
ii. If $A_3 = B_3$ and $A_2 = 1$ and $B_2 = 0$
iii. If $A_3 = B_3$, $A_2 = B_2$ and $A_1 = 1$ and $B_1 = 0$
iv. If $A_3 = B_3$, $A_2 = B_2$, $A_1 = B_1$ and $A_0 = 1$ and $B_0 = 0$

Again, the condition, **A<B** is possible for the following four cases:

If $A_3 = 0$ and $B_3 = 1$

If $A_3 = B_3$ and $A_2 = 0$ and $B_2 = 1$

If $A_3 = B_3$, $A_2 = B_2$ and $A_1 = 0$ and $B_1 = 1$

If $A_3 = B_3$, $A_2 = B_2$, $A_1 = B_1$ and $A_0 = 0$ and $B_0 = 1$

And lastly, the condition, **A=B** is possible only when:

$A_3 = B_3$ , $A_2 = B_2$ , $A_1 = B_1$ , $A_0 = B_0$

So, to be exact, we will be comparing 1bit of two numbers, then we will gradually move on to 4 bits.

Before creating a circuit diagram on the basis of the above discussion, let us revisit the behavior of XOR and XNOR gate. Let us assume two 1bit number X and Y. Now let's create a Truth Table for this-

| **X** | **Y** | **XOR** | **XNOR** |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |

Here, we can see that, the output of XNOR-gate is logic 1 when inputs are equal. This will help us create our comparator circuit.

Now based on these, lets determine the expressions:

**A=B,**

$$(A_3'B_3+A_3B_3')'.\ (A_2'B_2+A_2B_2')'.\ (A_1'B_1+A_1B_1')'.\ (A_0'B_0+A_0B_0')'$$

Lets assume,

$(A_3'B_3+A_3B_3')' = x_3$

$(A_2'B_2+A_2B_2')' = x_2$

$(A_1'B_1+A_1B_1')' = x_1$

$(A_0'B_0+A_0B_0')' = x_0$

**A>B,**

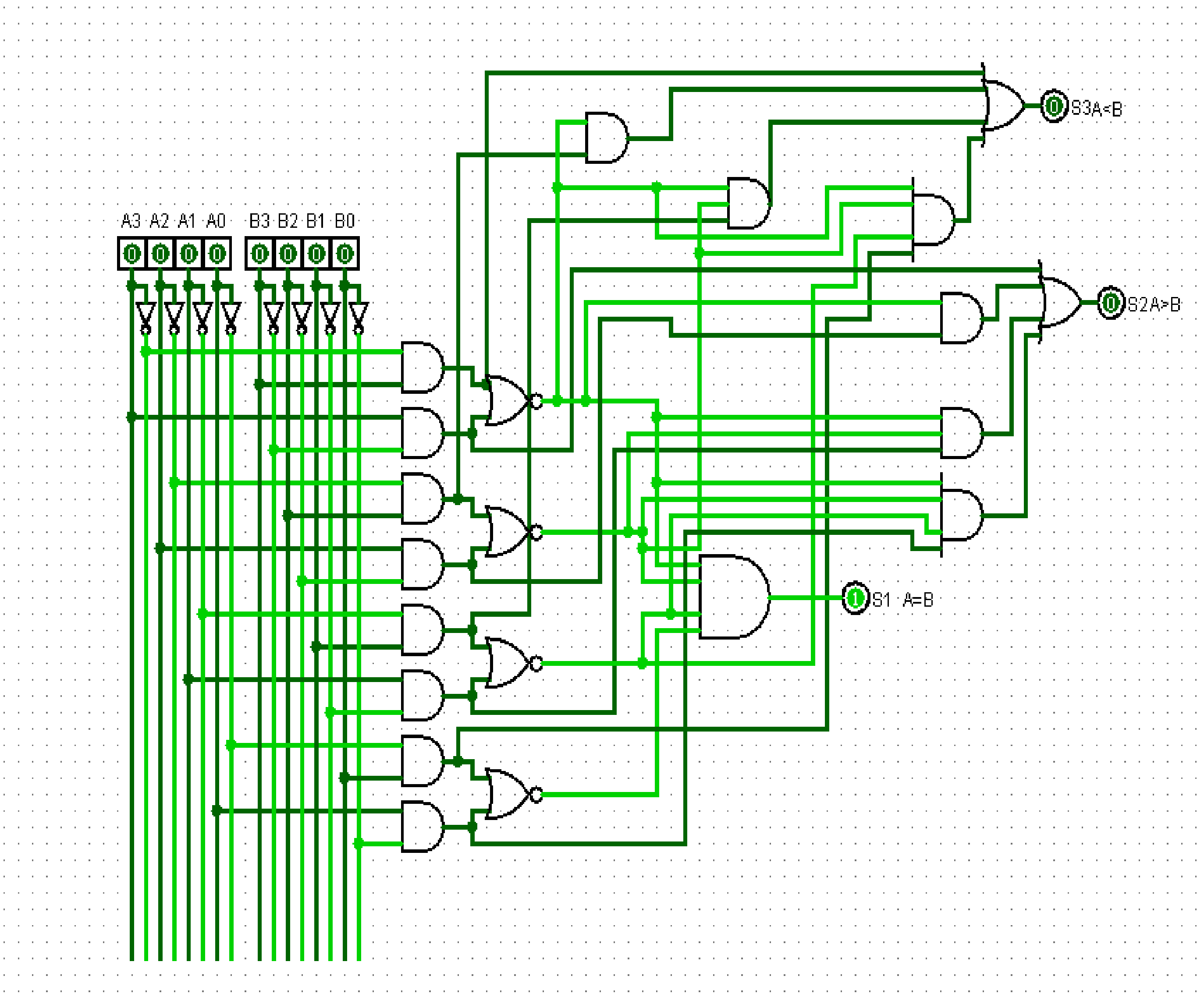
$$A_3B_3' + x_3.\ A_2B_2' + x_3.\ x_2.\ A_1B_1' + x_3.\ x_2.\ x_1.\ A_0B_0'$$

