K. J. Somaiya College of Engineering, Mumbai-77

(Autonomous College Affiliated to University of Mumbai)

HDL Mini Project

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Project Title – **8 – bit Digital Comparator**

1. Description / Theory :

Digital or Binary Comparators are made up from standard AND, NOR and NOT gates that compare the digital signals at their input terminals and produce an output depending upon the condition of those inputs.

For eg. along with being able to add and subtract binary numbers we need to be able to compare them and determine whether the value of input A is greater than, smaller than or equal to the value at input B etc. The digital comparator accomplishes this using several logic gates that operate on the principles of Boolean Algebra.

The two types of Digital Comparator are :

1. Identity Comparator

It has only one output terminal for when A=B.

2. Magnitude Comparator

It has three output terminals, one for each equality.

IC 74F521 is an 8-bit identity comparator which provides the low output if two 8-bit inputs are matched.

Shown below are the truth table and symbol of a comparator.

Truth table:

Inputs		Output
$\bar{I}_{A=B}$	A, B	$\overline{O}_{A=B}$
L	A = B (Note 1)	L
L	A ≠ B	H
H	A = B (Note 1)	H
H	A ≠ B	H

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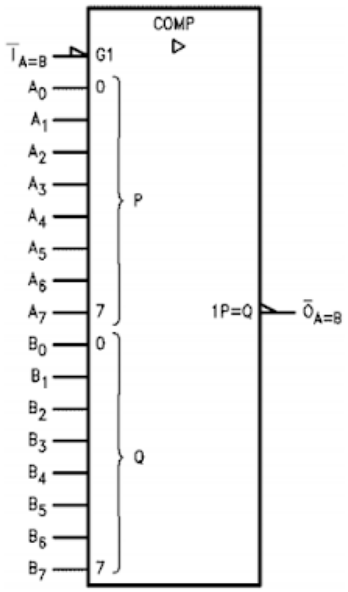
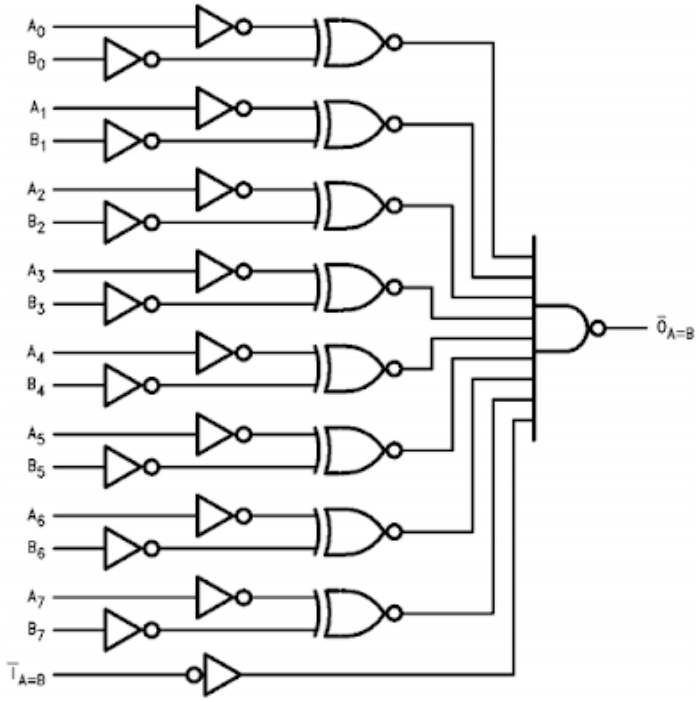
Logical symbol of Comparator :



Logic diagram (from Datasheet of 74L521) :



2. Implementation :

VHDL code for implementation of 8-bit Digital Identity Comparator

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
-- VHDL project: VHDL code for comparator
-- fpga4student.com FPGA projects, Verilog projects, VHDL projects

entity comparator is
port (
      clock: in std_logic;
      -- clock for synchronization
      A,B: in std_logic_vector(7 downto 0);
      -- Two inputs
      IAB: in std_logic; -- Expansion input ( Active low)
      Output: out std_logic -- Output = 0 when A = B
 );
end comparator;
architecture Behavioral of comparator is
signal AB: std_logic_vector(7 downto 0); -- temporary variables
signal Result: std_logic;
begin
AB(0) <= (not A(0)) xnor (not B(0));
        -- combinational circuit
 AB(1) <= (not A(1)) xnor (not B(1));
 AB(2) <= (not A(2)) xnor (not B(2));
 AB(3) <= (not A(3)) xnor (not B(3));
 AB(4) <= (not A(4)) xnor (not B(4));
 AB(5) <= (not A(5)) xnor (not B(5));
 AB(6) <= (not A(6)) xnor (not B(6));
 AB(7) <= (not A(7)) xnor (not B(7));
 -- fpga4student.com FPGA projects, Verilog projects, VHDL projects
```

