American International University- Bangladesh
Department of Engineering (EEE)
EEE2206: Digital Logic Design Laboratory

Title: Design of a 1-Bit Comparator block using basic gates and design of n-bit comparator using 1-bit comparator block.

Abstract: The purpose of this experiment is to learn the design and behavior of Comparator circuits. Comparators are one of the basic parts of digital electronics.

Introduction: A magnitude comparator is a device that takes in two sets of inputs in its input and compares them to provide an output if they are equal, greater than or less than the other. In this experiment 1-bit comparator will be designed at first and using the 1-bit comparator block 2-bit comparator will be designed.

Theory and Methodology: Magnitude Comparators are combinational logic circuits that take 2 sets of data as its inputs and tests whether the value represented by one binary word is greater than, less than, or equal to the value represented by another binary word.

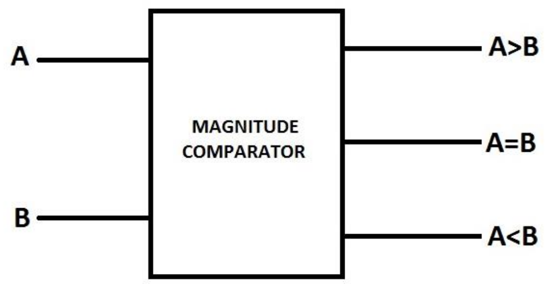

Fig.1: Block Diagram of 1 Bit Magnitude Comparator

Depending on the input combination for a 1-bit magnitude comparator, following behavior table can be developed using the logic expressions.

A=B if, A=B=0 or A=B=1;
A>B if A=1 and B=0;
A<B if A=0 and B=1;

A	B	A=B	A>B	A<B
0	0	1	0	0
0	1	0	0	1
1	0	0	1	0
1	1	1	0	0

The SOP expressions for the output lines can be written as

$$(A=B) = A'B'+AB;$$
$$(A<B) = AB';$$
$$(A>B) = A'B;$$

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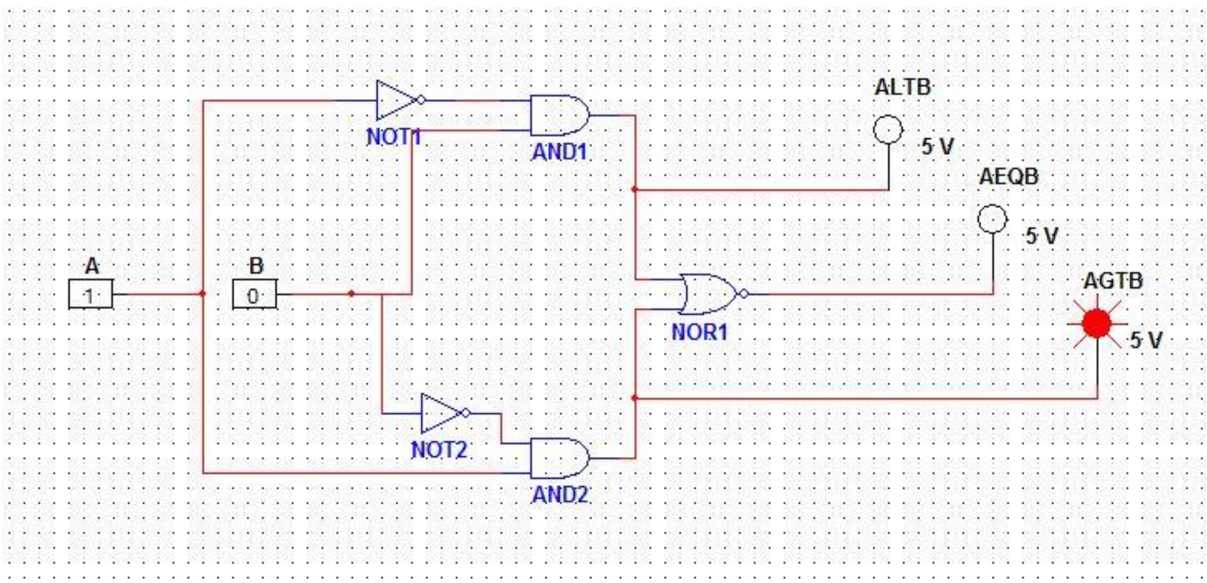