**A<B,**

$$A_3'B_3 + x_3.\ A_2'B_2 + x_3.\ x_2.\ A_1'B_1 + x_3.\ x_2.\ x_1.\ A_0'B_0$$

Now based on these expressions, lets draw the circuit in "Logisim Software"

## Circuit Diagram:




## Circuit Analysis:

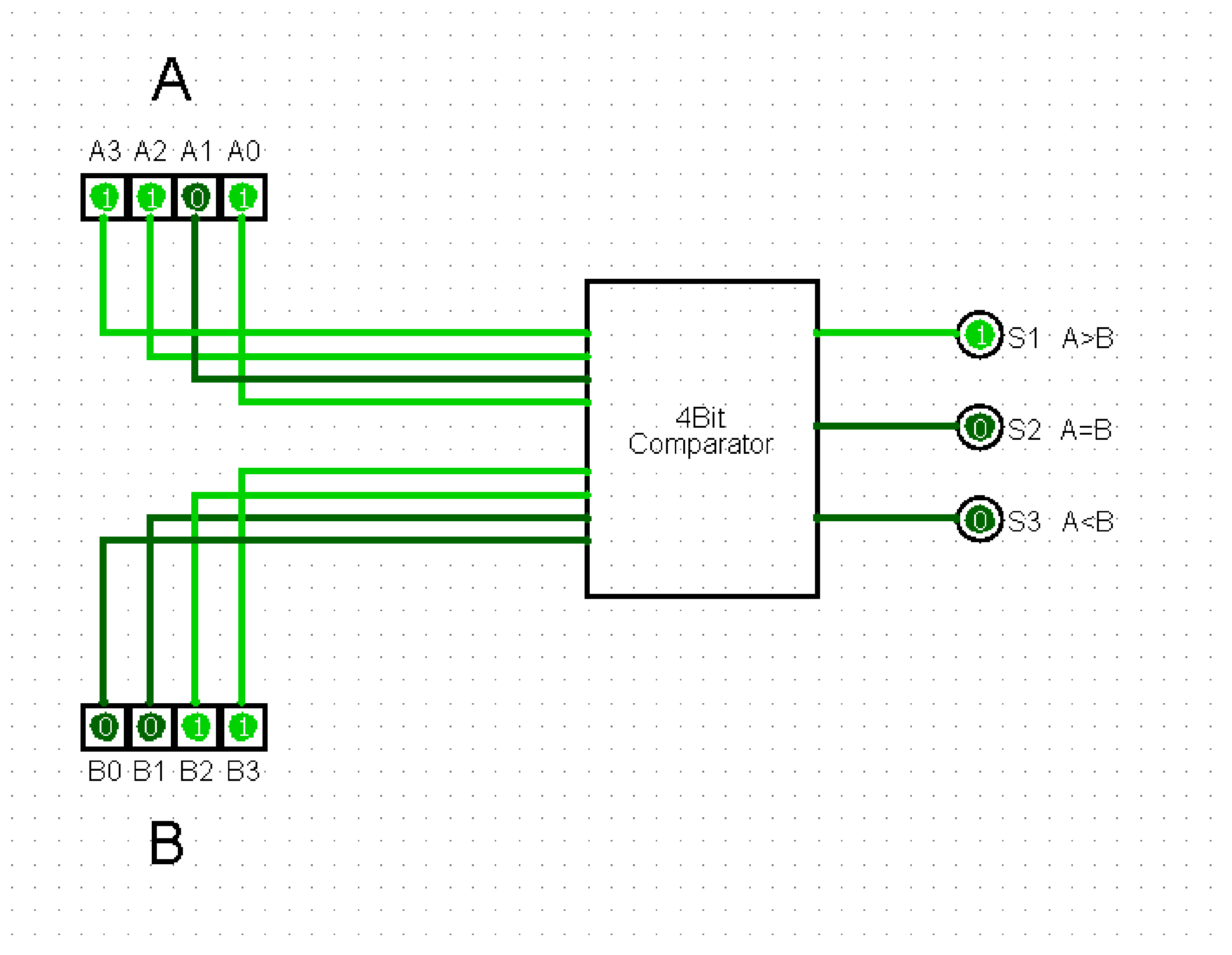
Based on the expressions, we have created a cuircuit diagram for the comparator. Here We have 2 binary 4bit inputs. There are 1bit three outputs; S1, S2 and S3 to flag the the conditions.