```
 process(clock)
 begin
 if(rising_edge(clock))then
   if(AB = x"FF" and IAB = '0') then
         -- check whether A = B and IAB =0 or not
            Result <= '0';
    else
     Result <= '1';
    end if;
 end if;
 end process;
 Output <= Result;
end Behavioral;
```

3. Test Bench code :

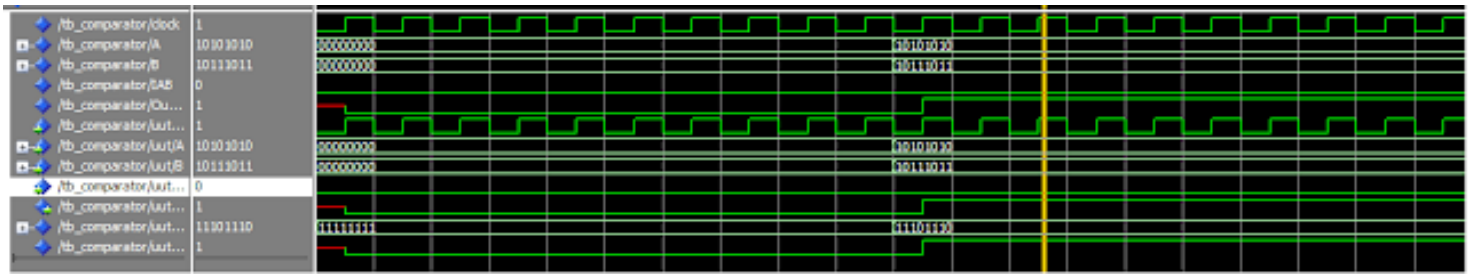
```
LIBRARY ieee;
USE ieee.std_logic_1164.ALL;
-- fpga4student.com FPGA projects, Verilog projects, VHDL projects
-- VHDL project: VHDL code for comparator
ENTITY tb_comparator IS
END tb_comparator;
ARCHITECTURE behavior OF tb_comparator IS
    -- Component Declaration for the Unit Under Test (UUT)
    COMPONENT comparator
    PORT(
         clock : IN  std_logic;
         A : IN  std_logic_vector(7 downto 0);
         B : IN  std_logic_vector(7 downto 0);
         IAB : IN  std_logic;
         Output : OUT  std_logic
```

```
        );
    END COMPONENT;

   --Inputs
   signal clock : std_logic := '0';
   signal A : std_logic_vector(7 downto 0) := (others => '0');
   signal B : std_logic_vector(7 downto 0) := (others => '0');
   signal IAB : std_logic := '0';
--Outputs
   signal Output : std_logic;
   -- Clock period definitions
   constant clock_period : time := 10 ns;
BEGIN
  -- Instantiate the Unit Under Test (UUT)
   uut: comparator PORT MAP (
          clock => clock,
          A => A,
          B => B,
          IAB => IAB,
          Output => Output
        );
   -- Clock process definitions
   clock_process :process
   begin
clock <= '0';
wait for clock_period/2;
clock <= '1';
wait for clock_period/2;
   end process;
    -- Stimulus process
   stim_proc: process
   begin
```

```
        -- hold reset state for 100 ns.
        wait for 100 ns;


 A <= x"AA";
 B <= x"BB";
        wait for clock_period*10;
 B <= x"AA";
        -- insert stimulus here
        wait;
    end process;
-- fpga4student.com FPGA projects, Verilog projects, VHDL projects
END;
```

4. Output and Simulation :

Simulation waveform for above VHDL code



5. Applications :

Listed below are some applications of these Digital Comparators –

- These comparators are used in address decoding circuitry in computers and microprocessor based devices to select a specific input/output device for the storage of data.
- These are used in control applications in which the binary numbers representing physical variables such as temperature, position etc. are compared with a reference value. Then the outputs from the comparator are used to drive the actuators so as to make the physical variables closest to the set or reference value.
- Process controllers
- Servo-motor control
- They are also used in password verification and biometric applications.

6. Advantages and disadvantages :

Advantages –

- In a digital system, a more precise representation of a signal can be obtained by using more binary digits to represent it. While this requires more digital circuits to process the signals, each digit is handled by the same kind of hardware.
- This is useful if we want to compare two variables and want to produce an output when any of the above three conditions are achieved. For example, produce an output from a counter when a certain count number is reached.
- We can also use this concept to implement word comparators which can provide results based on the comparison of two input words.

Disadvantages / Limitations –

- Since digital circuits operate only with digital signals, encoders and decoders are required for this process thus increasing the cost of equipment.
- Energy consumption is higher in digital circuits than analog circuits for similar signals processing. Thus the production of heat increases.
- This application can be implemented for small-level applications and thus cannot be used for major applications.

7. Future scope :

Computer – controlled digital systems can be controlled by software, allowing new functions to be added without changing hardware. The product's design errors can be corrected after the product is in a customer's hands.

Information storage can be easier than in analog ones. The noise-immunity of digital systems permits data to be stored and retrieved without degradation.

Thus, efforts must be made to implement this technology for various applications. Thus comparators can be further used for various microprocessor based applications which involve comparison of inputs.

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