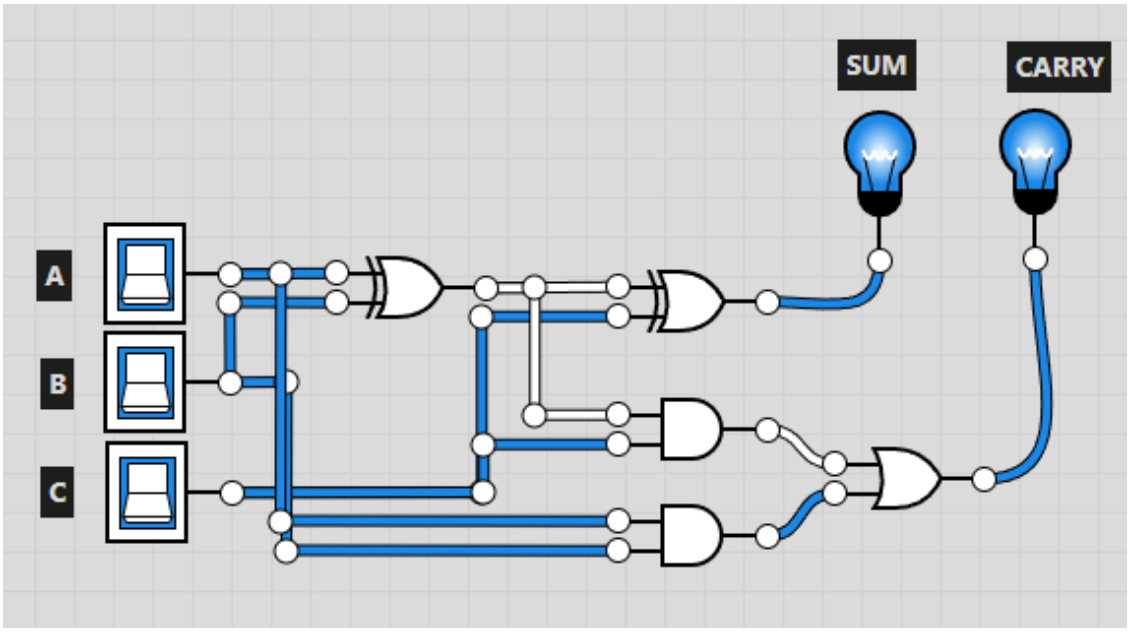
Grade Compensation

July 25, 2024

Dylan Liesenfelt

1 Give the logical structure of a 1-bit Full Adder with its functional description and truth table. Write the VHDL code of a 1-bit Full Adder.

Logical Structure:



Functional Description:

SUM = (A $\oplus$ B) $\oplus$ C

Carry = ((A $\oplus$ B)C) + (AB)

Truth Table:

A	B	C	SUM	CARRY
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

VHDL Code:

Design:

[ ]:
```
library IEEE;
use IEEE.std_logic_1164.all;

-- ENTITY
entity FullAdder is
port(
    A, B, C: in std_logic;
    Sum, Carry: out std_logic);
end FullAdder;

-- ARCHITECTURE
architecture dataflow of FullAdder is
signal xor1, xor2, and1, and2, or1: std_logic;
begin
    xor1 <= A xor B;
    xor2 <= xor1 xor C;
    and1 <= xor1 and C;
    and2 <= A and B;
    or1 <= and1 or and2;
    Sum <= xor2;
    Carry <= or1;
end dataflow;
```

Test Bench:

[ ]:
```
library IEEE;
use IEEE.std_logic_1164.all;

-- TESTBENCH ENTITY
entity testbench is
--empty
end testbench;
```

```
architecture tb of testbench is
-- DUT COMPONENT
component FullAdder is
port(
    A, B, C: in std_logic;
    Sum, Carry: out std_logic);
end component;

signal A_IN, B_IN, C_IN, SUM_OUT, CARRY_OUT : std_logic;

begin

-- CONNECT DUT
DUT: FullAdder port map(A_IN, B_IN, C_IN, SUM_OUT, CARRY_OUT);

        process
          begin
            A_IN <='0';
        B_IN <='0';
                C_IN <='0';
        wait for 1 ns;

              A_IN <='1';
              B_IN <='0';
                C_IN <='0';
              wait for 1 ns;

        A_IN <='0';
              B_IN <='1';
                C_IN <='0';
              wait for 1 ns;

        A_IN <='0';
              B_IN <='0';
                C_IN <='1';
              wait for 1 ns;

        A_IN <='1';
              B_IN <='1';
                C_IN<='1';
              wait for 1 ns;

              -- CLEAR INPUTS
              A_IN <='0';
              B_IN <='0';
                C_IN <='0';
              wait;
```

```
        end process;
end tb;
```

2 Simplify the following functional description using the algebraic method and mention the Boolean rule at each step.

Z(A,B,C,D) = ABCD + AB C D + AB C D + A B CD + A BCD + BC

1. Demorgan: ABCD + A(B'+C') + A(B'+C'+D') + A'B'CD'+ A'BCD + BC
2. Absorption: A(B'+C')D + A(B'+C'+D') + (A'+B)CD + BC
3. Distributive: ADB' + ADC' + AB' + AC' + AD' + (A'+B)CD + BC
4. Absorption: AB' + AC' +AD' + (A'+B')CD + BC
5. Distributive: AB' + AC' + D'(CA'+A) + CD'B' + BC
6. Absorption: A'B + AC' + D'(C+A) + CD'B' + BC
7. Distributive: AB' + AC' + D'(C+A) + C(D'B'+B)
8. Absorption: AB' + AC' + D'(C+A) + C(D'+B)
9. Distributive: AB' + AC' + D'C + D'A + CD'+ CB
10. Idempotent: AB' + AC' + D'C + D'A + CB
11. Consensus: AB' + AC' + D'C + CB

Simplified Expression: AB' + AC' + D'C + CB

3 Simplify the following functional description using the algebraic method and mention the Boolean rule at each step.

V(X,Y,Z)= X YZ + XY + XZ

1. Distributive: Y(X'Z + X) + XZ
2. Absorption: Y(Z + X) + XZ
3. Distribute: YZ + YX + XZ

Simplified Expression: YZ + YX + XZ