If A=B then S1=1

If A>B then S2=1

If A<B then S3=1

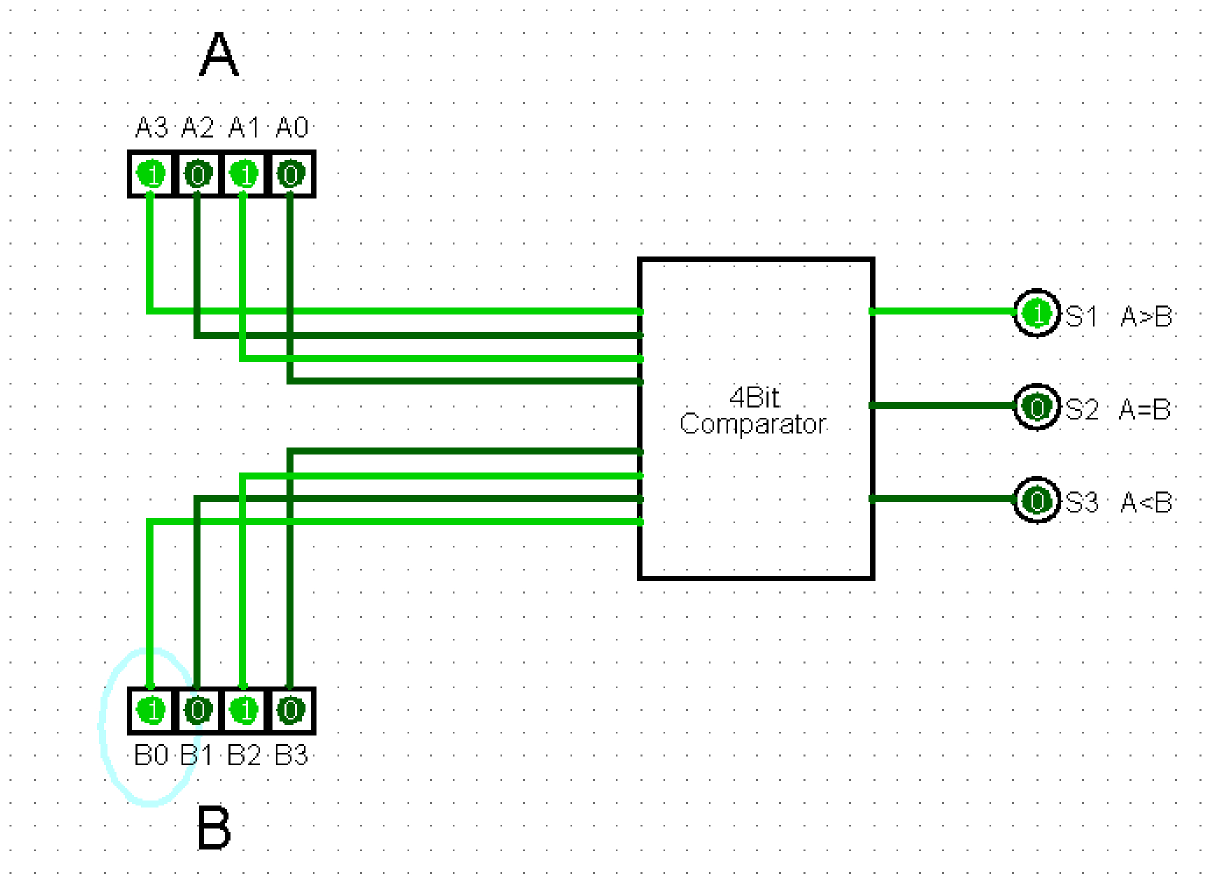
**Block Diagram:**




Using the circuit diagram, we have created this block. Here we can give inputs to two 4bit binary numbers; A and B. The number will be compared inside the block and then give us a feedback whether A is equal or greater or lesser than B. Outputs; S1, S2 and S3are of 1bit.