Fig.2: 1-Bit Comparator

2 Bit Comparator design using 1 bit block:
Using 1-bit blocks, n-bit Magnitude comparator can be designed.

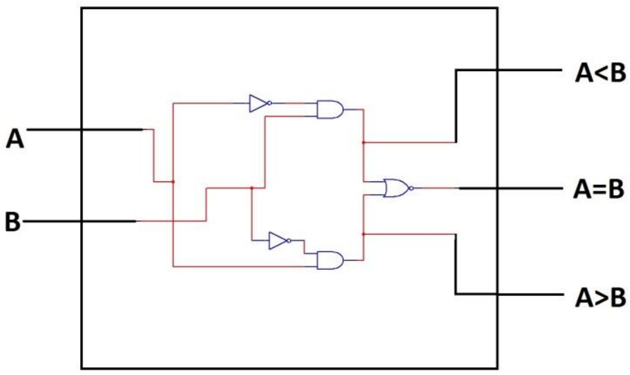


Fig.3: 1-Bit Comparator Block

Designing a 2-bit comparator using 1-bit blocks:
Let us consider 2 words,

Word A -> A_1A_0
Word B-> B_1B_0

For comparing, the following process is used as writing the logic equations.

For A=B,
If $(A_1=B_1)$ & $(A_0=B_0)$, then (A=B);

For A>B,
If $(A_1>B_1)$ then (A>B) or
if $(A_1=B_1)$ & $(A_0>B_0)$, then (A>B);

For A<B,
If $(A_1<B_1)$ then (A<B) or
if $(A_1=B_1)$ & $(A_0<B_0)$, then (A<B)

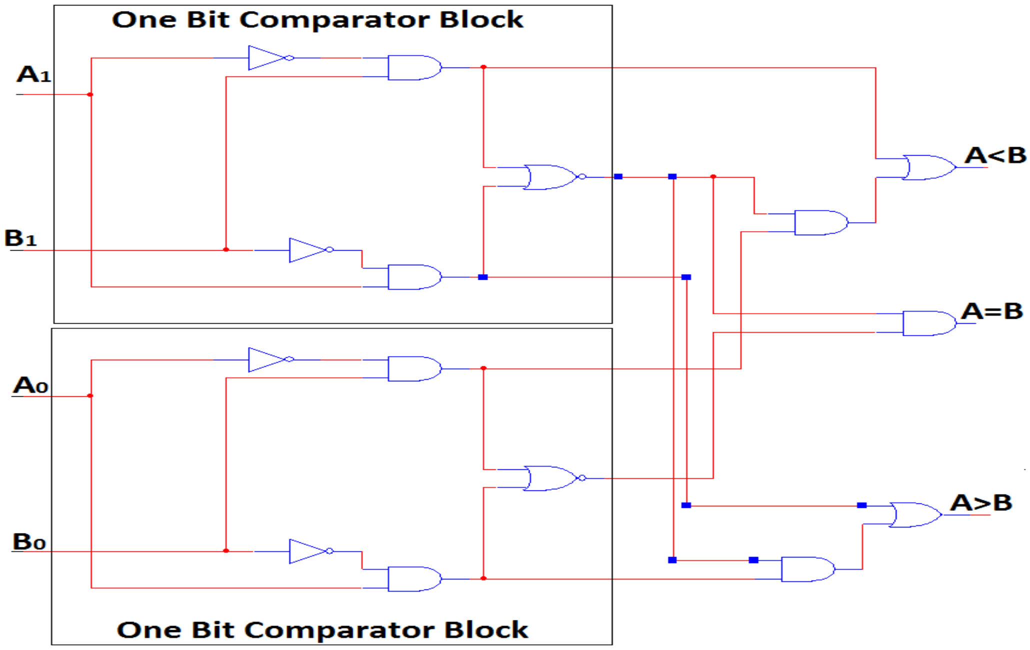


Fig.4: 2-Bit Comparator using 1_bit Comparator Block

For designing a 2-bit comparator using 1-bit comparator block, 2 1-bit comparator block, 3 AND gate and 2 OR gate is needed as shown in Fig.4.

