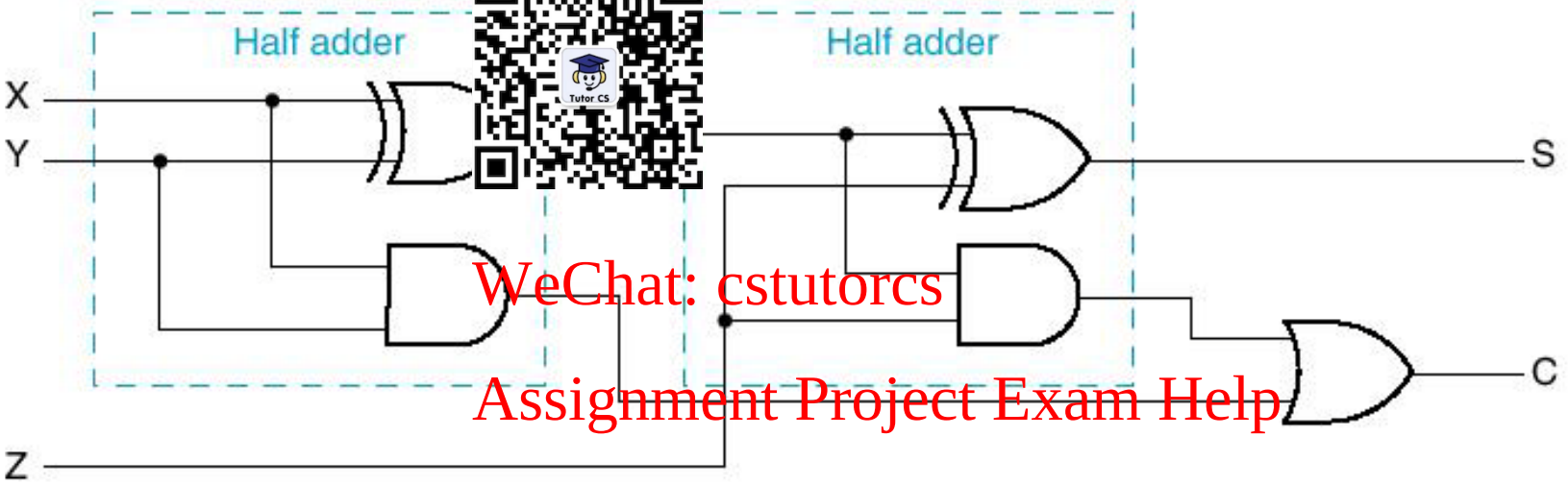
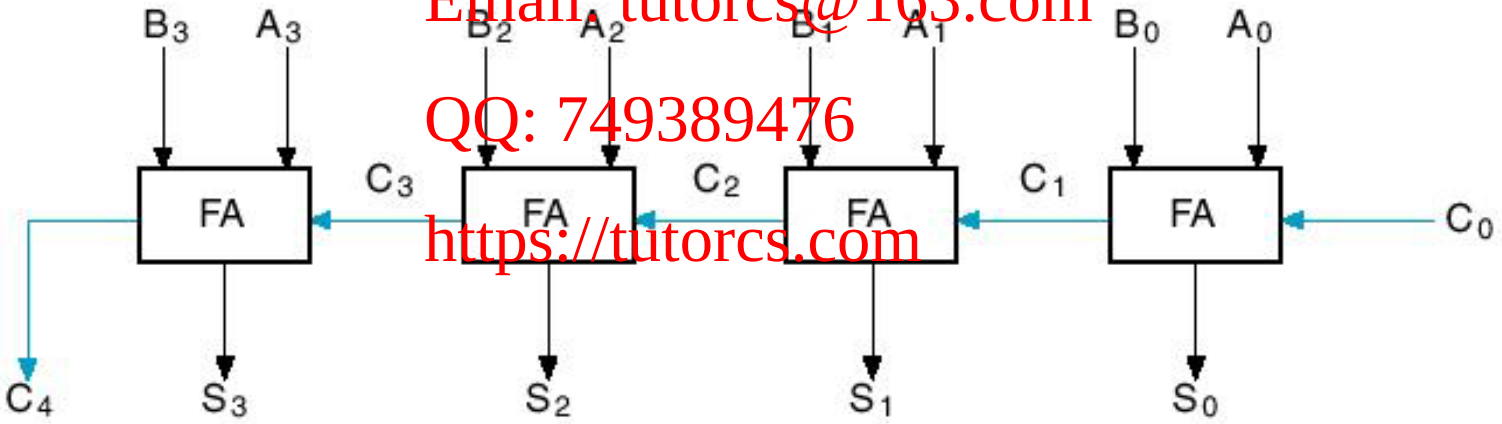
Hierarchical VHDL