**<u>Some Outputs and Analysis of Outputs:</u>**

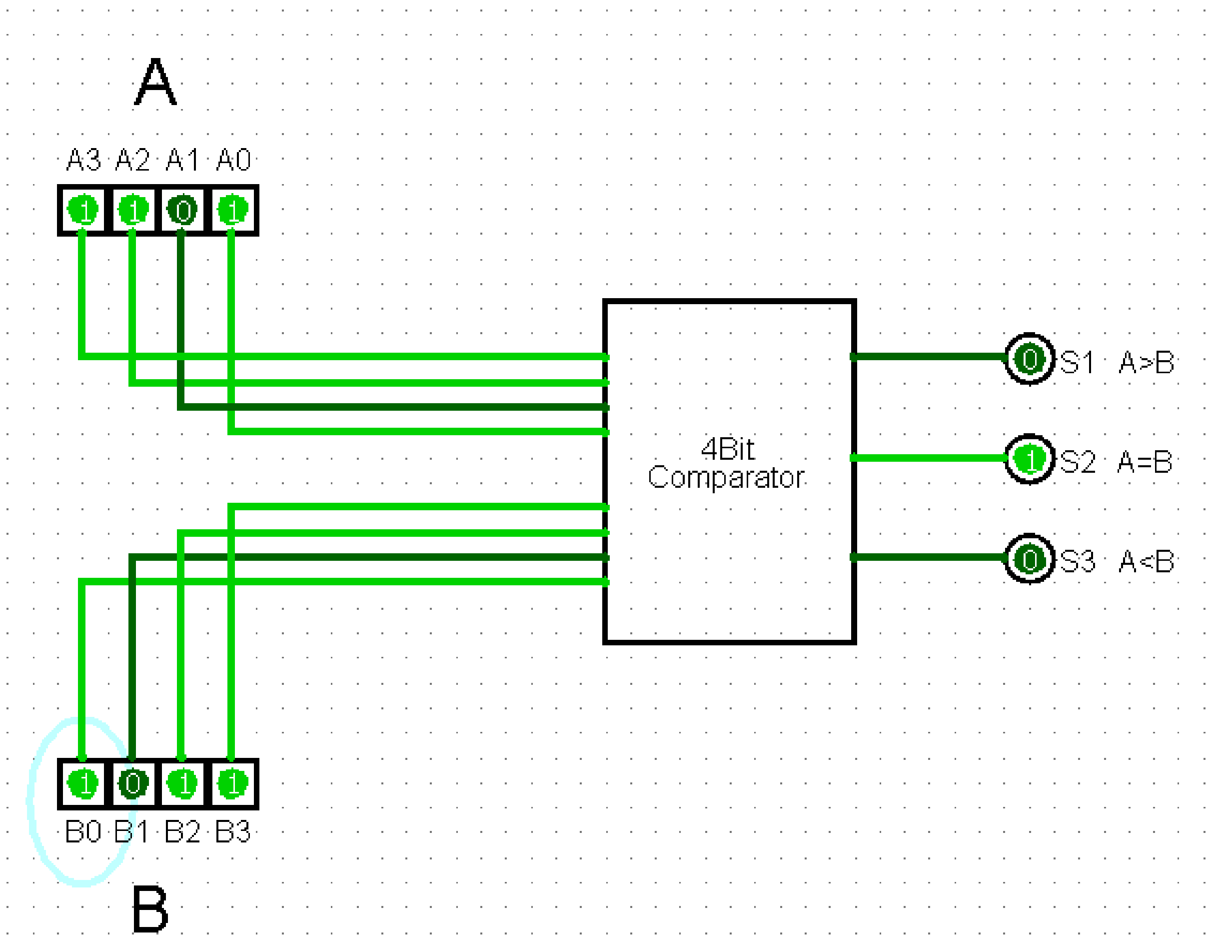
Here we will be testing our Comparator Circuit.




Here, we have taken $A=(1010)_2$ which means 10 in decimal and $B=(0101)_2$ which means 5 in decimal.

As, A>B so, S1 became 1.

