BPC-DE1 Lab_02

Github Digital-electronic-1 repository

Preparation task

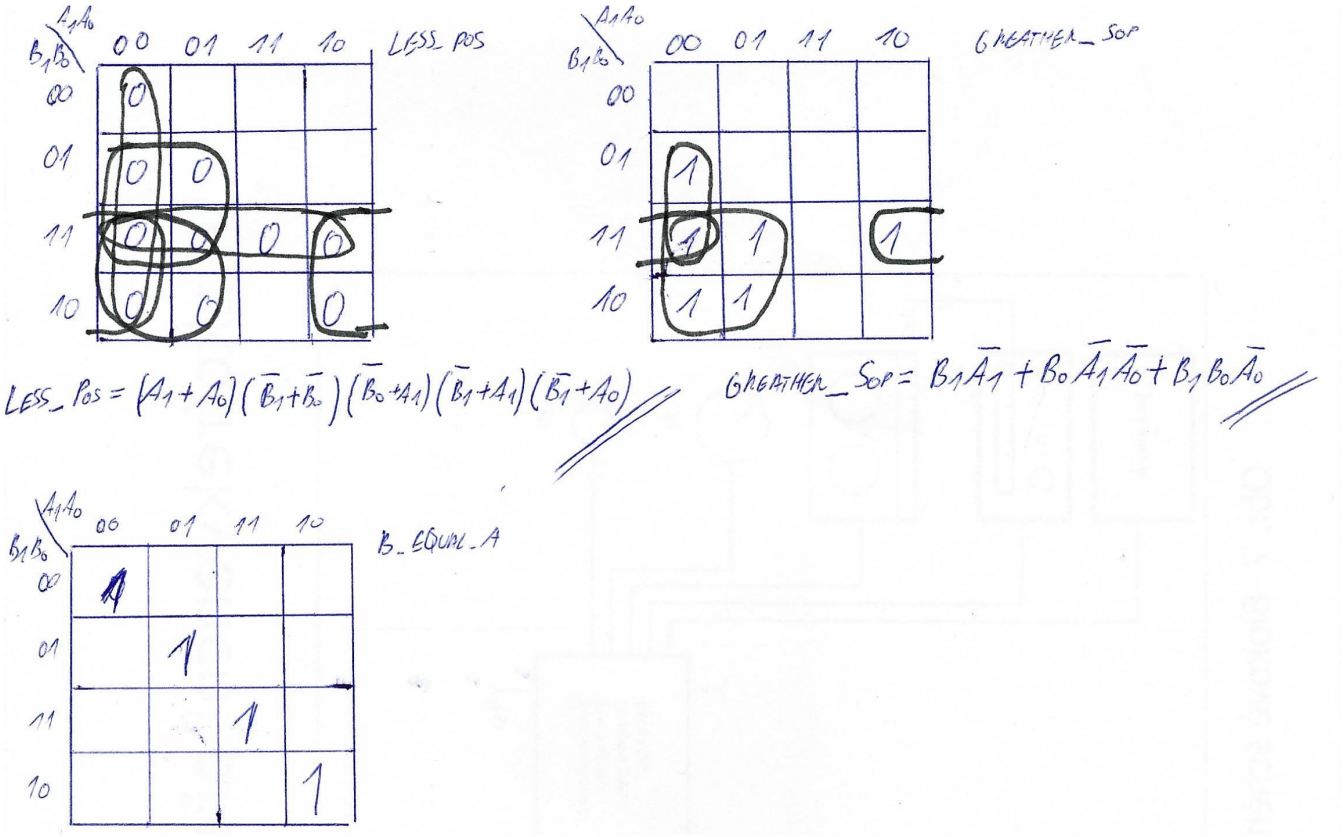
Truth Table for 2-bit comparator

Dec. equivalent	B[1:0]	A[1:0]	B is greater than A	B equals A	B is less than A
0	0 0	0 0	0	1	0
1	0 0	0 1	0	0	1
2	0 0	1 0	0	0	1
3	0 0	1 1	0	0	1
4	0 1	0 0	1	0	0
5	0 1	0 1	0	1	0

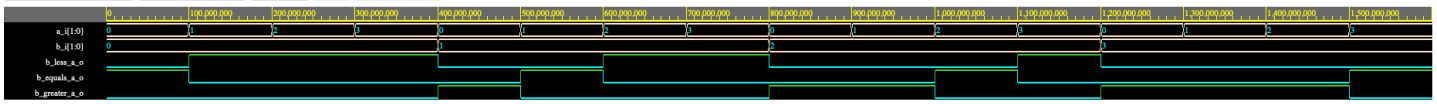
Dec. equivalent	B[1:0]	A[1:0]	B is greater than A	B equals A	B is less than A
6	0 1	1 0	0	0	1
7	0 1	1 1	0	0	1
8	1 0	0 0	1	0	0
9	1 0	0 1	1	0	0
10	1 0	1 0	0	1	0
11	1 0	1 1	0	0	1
12	1 1	0 0	1	0	0
13	1 1	0 1	1	0	0
14	1 1	1 0	1	0	0
15	1 1	1 1	0	1	0

2-bit comparator

K-maps and Sop/Pos functions



Simulation screenshots




```
[2021-02-17 06:32:48 EST] ghdl -i design.vhd testbench.vhd  && ghdl -m  tb_comparator_2bit && ghdl -r  tb_comparator_2bit   --vcd=dump.vcd && sed -i 's/^U/X/g; s/^-/X/g; s/^H/1/g; s/^L/0/g' dump.vcd
analyze design.vhd
analyze testbench.vhd
elaborate tb_comparator_2bit
testbench.vhd:51:9:@0ms:(report note): Stimulus process started
testbench.vhd:154:9:@1600ns:(report note): Stimulus process finished
Finding VCD file...
./dump.vcd
[2021-02-17 06:32:49 EST] Opening EPWave...
Done
```

