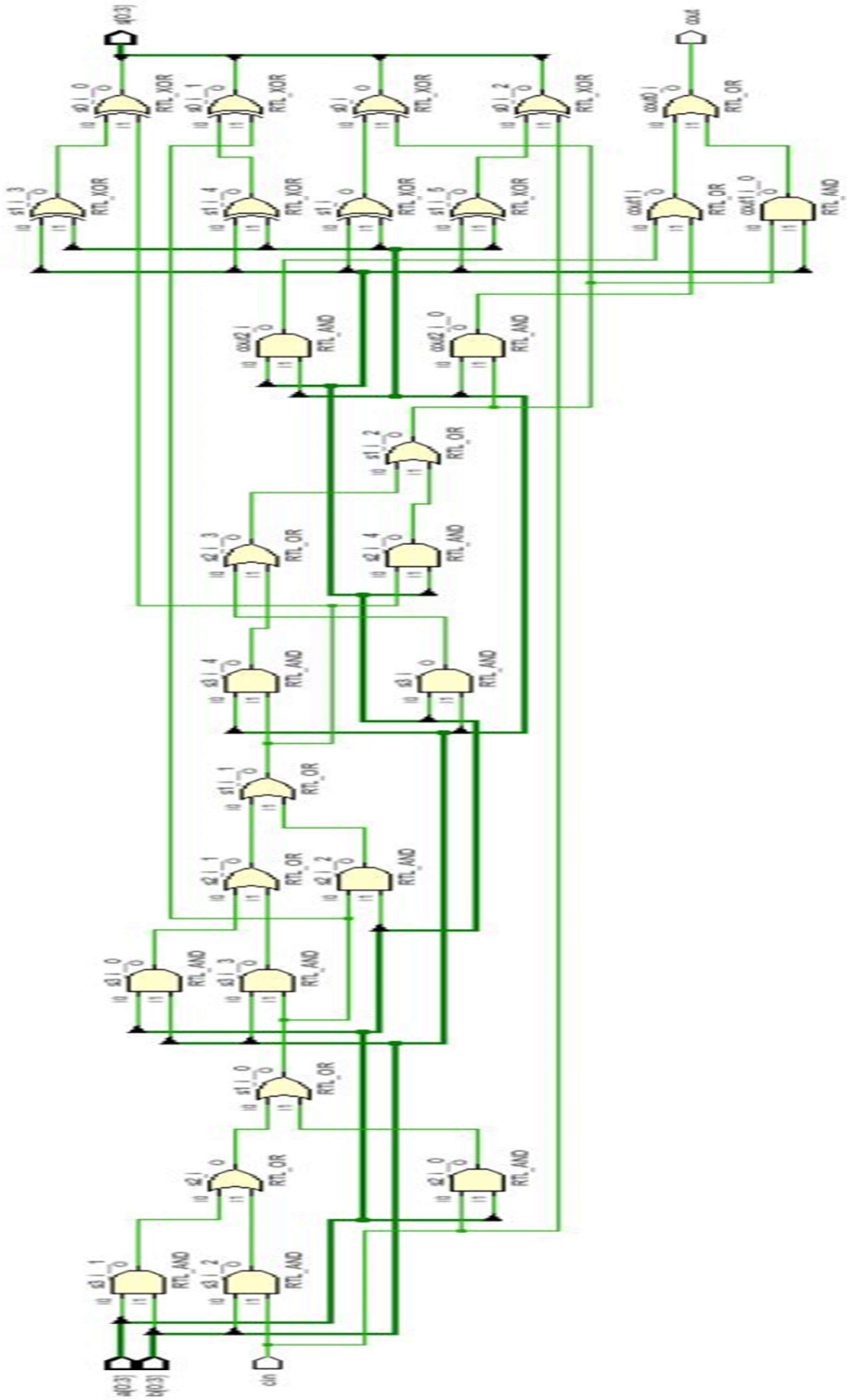
Practical 4

Aim: Write a VHDL code for 4 bit ripple carry adder using loop statement.

