Counters

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1 Administrivia

Announcements

Exam Friday.

Assignment

Read 6-1,6 for Monday.

From Last Time

Shift registers.

Outline

1. Ripple counters.
2. Synchronous counters.
3. VHDL.

Coming Up

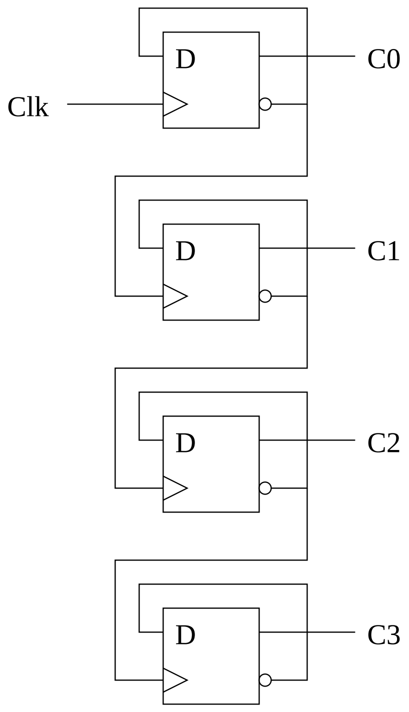
Memory, ROM.

2 Ripple Counters

The increment ripples — propagation delay problems.

Slow counters.

Basic idea:



1. Each flip-flop's !Q is fed back to D. What does this accomplish?
2. Flip-flop i's !Q is used to clock flip-flop $i + 1$. What does this accomplish?
3. Trace the propagation delay of the clock if the count is currently 1111 and a rising clock edge is applied.
4. Through what sequence, starting with 0000, does the counter count?

3 Synchronous Counters

1. All flip-flops receive same clock signal.

2. Still have some rippling. (Where?)

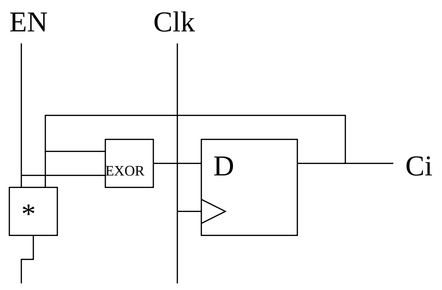
3. Inputs: clk, enable.

4. Outputs: count, carry output (for cascading).

5. After state table minimization, input equation for bit i:

$$C_i \oplus (C_0 \cdot C_1 \cdot \ldots \cdot C_{i-1} \cdot EN)$$

6. One bit slice for serial gating:



7. Serial vs. parallel gating.

4 VHDL

32 bit up counter with enable and reset.

```
-- Up counter with enable and reset
--
-- Note how en must be handled after the flip-flop generating
-- code.

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

```
entity counter is

  port (
    clk, reset_n, en : in  std_logic;
    q                : out std_logic_vector (31 downto 0);
    co               : out std_logic);

end counter;

architecture behavioral of counter is

  signal count : std_logic_vector (31 downto 0);

begin  -- behavioral

  q <= count;

  state: process (clk, reset_n)
  begin  -- process state
    if reset_n = '0' then
      count <= X"00000000";
    elsif clk'event and clk = '1' then
      if en = '1' then
        count <= count + X"00000001";
      end if;
    end if;
  end process state;

  carry_out: process (count, en)
  begin  -- process carry_out
    if count = X"FFFFFFFF" and en = '1' then
      co <= '1';
    else
      co <= '0';
    end if;
  end process carry_out;

end behavioral;
```