Playground link

Link to playgroundEDA.com 2-bit comparator

4-bit comparator

Design listing

```
entity comparator_4bit is
    port(
        a_i           : in  std_logic_vector(4 - 1 downto 0);
        b_i           : in  std_logic_vector(4 - 1 downto 0);
```

```
        B_greater_A_o    : out std_logic;       -- B is greather than A
        B_equals_A_o     : out std_logic;       -- B is equal to A
        B_less_A_o       : out std_logic        -- B is less than A
    );
end entity comparator_4bit;

--------------------------------------------------------------------------
-- Architecture body for 4-bit binary comparator
--------------------------------------------------------------------------
architecture Behavioral of comparator_4bit is
begin
    B_greater_A_o    <= '1' when (b_i = a_i) else '0';
    B_equals_A_o     <= '1' when (b_i = a_i) else '0';
    B_less_A_o       <= '1' when (b_i < a_i) else '0';
end architecture Behavioral;
```

Test-bench listing

```
entity tb_comparator_4bit is
    -- Entity of testbench is always empty
end entity tb_comparator_4bit;

--------------------------------------------------------------------------
-- Architecture body for testbench
--------------------------------------------------------------------------
architecture testbench of tb_comparator_4bit is

    -- Local signals
    signal s_a       : std_logic_vector(4 - 1 downto 0);
    signal s_b       : std_logic_vector(4 - 1 downto 0);
    signal s_B_greater_A : std_logic;
    signal s_B_equals_A  : std_logic;
    signal s_B_less_A    : std_logic;

begin

        port map(
            a_i           => s_a,
            b_i           => s_b,
            B_greater_A_o => s_B_greater_A,
            B_equals_A_o  => s_B_equals_A,
            B_less_A_o    => s_B_less_A
        );

    --------------------------------------------------------------------
    -- Data generation process 0
    --------------------------------------------------------------------
    p_stimulus : process
```

```
    begin
        -- Report a note at the begining of stimulus process
        report "Stimulus process started" severity note;


        -- First test values
        s_b <= "0000"; s_a <= "0000"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A = '0'))
        -- If false, then report an error
        report "Test failed for input combination: 0000, 0000" severity error;

        s_b <= "1100"; s_a <= "0101"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '1') and (s_B_equals_A = '0') and (s_B_less_A = '0'))
        -- If false, then report an error
        report "Test failed for input combination: 1100, 0101" severity error;

        s_b <= "0010"; s_a <= "0111"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '0') and (s_B_equals_A = '0') and (s_B_less_A = '1'))
        -- If false, then report an error
        report "Test failed for input combination: 0010, 0111" severity error;

        s_b <= "1111"; s_a <= "1111"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A = '0'))
        -- If false, then report an error
        report "Test failed for input combination: 1111, 1111" severity error;

        s_b <= "1111"; s_a <= "1010"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '1') and (s_B_equals_A = '0') and (s_B_less_A = '0'))
        -- If false, then report an error
        report "Test failed for input combination: 1111, 1010" severity error;

        s_b <= "0110"; s_a <= "1000"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '0') and (s_B_equals_A = '0') and (s_B_less_A = '1'))
        -- If false, then report an error
        report "Test failed for input combination: 0110, 1000" severity error;

        s_b <= "1011"; s_a <= "1101"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '0') and (s_B_equals_A = '0') and (s_B_less_A = '1'))
        -- If false, then report an error
        report "Test failed for input combination: 1011, 1101" severity error;

        s_b <= "1001"; s_a <= "0100"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '1') and (s_B_equals_A = '0') and (s_B_less_A = '0'))
```

```
        -- If false, then report an error
        report "Test failed for input combination: 1001, 0100" severity error;

        s_b <= "0101"; s_a <= "0101"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A = '0'))
        -- If false, then report an error
        report "Test failed for input combination: 0101, 0101" severity error;

        s_b <= "1110"; s_a <= "1100"; wait for 100 ns;
        -- Expected output
        assert ((s_B_greater_A = '1') and (s_B_equals_A = '0') and (s_B_less_A = '0'))
        -- If false, then report an error
        report "Test failed for input combination: 1110, 1100" severity error;


        -- Report a note at the end of stimulus process
        report "Stimulus process finished" severity note;
        wait;
    end process p_stimulus;

end architecture testbench;
```

Terminal listing (with error)

```
[2021-02-18 05:40:57 EST] ghdl -i design.vhd testbench.vhd  && ghdl -m
tb_comparator_4bit && ghdl -r  tb_comparator_4bit
analyze design.vhd
analyze testbench.vhd
elaborate tb_comparator_4bit
testbench.vhd:51:9:@0ms:(report note): Stimulus process started
testbench.vhd:57:9:@100ns:(assertion error): Test failed for input combination: 0000,
0000
testbench.vhd:63:9:@200ns:(assertion error): Test failed for input combination: 1100,
0101
testbench.vhd:75:9:@400ns:(assertion error): Test failed for input combination: 1111,
1111
testbench.vhd:81:9:@500ns:(assertion error): Test failed for input combination: 1111,
1010
testbench.vhd:99:9:@800ns:(assertion error): Test failed for input combination: 1001,
0100
testbench.vhd:105:9:@900ns:(assertion error): Test failed for input combination:
0101, 0101
testbench.vhd:111:9:@1us:(assertion error): Test failed for input combination: 1110,
1100
testbench.vhd:117:9:@1us:(report note): Stimulus process finished
Done
```

Playground link

Link to PlaygroundEDA.com 4-bit comparator