Code:

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;

entity ripplecarryadder_4bit is
    Port ( a : in STD_LOGIC_VECTOR (0 to 3);
           b : in STD_LOGIC_VECTOR (0 to 3);
           cin : in STD_LOGIC;
           s : out STD_LOGIC_VECTOR (0 to 3);
           cout : out STD_LOGIC);
end ripplecarryadder_4bit;

architecture Behavioral of ripplecarryadder_4bit is

begin

process(a,b,cin)

variable i:INTEGER:=0;
variable c:std_logic_vector(0 to 4):="00000";

   begin
   c(0):=cin;

   lop: for i in 0 to 3 loop

      s(i)<=a(i) xor b(i) xor c(i);
      c(i+1):=(a(i) and b(i)) or (b(i) and c(i)) or (c(i) and a(i));

   end loop lop;
  cout <= c(4);
end process;

end Behavioral;
```

RTL DIAGRAM:


a[0:3]
cout
g0_0
g0_1
g0_2
RTL_XOR
cout0_1
RTL_OR
s1_3
s1_4
s1_5
cout1_1
cout1_0
RTL_AND
cout2_1
cout2_0
s1_2
s2_3
s2_4
s3_4
s3_1
s1_1
s2_1
s2_2
s3_0
s3_3
s1_0
s2_0
s3_2
b[0:3]
cin

Test bench Code :

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
entity Tb_ripplecarryadder_4bit is
-- Port ( );
end Tb_ripplecarryadder_4bit;

architecture Behavioral of Tb_ripplecarryadder_4bit is
component ripplecarryadder_4bit is
    Port ( a : in STD_LOGIC_VECTOR (0 to 3);
           b : in STD_LOGIC_VECTOR (0 to 3);
           cin : in STD_LOGIC;
           s : out STD_LOGIC_VECTOR (0 to 3);
           cout : out STD_LOGIC);
end component ripplecarryadder_4bit;

signal a : STD_LOGIC_VECTOR (0 to 3);
signal b : STD_LOGIC_VECTOR (0 to 3);
signal cin :STD_LOGIC;
signal s : STD_LOGIC_VECTOR (0 to 3);
signal cout :STD_LOGIC;
begin

u1:ripplecarryadder_4bit port map(a,b,cin,s,cout);
process
begin
cin<='0';
a<="0000";
b<="0000";
wait for 10ns;
b<="0001";
wait for 10ns;
b<="0010";
wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
wait for 10ns;
b<="0101";
wait for 10ns;
b<="0110";
wait for 10ns;
b<="0111";
wait for 10ns;
b<="1000";
wait for 10ns;
b<="1001";
wait for 10ns;
b<="1010";
wait for 10ns;
b<="1011";
wait for 10ns;
b<="1100";
wait for 10ns;
b<="1101";
wait for 10ns;
b<="1110";
wait for 10ns;
b<="1111";
wait for 50ns;
a<="0001";
b<="0000";
wait for 10ns;
b<="0001";
wait for 10ns;
b<="0010";
wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
wait for 10ns;
b<="0101";
wait for 10ns;
b<="0110";
wait for 10ns;
b<="0111";
wait for 10ns;
b<="1000";
wait for 10ns;
b<="1001";
wait for 10ns;
b<="1010";
wait for 10ns;
b<="1011";
wait for 10ns;
b<="1100";
wait for 10ns;
b<="1101";
wait for 10ns;
b<="1110";
wait for 10ns;
b<="1111";
wait for 50ns;
a<="0010";
b<="0000";
wait for 10ns;
b<="0001";
wait for 10ns;
b<="0010";
wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
wait for 10ns;
b<="0101";
wait for 10ns;
b<="0110";
wait for 10ns;
b<="0111";
wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
b<="1011";
wait for 10ns;
b<="1100";
wait for 10ns;
b<="1101";
wait for 10ns;
b<="1110";
wait for 10ns;
b<="1111";
wait for 50ns;
a<="0011";
