My DE1 repisitory link

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Combinational logic

Truth table

Dec. equivalent	B[1:0]	A[1:0]	B > A	B = A	B is < 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 = !a!b!c!d + !dc!ba + d!cb!a + dcba

less_PoS = (d+c+b+a) (d+!c+b+a) (d+!c+b+!a) (!d+c+b+a) (!d+c+b+!a) (!d+c+!+a) (!d+!c+b+a) (!d+!c+b+!a) (!d+!c+!b+a) (!d+!c+!b+!a)

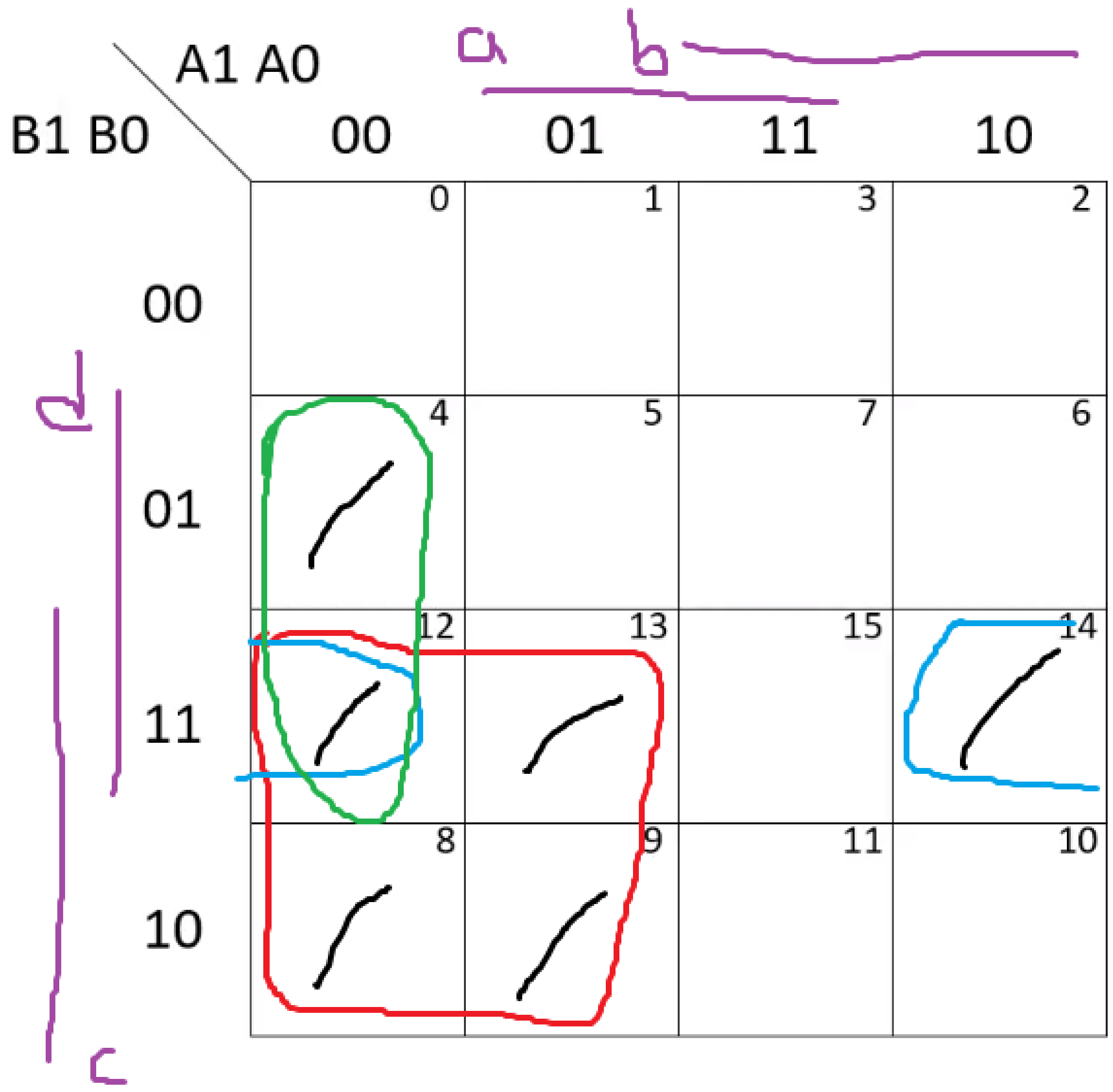