4-Bit Ripple Carry Adder





Hierarchical VHDL (Page 1)

4-Bit Ripple Carry Adder

```
-- 4-bit A          archical Dataflow/Structural
library ie
use ieee.std_logic_1164.all;
entity half_adder is
  port (x, y : in std_logic;
        s, c : out std_logic);
end half_adder;

architecture dataflow_3 of half_adder is
  begin
    s <= x xor y;
    c <= x and y;
end dataflow_3;
```

Hierarchical VHDL (Page 2)

4-Bit Ripple Carry Adder

```
library ieee;
use ieee.std_logic_1164.all;
entity full_adder is
  port (x, y, z : in std_logic;
        s, c : out std_logic);
end full_adder;
```

Hierarchical VHDL (Page 3)

4-Bit Ripple Carry Adder

```
architecture dataflow_3 of full_adder is
  component half_adder
    port(x, y : in std_logic;
         s, c : out std_logic);
  end component;
  signal hs, hc, tc: std_logic;
  begin
    HA1: half_adder
      port map (x, y, hs, hc);
    HA2: half_adder
      port map (hs, z, s, tc);
    c <= tc or hc;
end struc_dataflow_3;
```

Hierarchical VHDL (Page 4)

4-Bit Ripple Carry Adder

```
library i
use ieee.std_logic_1164.all;
entity adder_4 is
  port(B, A : in std_logic_vector(3 downto 0);
       C0 : in std_logic;
       S : out std_logic_vector(3 downto 0);
       C4: out std_logic);
end adder_4;
```

Hierarchical VHDL (Page 5)

4-Bit Ripple Carry Adder

```
architectu                4 of adder_4 is
  compon
    port(x, y, z : in std_logic;
         s, c : out std_logic);
  end component;
  signal C: std_logic_vector(3 downto 1);
  begin
    Bit0: full_adder
      port map (B(0), A(0), C0, S(0), C(1));
    Bit1: full_adder
      port map (B(1), A(1), C(1), S(1), C(2));
    Bit2: full_adder
      port map (B(2), A(2), C(2), S(2), C(3));
    Bit3: full_adder
      port map (B(3), A(3), C(3), S(3), C4);
end structural_4;
```

4-Bit Full Adder

Behavioral Description

```
-- 4-bit A                    al Description
library ie
use ieee.                    4.all;
use ieee.std_logic_unsigned.all;

entity adder_4_b is
      port(B, A : in std_logic_vector(3 downto 0);
           C0 : in std_logic;
           S : out std_logic_vector(3 downto 0);
           C4: out std_logic);
end adder_4_b;

architecture behavioral of adder_4_b is
signal sum: std_logic_vector(4 downto 0);
begin
  sum <= ('0' & A) + ('0' & B) + ("0000" & C0);
  C4 <= sum(4);
  S <= sum(3 downto 0);
end behavioral;
```

Positive Edge-Triggered D Flip-Flop

Process Description (entity)

```
-- Positive Edge-Triggered D Flip-Flop with Reset:
-- VHDL Process Description
library ieee;
use ieee.std_logic_1164.all;
entity dff is
  port(CLK, RESET, D: in std_logic;
       Q, Q_n: out std_logic);
end dff;
```

Positive Edge-Triggered D Flip-Flop

Process Description (architecture)

```
architecture of dff is
-- Implements a positive edge-triggered bit state storage
-- with asynchronous reset.
  signal state: std_logic;
begin
  Q <= state;
  Q_n <= not state;
  process (CLK, RESET)
  begin
    if (RESET = '1') then
      state <= '0';
    else
      if (CLK'event and CLK = '1') then
        state <= D;
      end if;
    end if;
  end process;
end;
```