b<="0000";
wait for 10ns;
b<="0001";
wait for 10ns;
b<="0010";
wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
wait for 10ns;
b<="0101";
wait for 10ns;
b<="0110";
wait for 10ns;
b<="0111";
wait for 10ns;
b<="1000";
wait for 10ns;
b<="1001";
wait for 10ns;
b<="1010";
wait for 10ns;
b<="1011";
wait for 10ns;
b<="1100";
wait for 10ns;
b<="1101";
wait for 10ns;
b<="1110";
wait for 10ns;
b<="1111";
wait for 50ns;
a<="0100";
b<="0000";
wait for 10ns;
b<="0001";
wait for 10ns;
b<="0010";
wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
wait for 10ns;
b<="0101";
wait for 10ns;
b<="0110";
wait for 10ns;
b<="0111";
wait for 10ns;
b<="1000";
wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
b<="1111";
wait for 50ns;
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wait for 10ns;
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wait for 10ns;
b<="0011";
wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 50ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
b<="1111";
wait for 50ns;
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wait for 10ns;
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wait for 10ns;
b<="0010";
wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
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wait for 10ns;
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wait for 10ns;
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wait for 10ns;
b<="1111";
wait for 50ns;
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b<="0000";
wait for 10ns;
b<="0001";
wait for 10ns;
b<="0010";
wait for 10ns;
b<="0011";
wait for 10ns;
b<="0100";
wait for 10ns;
b<="0101";
wait for 10ns;
b<="0110";
wait for 10ns;
b<="0111";
wait for 10ns;
b<="1000";
wait for 10ns;
b<="1001";
wait for 10ns;
b<="1010";
wait for 10ns;
b<="1011";
wait for 10ns;
```

```
b<="1100"; wait for 10ns; b<="1101"; wait for 10ns; b<="1110"; wait for 10ns; b<="1111"; wait for 50ns;
a<="1111"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns;
b<="1101"; wait for 10ns; b<="1110"; wait for 10ns; b<="1111"; wait for 50ns;
a<="1110"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns;
b<="1110"; wait for 10ns; b<="1111"; wait for 50ns;
a<="1101"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns;
b<="1111"; wait for 50ns;
a<="1100"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns;
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b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns;
b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns;
b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns; b<="1101"; wait for 10ns;
b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns; b<="1101"; wait for 10ns; b<="1110"; wait for 10ns;
b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns; b<="1101"; wait for 10ns; b<="1110"; wait for 10ns; b<="1111"; wait for 10ns;