Karnaugh Maps

Karnaugh map for "equals" function

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

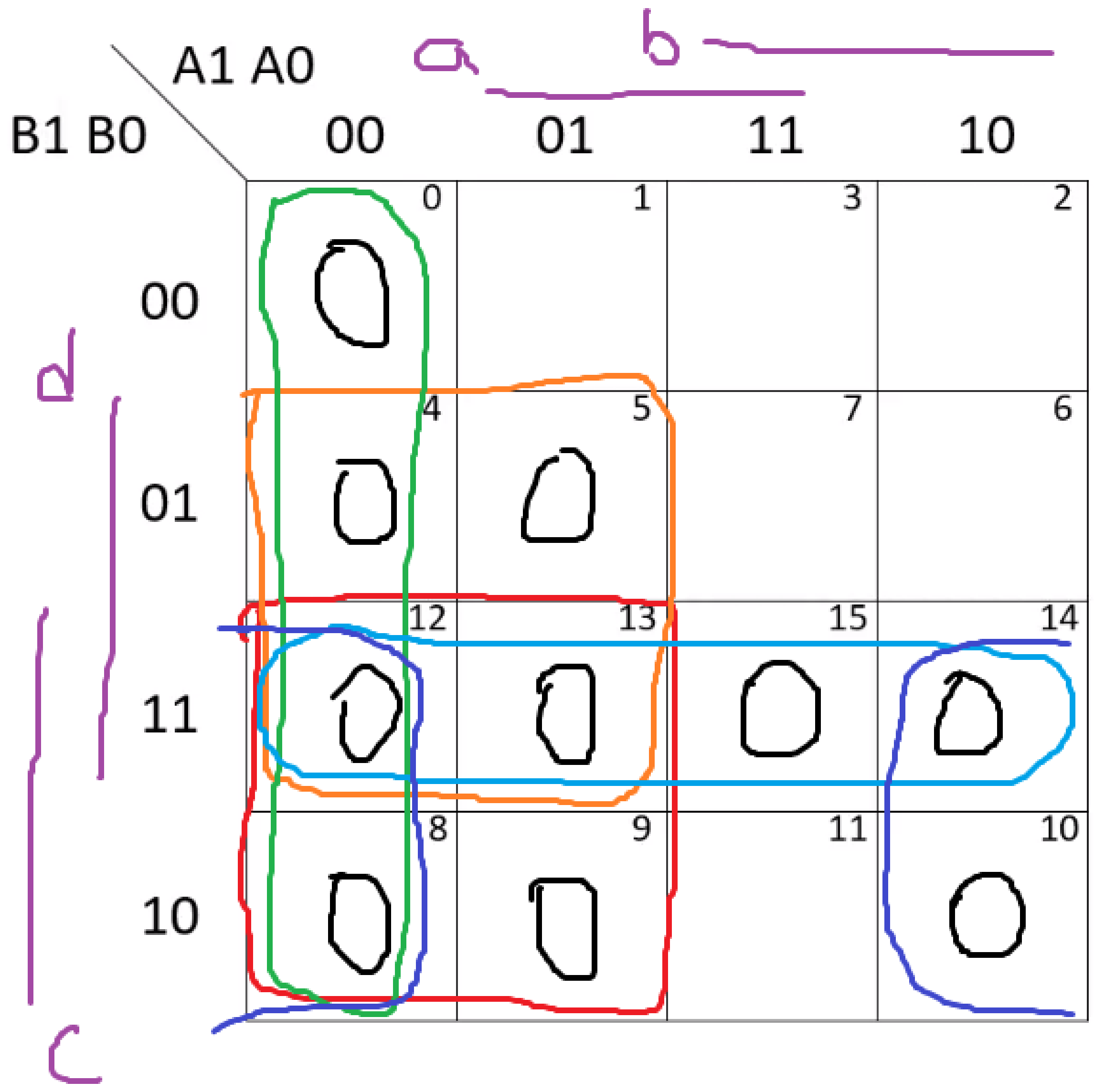
equals_SoP = !a!b!c!d + !dc!ba + d!cb!a + dcba

Karnaugh map for "greater than" function



greater_SoP_min = c!b + d!b!a + dc!a

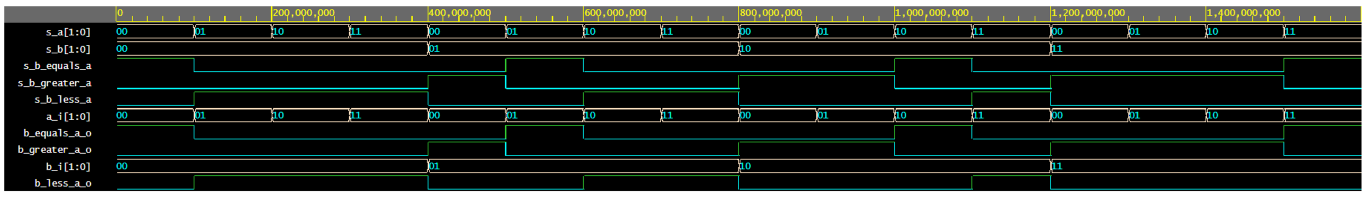
Karnaugh map for "less than" function



less_PoS_min = (!c + !b) * (!d + !b) * (!c + a) * (a + b) * (!d + !c)

