Digital Design

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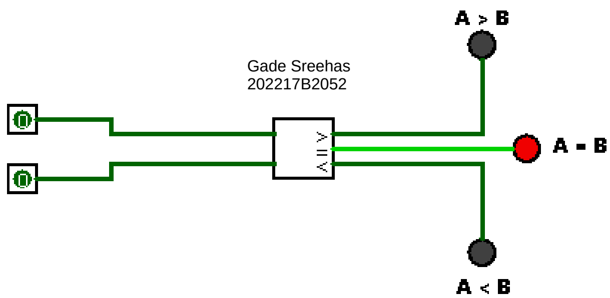
What is Comparator?

A **comparator** takes two numbers as input in binary form and determines whether one number is greater than, less than or equal to the other number.

Simple Comparator



<u>4-bit Comparator with Gates</u>:

Let's consider 2 inputs A, B of 4 bit each.

A→ A_3, A_2, A_1, A_0

B→ B_3, B_2, B_1, B_0

where A_3, B_3 is MSB and A_0, B_0 is the LSB.

Inputs A and B are equal if the corresponding bit of each input are equal i.e.

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

2 bits are equal if the output of their XNOR is 1.

$X_i = A_iB_i + A_i'B_i' = (A_iB_i' + A_i'B_i)'$

XNOR Truth Table

A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

1) A = B

   Inputs A and B will be equal when $A_3 = B_3$, $A_2 = B_2$, $A_1 = B_1$ and $A_0 = B_0$

   $X_i = (A_iB_i' + A_i'B_i)'$

   Output: $X_3\ X_2\ X_1\ X_0$

2) A >B

   Input A will be greater than B when iff

   $A_3 = 1$ and $B_3 = 0$ (or)
   $A_3 = B_3$ and $A_2 = 1$ and $B_2 = 0$ (or)
   $A_3 = B_3$, $A_2 = B_2$ and $A_1 = 1$ and $B_1 = 0$ (or)
   $A_3 = B_3$, $A_2 = B_2$, $A_1 = B_0$ and $A_0 = 1$ and $B_0 = 0$
   Output: $A_3B_3' + X_3\ A_2B_2' + X_3X_2\ A_1B_1' + X_3X_2X_1\ A_0B_0'$

3) A<B

   Input A will be lesser than B when iff

   $A_3 = 0$ and $B_3 = 1$ (or)
   $A_3 = B_3$ and $A_2 = 0$ and $B_2 = 1$ (or)
   $A_3 = B_3$, $A_2 = B_2$ and $A_1 = 0$ and $B_1 = 1$ (or)
   $A_3 = B_3$, $A_2 = B_2$, $A_1 = B_0$ and $A_0 = 0$ and $B_0 = 1$
   Output: $A_3'B_3 + X_3\ A_2'B_2 + X_3X_2\ A_1'B_1 + X_3X_2X_1\ A_0'B_0$

