02 - Logic

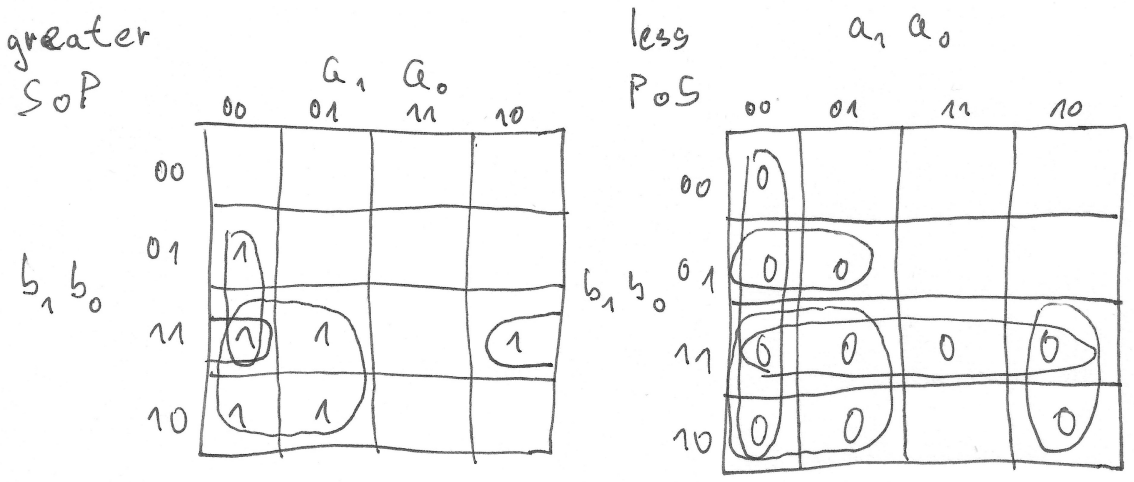
EDA Playground link for 2-bit comparator

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
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

equals_SoP = m0 + m5 + m10 + m15 = (!b1.!b0.!a1.!a0) + (!b1.b0.!a1.a0) + (b1.!b0.a1.!a0) + (b1.b0.a1.a0)

less_PoS = M0 . M4 . M5 . M8 . M9 . M10 . M12 . M13 . M14 . M15 =
= (b1+b0+a1+a0).(b1+!b0+a1+a0).(b1+!b0+a1+!a0).(!b1+b0+a1+a0).(!b1+b0+a1+!a0).
(!b1+b0+!a1+a0).(!b1+!b0+a1+a0).(!b1+!b0+a1+!a0).(!b1+!b0+!a1+a0).(!b1+!b0+!a1+!a0)

Karnaugh maps for 2-bit



$$greater\_SoP = b_1\bar{a}_1 + b_0\bar{a}_1\bar{a}_0 + b_1 b_0\bar{a}_0$$

$$less\_PoS = (a_1 + a_0)\cdot(\bar{b}_1 + \bar{b}_0)\cdot(\bar{b}_1 + a_1)\cdot(\bar{b}_0 + a_1)\cdot(\bar{b}_1 + a_0)$$

B1 B0 \ A1 A0	00	01	11	10
00	1	0	0	0
01	0	1	0	0
11	0	0	1	0
10	0	0	0	1

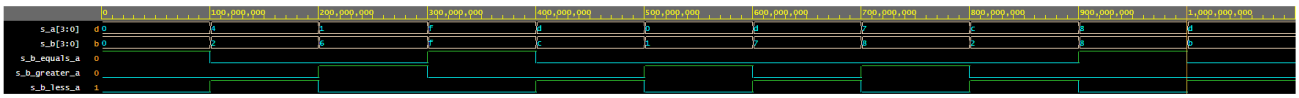
4-bit comparator

EDA Playground link for 4-bit comparator

```
95          assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A = '0'))
96          report "Test failed for input combination: 1000, 1000" severity error;
97
98          s_b <= "1011"; s_a <= "1101"; wait for 100 ns;
99          assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A = '0'))
100         report "Test failed for input combination: 1011, 1101" severity error;
101
102
103         -- WRITE OTHER TESTS HERE
104
105
106         -- Report a note at the end of stimulus process
107         report "Stimulus process finished" severity note;
108         wait;
109     end process p_stimulus;
110
111 end architecture testbench;
112
```

Log Share

```
[2021-02-17 06:54:04 EST] ghdl -i design.vhd testbench.vhd  && ghdl -m  tb_comparator_2bit && ghdl -r  tb_
analyze design.vhd
analyze testbench.vhd
elaborate tb_comparator_2bit
testbench.vhd:51:9:@0ms:(report note): Stimulus process started
testbench.vhd:99:16:@1100ns:(assertion error): Test failed for input combination: 1011, 1101
testbench.vhd:107:9:@1100ns:(report note): Stimulus process finished
Finding VCD file...
./dump.vcd
[2021-02-17 06:54:05 EST] Opening EPWave...
Done
```



VHDL testbench

```
p_stimulus : process
    begin

        report "Stimulus process started" severity note;

                s_b <= "0000"; s_a <= "0000"; wait for 100 ns;
                assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A
= '0'))
        report "Test failed for input combination: 0000, 0000" severity error;

                s_b <= "0010"; s_a <= "0100"; wait for 100 ns;
                assert ((s_B_greater_A = '0') and (s_B_equals_A = '0') and (s_B_less_A
= '1'))
        report "Test failed for input combination: 0010, 0100" severity error;

                s_b <= "0110"; s_a <= "0001"; wait for 100 ns;
                assert ((s_B_greater_A = '1') and (s_B_equals_A = '0') and (s_B_less_A
= '0'))
        report "Test failed for input combination: 0110, 0001" severity error;
```

```
                s_b <= "1111"; s_a <= "1111"; wait for 100 ns;
                assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A
= '0'))
        report "Test failed for input combination: 1111, 1111" severity error;

                s_b <= "1100"; s_a <= "1101"; wait for 100 ns;
                assert ((s_B_greater_A = '0') and (s_B_equals_A = '0') and (s_B_less_A
= '1'))
        report "Test failed for input combination: 1100, 1101" severity error;

                s_b <= "0001"; s_a <= "0000"; wait for 100 ns;
                assert ((s_B_greater_A = '1') and (s_B_equals_A = '0') and (s_B_less_A
= '0'))
        report "Test failed for input combination: 0001, 0000" severity error;

                s_b <= "0111"; s_a <= "1101"; wait for 100 ns;
                assert ((s_B_greater_A = '0') and (s_B_equals_A = '0') and (s_B_less_A
= '1'))
        report "Test failed for input combination: 0111, 1101" severity error;

                s_b <= "1000"; s_a <= "0111"; wait for 100 ns;
                assert ((s_B_greater_A = '1') and (s_B_equals_A = '0') and (s_B_less_A
= '0'))
        report "Test failed for input combination: 1000, 0111" severity error;

                s_b <= "0010"; s_a <= "1100"; wait for 100 ns;
                assert ((s_B_greater_A = '0') and (s_B_equals_A = '0') and (s_B_less_A
= '1'))
        report "Test failed for input combination: 0010, 1100" severity error;

                s_b <= "1000"; s_a <= "1000"; wait for 100 ns;
                assert ((s_B_greater_A = '0') and (s_B_equals_A = '1') and (s_B_less_A
= '0'))
        report "Test failed for input combination: 1000, 1000" severity error;

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


        report "Stimulus process finished" severity note;
        wait;
    end process p_stimulus;
```

VHDL design

```
architecture Behavioral of comparator_2bit 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;
```