2-bit Karnaugh map

Result



Link

EDA Playground link for 2-bit Karnaugh map

4-bit Karnaugh map

Design Code

```
library ieee;
use ieee.std_logic_1164.all;

------------------------------------------------------------------------
-- Entity declaration for 4-bit binary comparator
------------------------------------------------------------------------
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);

        -- COMPLETE ENTITY DECLARATION
        B_greater_A_o : out std_logic;
        B_equals_A_o  : out std_logic;
        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;
```

Testbanch Code

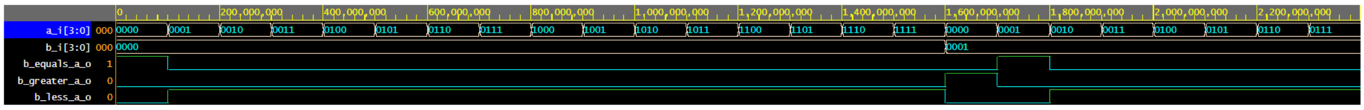
```
library ieee;
use ieee.std_logic_1164.all;

------------------------------------------------------------------------
-- Entity declaration for testbench
------------------------------------------------------------------------
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
    -- Connecting testbench signals with comparator_2bit entity (Unit Under Test)
    uut_comparator_4bit : entity work.comparator_4bit
        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
    --------------------------------------------------------------------
    p_stimulus : process
    begin
        -- Report a note at the begining of stimulus process
        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 <= "0000"; s_a <= "0001"; 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: 0000, 0001" severity error;

        s_b <= "0000"; s_a <= "0010"; 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: 0000, 0010" severity error;

        s_b <= "0000"; s_a <= "0011"; 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: 0000, 0011" severity error;

        s_b <= "0000"; 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: 0000, 0100" severity error;

        s_b <= "0000"; s_a <= "0101"; 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: 0000, 0101" severity error;

        s_b <= "0000"; s_a <= "0110"; 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: 0000, 0110" severity error;

        s_b <= "0000"; s_a <= "0111"; 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: 0000, 0111" severity error;

        s_b <= "0000"; s_a <= "1000"; 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: 0000, 1000" severity error;

        s_b <= "0000"; s_a <= "1001"; 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: 0000, 1001" severity error;

        s_b <= "0000"; s_a <= "1010"; 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: 0000, 1010" severity error;

        s_b <= "0000"; s_a <= "1011"; 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: 0000, 1011" severity error;

        s_b <= "0000"; 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: 0000, 1100" severity error;

        s_b <= "0000"; 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: 0000, 1101" severity error;

        s_b <= "0000"; s_a <= "1110"; 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: 0000, 1110" severity error;

        s_b <= "0000"; s_a <= "1111"; 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: 0000, 1111" 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 <= "0001"; s_a <= "0001"; 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: 0001, 0001" severity error;

        s_b <= "0001"; s_a <= "0010"; 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: 0001, 0010" severity error;

        s_b <= "0001"; s_a <= "0011"; 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: 0001, 0011" severity error;

        s_b <= "0001"; 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: 0001, 0100" severity error;

        s_b <= "0001"; s_a <= "0101"; 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: 0001, 0101" severity error;

        s_b <= "0001"; s_a <= "0110"; 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: 0001, 0110" severity error;

        s_b <= "0001"; s_a <= "0111"; 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: 0001, 0111" 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;
```

Error example

```
elaborate tb_comparator_4bit
testbench.vhd:51:9:@0ms:(report note): Stimulus process started
testbench.vhd:67:9:@400ns:(assertion error): Test failed for input combination:
0000, 0011
testbench.vhd:95:9:@1100ns:(assertion error): Test failed for input combination:
0000, 1010
testbench.vhd:123:9:@1800ns:(assertion error): Test failed for input combination:
0001, 0001
testbench.vhd:139:9:@2200ns:(assertion error): Test failed for input combination:
0001, 0101
testbench.vhd:152:9:@2400ns:(report note): Stimulus process finished
Finding VCD file...
```

Result



Link

EDA Playground link for 4-bit Karnaugh map