The truth table for a 4-bit comparator

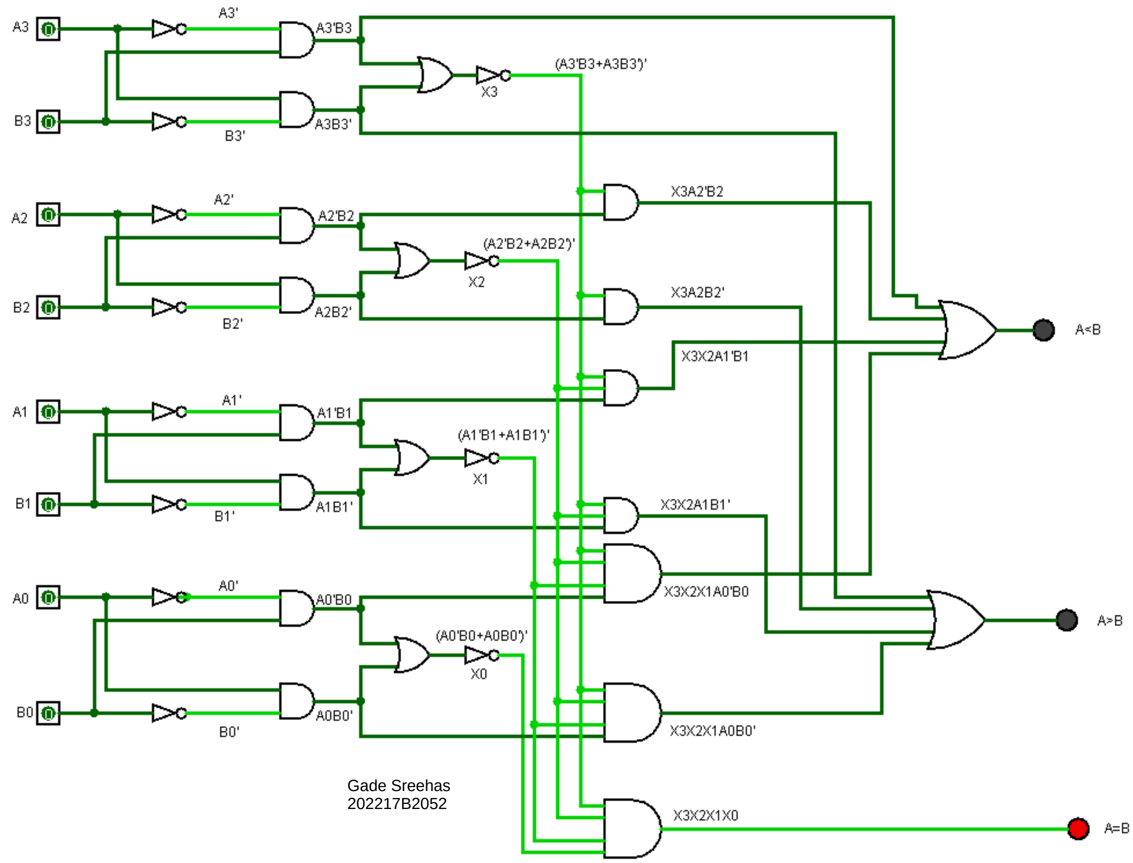
Comparing Inputs				Outputs		
A_3B_3	A_2B_2	A_1B_1	A_0B_0	A>B	A<B	A=B
$A_3 > B_3$	x	x	x	1	0	0
$A_3 < B_3$	x	x	x	0	1	0
$A_3 = B_3$	$A_2 > B_2$	x	x	1	0	0
$A_3 = B_3$	$A_2 < B_2$	x	x	0	1	0
$A_3 = B_3$	$A_2 = B_2$	$A_1 > B_1$	x	1	0	0
$A_3 = B_3$	$A_2 = B_2$	$A_1 < B_1$	x	0	1	0
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 > B_0$	1	0	0
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 < B_0$	0	1	0
$A_3 = B_3$	$A_2 = B_2$	$A_1 = B_1$	$A_0 = B_0$	0	0	1

In the above table 0 = Low Voltage level, 1 = High Voltage level and x = Don't Care

Circuit Components: -

1. 8 data inputs of 1 – bits: - A_3, A_2, A_1, A_0, B_3, B_2, B_1, B_0
2. To Implementing XNOR for 8 bits we require 12 NOT gates, 8 AND gates and 4 OR gates.
3. 1 AND gate of 4 inputs is required for output "A = B"
4. 3 AND gates and 1 OR gates of 4 inputs are required for output "A > B"
5. 3 AND gates and 1 OR gates of 4 inputs are required for output "A < B"