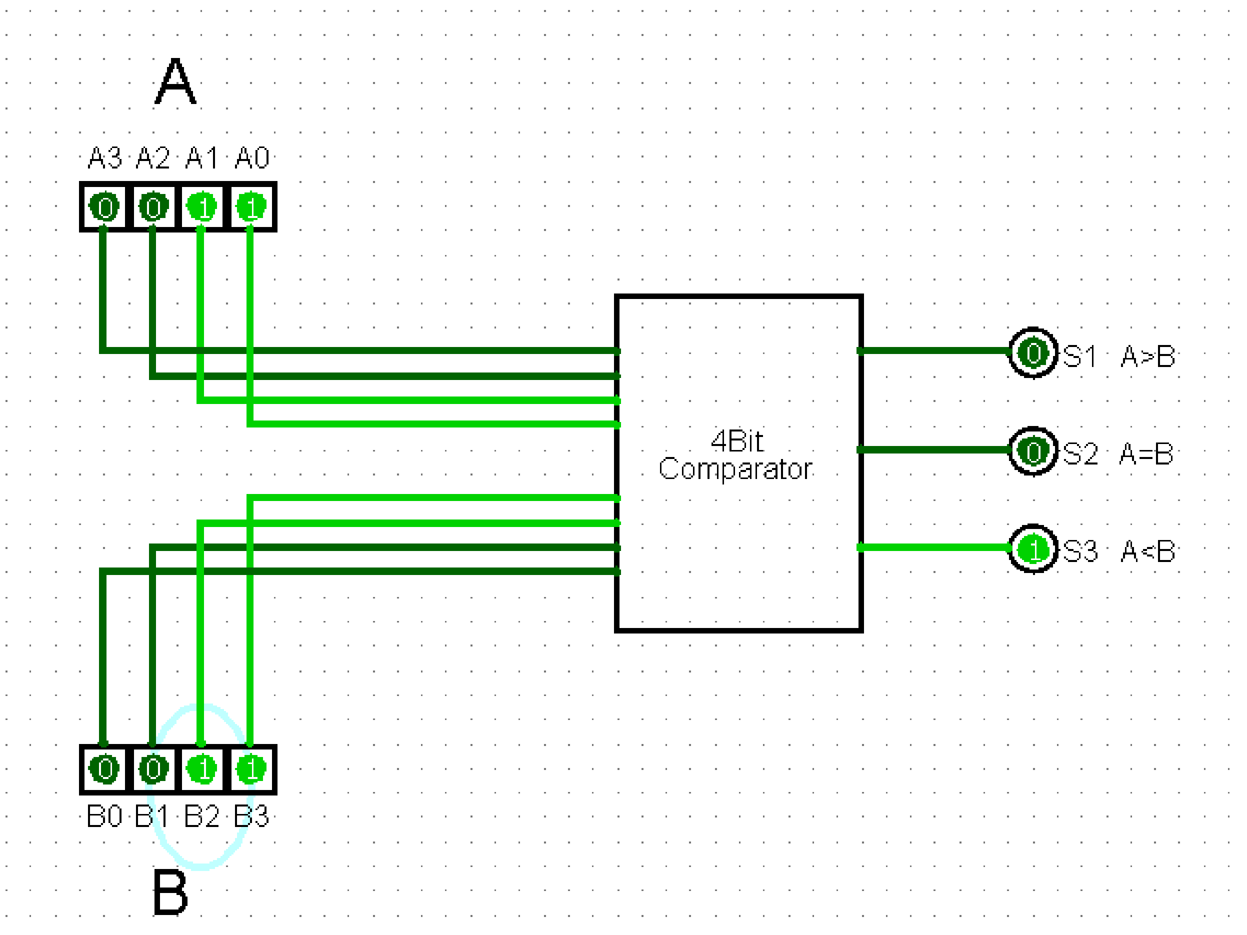
And, S2,S3=0




Here, we have taken A and B both $=(1101)_2$ which means 13 in decimal.

As, A=B so, S2 became 1.

And, S1,S3=0




Lastly, we have taken A=$(0011)_2$ which means 3 in decimal and B=$(1100)_2$ which means 12 in decimal.

As, A<B so, 31 became 1.