b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns; b<="1101"; wait for 10ns; b<="1110"; wait for 10ns; b<="1111"; wait for 50ns;
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b<="0000"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns; b<="1101"; wait for 10ns; b<="1110"; wait for 10ns; b<="1111";
a<="0110"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns;
a<="0101"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns; b<="1101"; wait for 10ns;
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a<="0011"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns;
a<="0010"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns;
a<="0001"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns;
cin<='1'; a<="0000"; wait for 10ns; b<="0000"; wait for 10ns; b<="0001"; wait for 10ns; b<="0010"; wait for 10ns; b<="0011"; wait for 10ns; b<="0100"; wait for 10ns; b<="0101"; wait for 10ns; b<="0110"; wait for 10ns; b<="0111"; wait for 10ns; b<="1000"; wait for 10ns; b<="1001"; wait for 10ns; b<="1010"; wait for 10ns; b<="1011"; wait for 10ns; b<="1100"; wait for 10ns;
```
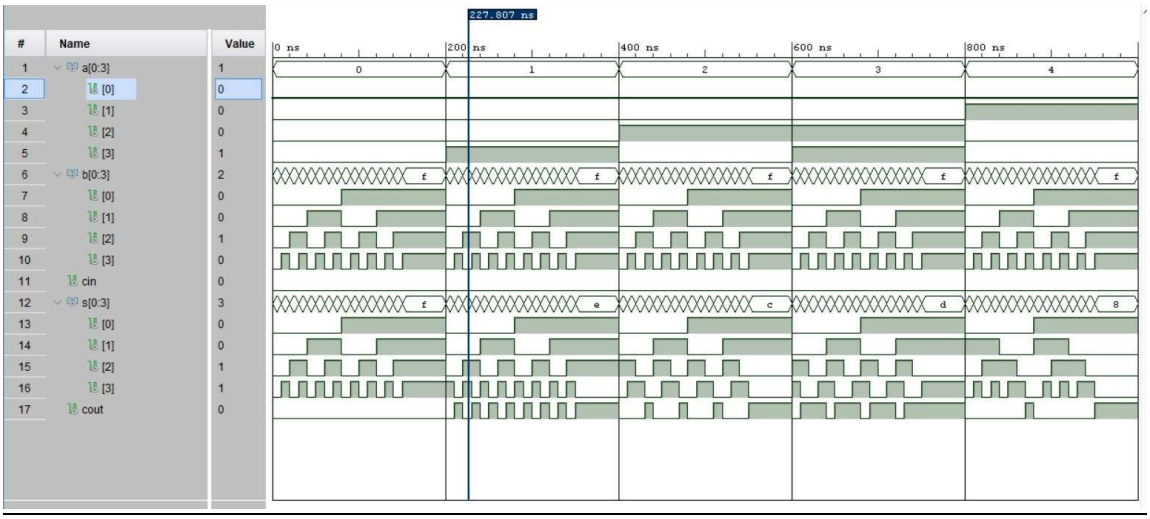

```
b<="0111" wait for wait for b<="1010" wait for b<="0001" b<="1101" wait for b<="0100" a<="1110" wait for b<="0111"
; 10ns; 10ns; ; 10ns; ; ; 10ns; ; ; 10ns; ;
wait for b<="0011" b<="1111" wait for b<="0110" wait for wait for b<="1001" wait for b<="0000" b<="1100" wait for
10ns; ; ; 10ns; ; 10ns; 10ns; ; 10ns; ; ; 10ns;
b<="1000" wait for wait for b<="1011" wait for b<="0010" b<="1110" wait for b<="0101" wait for wait for b<="1000"
; 10ns; 50ns; ; 10ns; ; ; 10ns; ; 10ns; 10ns; ;
wait for b<="0100" wait for b<="0111" wait for wait for b<="1010" wait for b<="0001" b<="1101" wait for
10ns; ; a<="1001" 10ns; ; 10ns; 10ns; ; 10ns; ; ; 10ns;
b<="1001" wait for ; b<="1100" wait for b<="0011" b<="1111" wait for b<="0110" wait for wait for b<="1001"
; 10ns; b<="0000" ; 10ns; ; ; 10ns; ; 10ns; 10ns; ;
wait for b<="0101" ; wait for b<="1000" wait for wait for b<="1011" wait for b<="0010" b<="1110" wait for
10ns; ; wait for 10ns; ; 10ns; 50ns; ; 10ns; ; ; 10ns;
b<="1010" wait for 10ns; b<="1101" wait for b<="0100" wait for b<="0111" wait for wait for b<="1010"
; 10ns; b<="0001" ; 10ns; ; a<="1100" 10ns; ; 10ns; 10ns; ;
wait for b<="0110" ; wait for b<="1001" wait for ; b<="1100" wait for b<="0011" b<="1111" wait for
10ns; ; wait for 10ns; ; 10ns; b<="0000" ; 10ns; ; ; 10ns;
b<="1011" wait for 10ns; b<="1110" wait for b<="0101" ; wait for b<="1000" wait for wait for b<="1011"
; 10ns; b<="0010" ; 10ns; ; wait for 10ns; ; 10ns; 50ns; ;
wait for b<="0111" ; wait for b<="1010" wait for 10ns; b<="1101" wait for b<="0100" wait for
10ns; ; wait for 10ns; ; 10ns; b<="0001" ; 10ns; ; a<="1111" 10ns;
b<="1100" wait for 10ns; b<="1111" wait for b<="0110" ; wait for b<="1001" wait for ; b<="1100"
; 10ns; b<="0011" ; 10ns; ; wait for 10ns; ; 10ns; b<="0000" ;