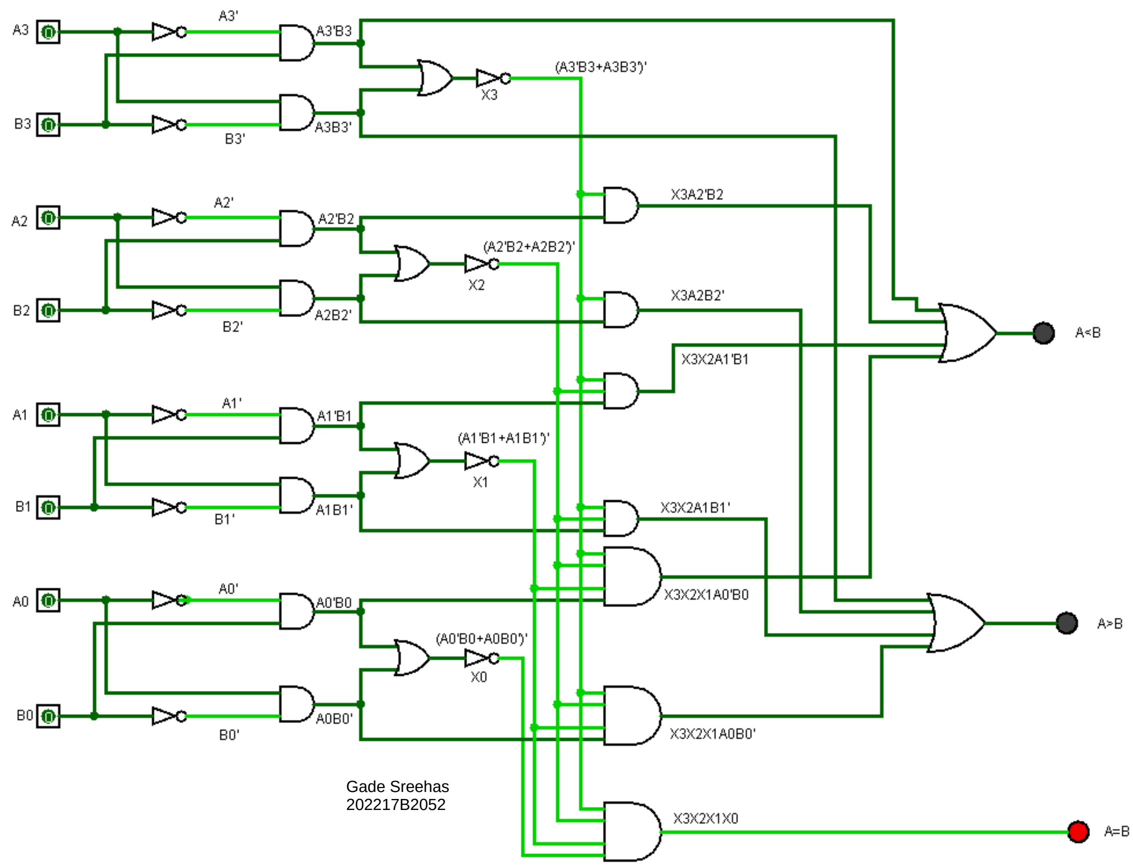
Labeling equation for comparator: -



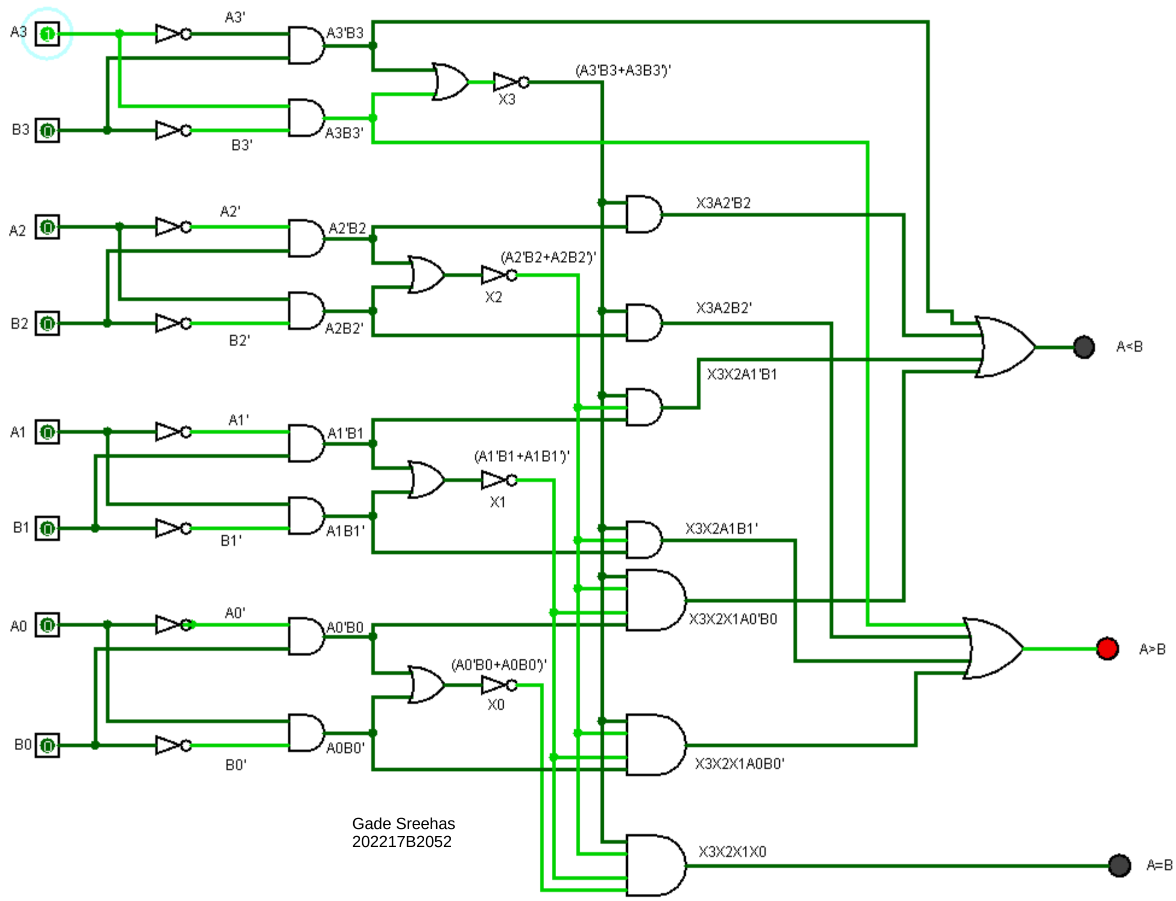
Designing the circuit based on the above equations, we get the following logic diagram for a 4-bit comparator.

