1 Administrivia

Announcements

Friday’s exam will cover:

- Chapter 3: Sections 8–10, 13.
- Chapter 4: Sections 1–8.

Assignment

Read 5.4–5.

From Last Time

Registers

Outline

1. Shift registers defined.

2. Serial Addition.
3. VHDL

Coming Up

Counters

2 Shift registers defined

1. Why is a parallel register parallel?

2. So, we would expect a shift (serial) register to look like:

SO = SI four clocks later.

Using 2-1 muxes, how would you modify this to incorporate a shift control signal?

3. Parallel register with shift:

D and Q are buses.
3 Serial Addition

1. Suppose you have two serial bit streams, A and B. Design a serial adder using one one bit full adder and one D flip-flop.

If A and B are \( n \) bits, the output can be how many bits?

2. Suppose A and B are shifted in on a single bit line. Is it possible for us to do the addition? (One shift register needed.)

3. What does a left shift by one do to the value of an unsigned number?

Use this to design a sequential circuit which takes A as serial input and outputs 3A.

4 VHDL for Serial Registers

Parallel load, shift left or right, hold.

```vhdl
-- Parallel load shift register. Shift left or right.
-- Mode bits:
-- 00: hold
-- 01: load
-- 10: shift left (toward msb)
-- 11: shift right (toward lsb)
--
-- msi: most significant shift in.
-- lsi: least significant shift in.
library ieee;
use ieee.std_logic_1164.all;

entity shift_reg is
  port (d : in std_logic_vector (31 downto 0);
        mode : in std_logic_vector (1 downto 0);
        clk, reset_n : in std_logic;
        msi, lsi : in std_logic;
        q : out std_logic_vector (31 downto 0));
end entity shift_reg;
```
end shift_reg;

architecture behavioral of shift_reg is

  signal state : std_logic_vector (31 downto 0);

begin  -- behavioral

  q <= state;  -- Update output.

  state_register: process (clk, reset_n)
  begin  -- process state_register
    if reset_n = '0' then  -- asynchronous reset (active low)
      state <= X"00000000";
    elsif clk'event and clk = '1' then  -- rising clock edge
      if mode = "00" then  -- Hold.
        state <= state;
      elsif mode = "01" then  -- Load.
        state <= d;
      elsif mode = "10" then  -- Shift left.
        state <= state (30 downto 0) & lsi;
      else  -- Shift right.
        state <= msi & state (31 downto 1);
      end if;
    end if;
  end process state_register;

end behavioral;