Similarly, a **3-bit magnitude comparator** can also be designed using the same concept. Considering,

Word $A=A_2A_1A_0$ and
Word $B=B_2B_1B_0$;

For A=B,
If $(A_2=B_2)$ & $(A_1=B_1)$ & $(A_0=B_0)$, then $(A=B)$;
For A>B,
If $(A_2>B_2)$ then $(A>B)$ or
If $(A_2=B_2)$ & $(A_1>B_1)$ then $(A>B)$ or
If $(A_2=B_2)$ & $(A_1=B_1)$ & $(A_0>B_0)$, then $(A>B)$;
For A<B,
If $(A_2<B_2)$ then $(A<B)$ or
If $(A_2=B_2)$ & $(A_1<B_1)$ then $(A<B)$ or
If $(A_2=B_2)$ & $(A_1=B_1)$ & $(A_0<B_0)$, then $(A<B)$

Note: For designing the comparator system, if 2 of the output conditions are not satisfied, the third condition is always true, since, in a 3 output system there should be always one output that should be high. Just like an MCQ question with 3 choices, if 2 of the choices are wrong, the third choice is/should be right.

Prelab Homework:
Students must install Multisim software and MUST present the simulation results using ICs to the instructor before the start of the experiment.

Apparatus:

1. Digital trainer board
2. IC 7402:1 pc
3. IC 7404:1 pc
4. IC 7408:2 pcs
5. IC 7432:1 pc
6. IC 7485: 1pc
7. Connecting wires

Precautions: The IC contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages. For proper operation, V_{in} and V_{out} should be constrained to the range GND (V_{in} and V_{out}) to V_{CC}.

Connecting the ICs according to their pin configuration carefully and connecting the wires with the ICs to make sure that they are firmly connected, checking whether all the data switches and output showing LEDs are working.

Experimental Procedure:

1. Determine the output and the truth tables of the logic circuits for 1-bit comparator and a 2-bit comparator in the theory and methodology part.
2. Determine which gates and how many of them are required check and detect all the IC numbers.
3. Carefully place the ICs on the Trainer Board and bias them by connecting them to the +5 volt DC supply and ground.
4. Connect those using wires according to the logic diagram; connect the outputs to the LEDs.
5. Check and note down the outputs by giving different inputs according to the conditions given in table-1 and table-2 and fill up table-1 and table-2 by verifying the output LED state.
6. Design a 4-bit magnitude comparator using IC 74LS85 and verify its operation with the input conditions provided in table-3

Table-1 Condition of Output LED for different input condition for 1 bit comparator

A	B	A=B	A>B	A<B
0	0			
0	1			
1	0			
1	1			

Table-2 Condition of Output LED for different input condition for 2 bit comparator

A_1	B_1	A_0	B_0	A=B	A>B	A<B
0	1	0	0			
1	0	1	1			
1	1	0	0			
1	0	0	1			

Table-3 Condition of Output LED for different input condition for 4 bit comparator IC

A_3	B_3	A_2	B_2	A_1	B_1	A_0	B_0	A=B	A>B	A<B
1	0	1	1	0	1	0	0			
1	1	0	1	1	0	1	1			
1	0	0	1	1	1	0	0			
1	1	0	0	1	1	0	0			

Results and Discussion: Students will implement the circuit in the Trainer Board and match the theoretically obtained truth table by matching outputs for individual input configurations. If the practically obtained truth table does not match they will also investigate the errors.

Students will summarize the experiment and discuss it as a whole. They will observe that the method of deriving logic equations and truth tables is valid and effective. They will also see whether they can make the circuit efficient by reducing the number of gates used. They will also include any limitations of the process. If the connection is not loose, gates are properly biased, all the output LEDs are working and the ICs that are being used are not broken; and then the practically obtained truth table should exactly match the theoretical one. Which will, in turn validate the process.