wait for b<="1000" ; wait for b<="1011" wait for 10ns; b<="1110" wait for b<="0101" ; wait for
10ns; ; wait for 50ns; ; 10ns; b<="0010" ; 10ns; ; wait for 10ns;
b<="1101" wait for 10ns; wait for b<="0111" ; wait for b<="1010" wait for 10ns; b<="1101"
; 10ns; b<="0100" a<="1010" 10ns; ; wait for 10ns; ; 10ns; b<="0001" ;
wait for b<="1001" ; wait for b<="1100" wait for 10ns; b<="1111" wait for b<="0110" ; wait for 10ns;
10ns; ; wait for b<="0000" ; 10ns; b<="0011" ; 10ns; ; wait for b<="1110"
b<="1110" wait for 10ns; ; wait for b<="1000" ; wait for 50ns; ; 10ns; b<="0010" ;
; 10ns; b<="0101" wait for 10ns; ; wait for 10ns; wait for b<="0111" ; wait for
wait for b<="1010" ; wait for b<="1101" wait for 10ns; b<="0100" a<="1101" 10ns; ; 10ns;
10ns; ; wait for b<="0001" ; 10ns; b<="1001" ; wait for b<="0000" ; b<="1100" wait for 10ns;
b<="1111" wait for 10ns; ; wait for 10ns; ; wait for b<="1100" wait for 10ns; b<="1111"
; 10ns; b<="0110" wait for 10ns; b<="1110" wait for 10ns; b<="0101" wait for 10ns; b<="1101" ; 10ns; b<="0011" ;
wait for b<="1011" ; wait for b<="0010" ; 10ns; b<="1010" ; wait for b<="0001" ; b<="1000" wait for 50ns;
50ns; ; wait for 10ns; ; wait for b<="0111" wait for 10ns; b<="1111" ; wait for b<="0100" ; 10ns; ;
wait for 10ns; b<="0011" ; wait for b<="1011" wait for 10ns; b<="0110" ; wait for b<="1001" ; wait for
a<="1000" 10ns; b<="0111" wait for 10ns; b<="1111" wait for 10ns; b<="0101" wait for 10ns; b<="1110" ; 10ns; b<="0100" end
; b<="1100" ; wait for b<="0011" ; wait for b<="1011" wait for 10ns; b<="0010" ; wait for b<="1010" ; wait for process;
b<="0000" ; wait for 10ns; ; wait for 50ns; ; 10ns; b<="0001" ; wait for b<="1001" ; wait for end
; wait for 10ns; b<="1000" wait for 10ns; wait for 10ns; b<="0000" wait for 10ns; b<="1110" wait for 10ns; b<="0101" Behavioral
wait for 10ns; b<="1101" ; wait for b<="0100" a<="1011" 10ns; b<="0111" wait for b<="1010" ; wait for ;
10ns; b<="0001" ; wait for 10ns; ; ; b<="1100" ; wait for b<="0010" ; wait for b<="1001" ;
; wait for 10ns; b<="1001" wait for b<="0000" ; wait for b<="0011" ; wait for b<="1000" ;
wait for 10ns; b<="1110" ; wait for b<="0101" wait for 10ns; wait for b<="1011" ; wait for
10ns; b<="0010" ; wait for b<="0101" wait for 10ns; b<="1000" wait for 50ns; ; wait for
; 10ns; ; 10ns; ; 10ns; 10ns;
```

SIMULATION WAVEFORM :



Name	Slack	Levels	Routes	High Fanout	From	To	Total Delay	Logic Delay	Net Delay	Requirement	Source Clock
Path 1	∞	4	5	3	a[0]	cout	5.970	3.904	2.066	∞	input port clock
Path 2	∞	4	5	3	a[0]	s[2]	5.970	3.904	2.066	∞	input port clock
Path 3	∞	4	5	3	a[0]	s[3]	5.964	3.898	2.066	∞	input port clock
Path 4	∞	3	4	3	cin	s[0]	5.351	3.752	1.599	∞	input port clock
Path 5	∞	3	4	3	a[0]	s[1]	5.351	3.752	1.599	∞	input port clock

SYNTHESIS SUMMARY:

Resource	Utilization	Available	Utilization %
LUT	4	17600	0.02
IO	14	100	14.00

Maximum Combinational Delay: 5.970nSec