And, S1,S2=0

## Verilog Code:

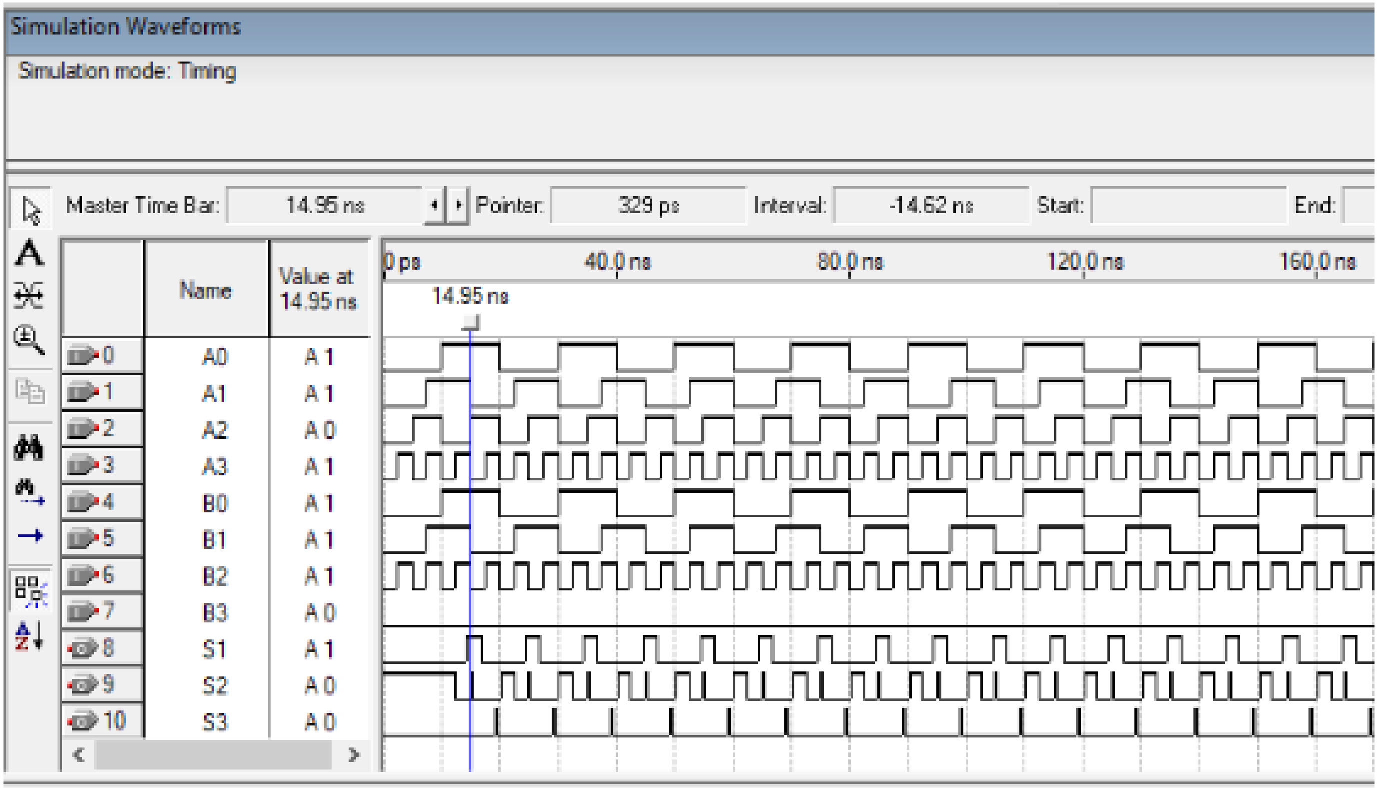
Now we will simulate the circuit using the "Quartus-2" software. We will write a Behavioral Verilog Code.

Comp4bit

```verilog
module Comp4bit(A0,A1,A2,A3,B0,B1,B2,B3,S1,S2,S3);

    input A0,A1,A2,A3,B0,B1,B2,B3;

    output reg S1,S2,S3;

    always @(A0,A1,A2,A3,B0,B1,B2,B3)
    begin
    S1=0;
    S2=0;
    S3=0;

    if(A3==B3 & A2==B2 & A1==B1 & A0==B0)S2=1;

    else if(A3>B3)S1 =1;
    else if(A3==B3 & A2 > B2)S1 =1;
    else if(A3==B3 & A2==B2 & A1>B1)S1 =1;
    else if(A3==B3 & A2==B2 & A1==B1 & A0 > B0 )S1 =1;

    else if(A3<B3)S3=1;
    else if(A3==B3 & B2>A2)S3=1;
    else if(A3==B3 & A2==B2 & B1>A1)S3=1;
    else if(A3==B3 & A2==B2 & B1==A1 & B0>A0)S3=1;


endmodule
```

we have written the code using If-Else statement. We had three condtions. Either A will be equal to B or greater than be or lesser than B. We have derived these conditions to write the code.

## <u>Output and Analysis:</u>




Here we can see that, we have given input for A=(1011)2 which means 11 in decimal and B=(0111)2 which means 7 in decimal.

Here, A>B, that’s why, S1=1

And S2,S3=0

## Conclusion:

In this mini-project, our objective was to create a 4 bit binary comparator circuit which takes A and B as input. We have theoretically developed our idea of how the circuit should work. Then we have determined the boolean expressions and based on those,we have created the circuit using “Logisim Software”. Then using that circuit we have created a block diagram and tested our Comparator Circuit. After successfully testing our circuit, we have simulated our circuit in “Quartus-2 software”. We have written a behavioral Verilog Code for our software using If-Else Statement and then tested the output for our 4Bit Comparator Circuit. It is important to note that, we have tried our best to optimise anysort of human error for best results.

**THE END**