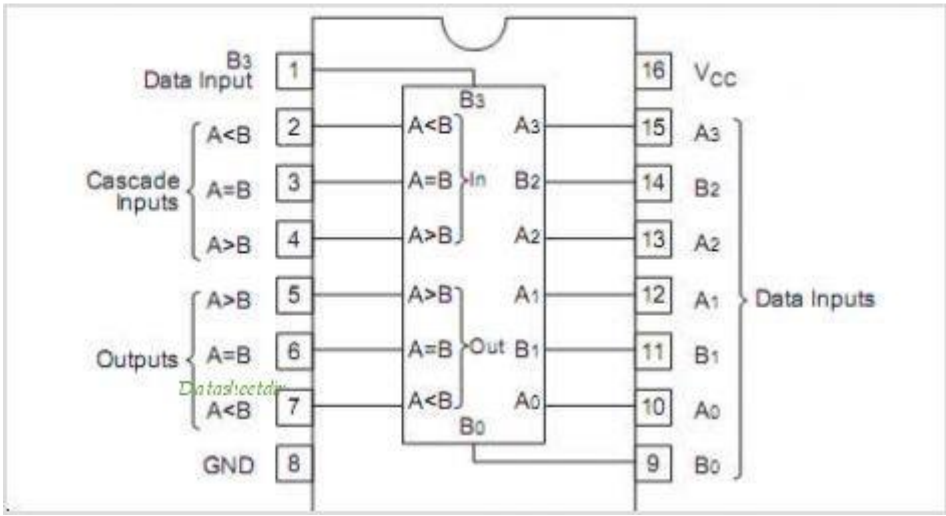
Report:

1. Design a comparator circuit for comparing two words, each of 5 bits of input using 1 bit block.
2. Design the above system with MULTISIM.
3. Design a 4 bit comparator with IC 4585BD from your MULTISIM library and show the output simulation for the inputs provided in table-3.

Reference: Thomas L. Floyd, “Digital Fundamentals”, available Edition, Prentice Hall International Inc.

Appendix:

Pin configuration for IC-74LS85



Multisim: Multisim simulation for the given problems are given below-

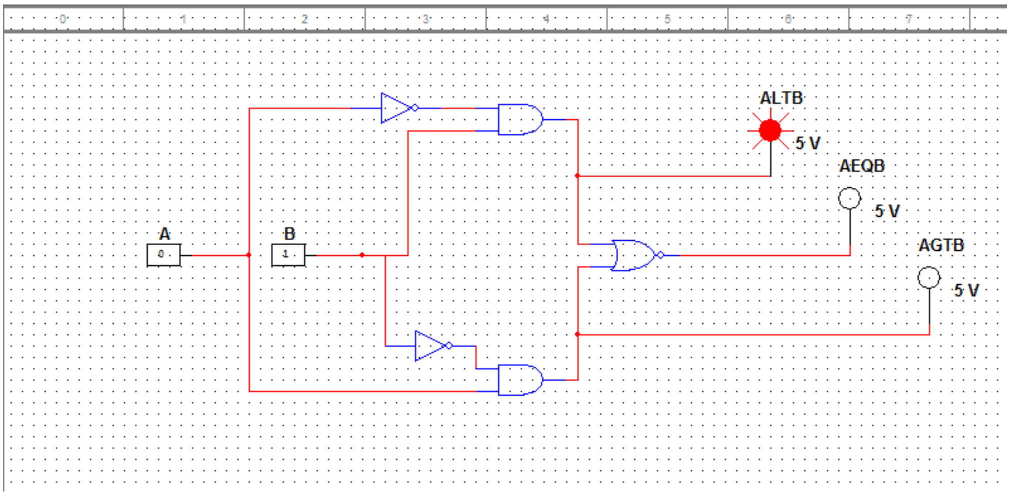


Fig.6: Simulation of 1-Bit comparator

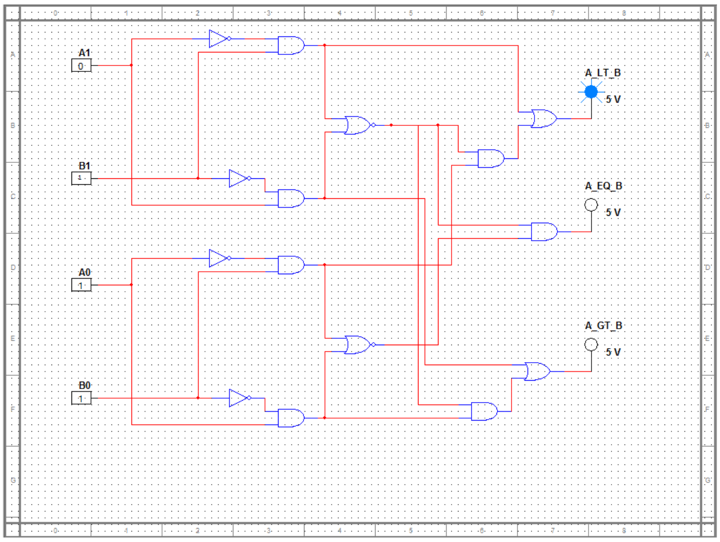


Fig.7: Simulation of 2-Bit comparator using 1-bit comparator block.