For,

1) A = B



2) A > B



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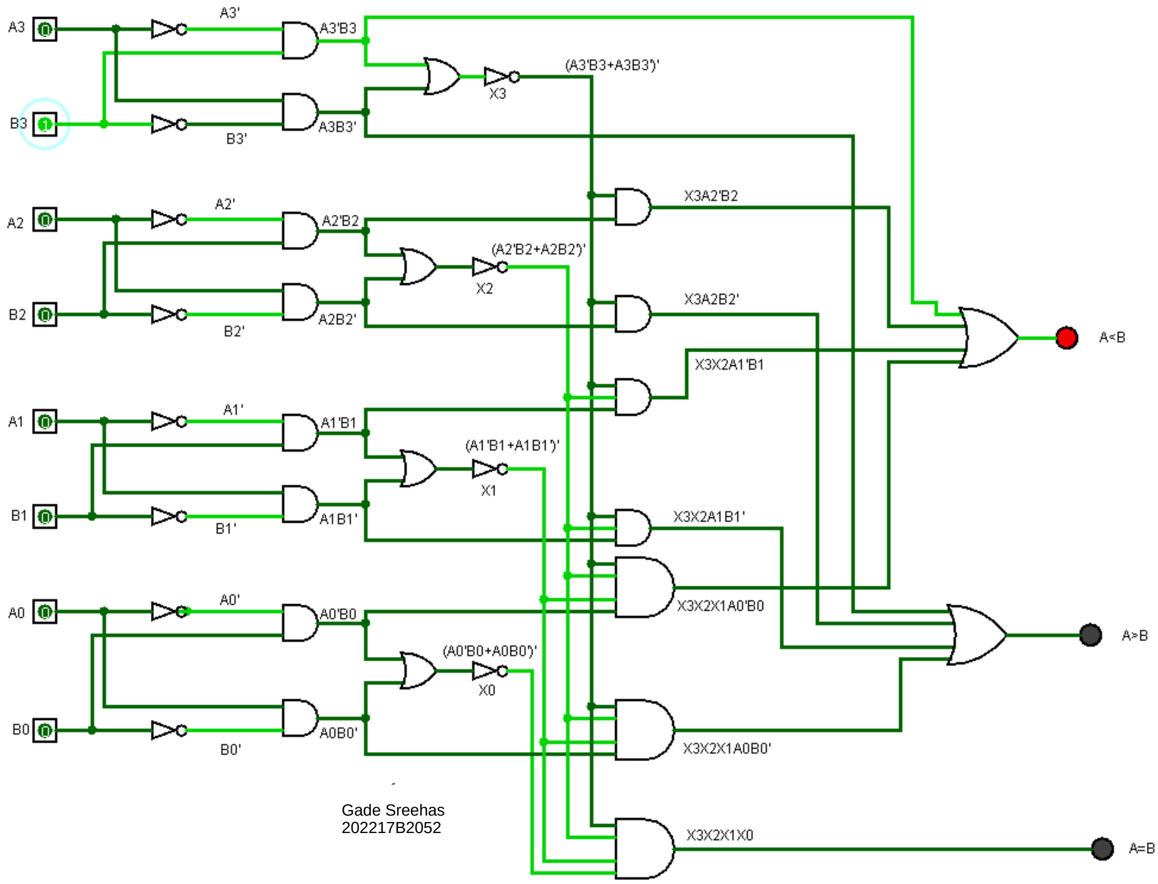
3) A < B


A3
B3
A2
B2
A1
B1
A0
B0
A3'
B3'
A2'
B2'
A1'
B1'
A0'
B0'
A3'B3
A3B3'
A2'B2
A2B2'
A1'B1
A1B1'
A0'B0
A0B0'
(A3'B3+A3B3')'
X3
(A2'B2+A2B2')'
X2
(A1'B1+A1B1')'
X1
(A0'B0+A0B0')'
X0
X3A2'B2
X3A2B2'
X3X2A1'B1
X3X2A1B1'
X3X2X1A0'B0
X3X2X1A0B0'
X3X2X1X0
A<B
A>B
A=B
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