For designing a 4 Bit comparator, we will be using IC 4585BD_5V

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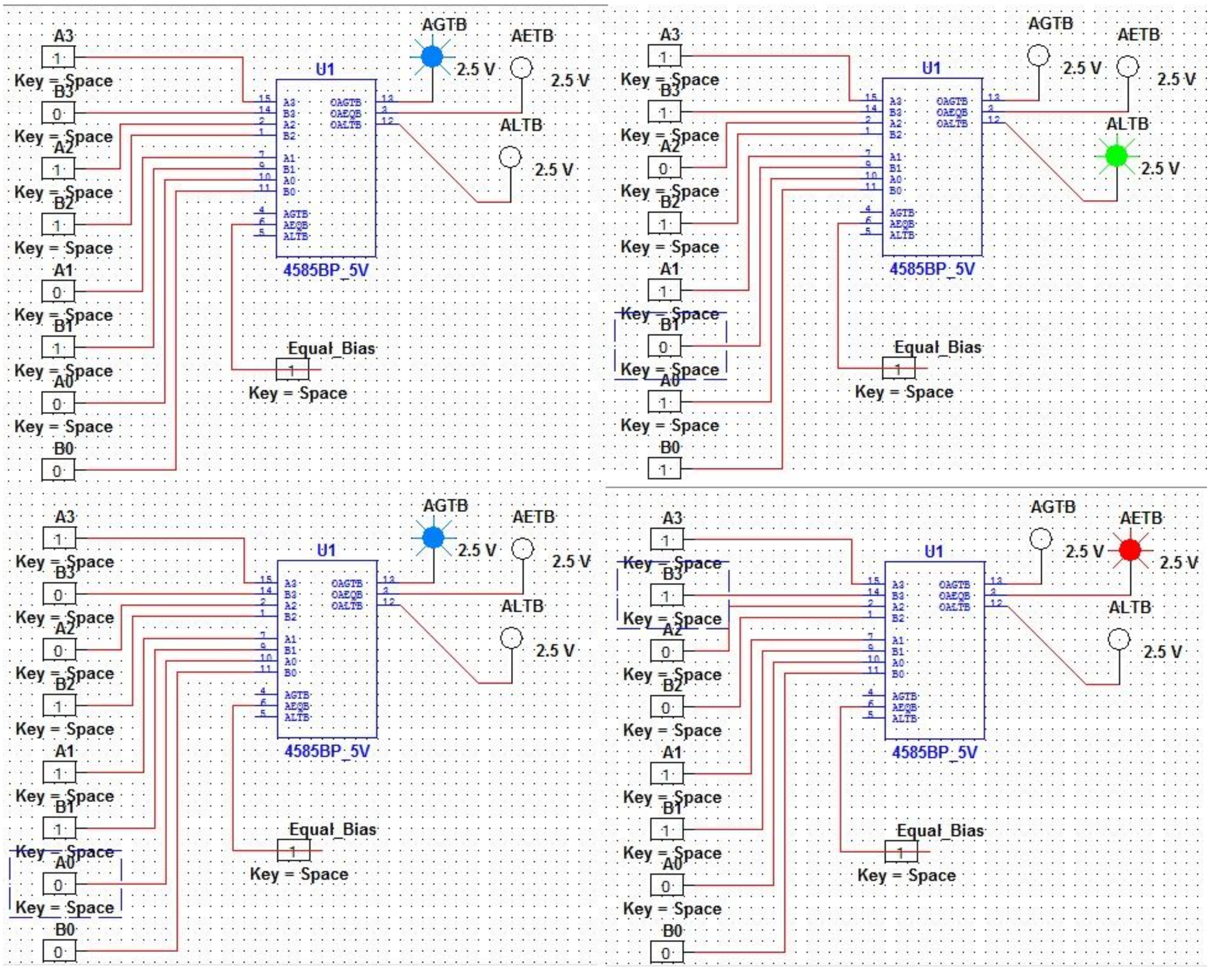

Fig.5: 4-Bit comparator IC