Digital Systems

Digital HW design with VHDL in a nutshell

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Outline

1 Introduction

Section 1

Introduction

Digital hardware: 2 types of hardware primitives

Combinatorial gates

- inverters, and, or, xor, 1-bit full adders, 1-bit multiplexers
- inputs ⇒ boolean computation ⇒ outputs
- inputs change ⇒ electrical signals propagate
- propagation delay
  - performance
  - critical path
  - maximum clock frequency
- no loops

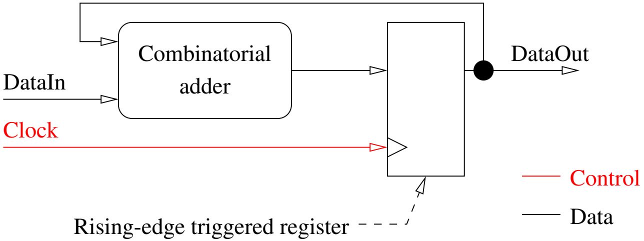
Digital hardware: 2 types of hardware primitives

Memory elements

- latches, D-flip-flops, RAMs. . .
- data inputs, control inputs and data outputs
- do not react immediately to any inputs changes
- react on a particular combination of control inputs
- example: rising-edge triggered D-flip-flop (DFF)
  - clock input
  - data input
  - clock rising edge ⇒ data input sampled
  - data output = currently sampled input
  - data output stable until next rising edge of clock
  - even if the data input changes in between
- think of a digital camera
  - clock = press button
  - data input = scene
  - data output = displayed picture

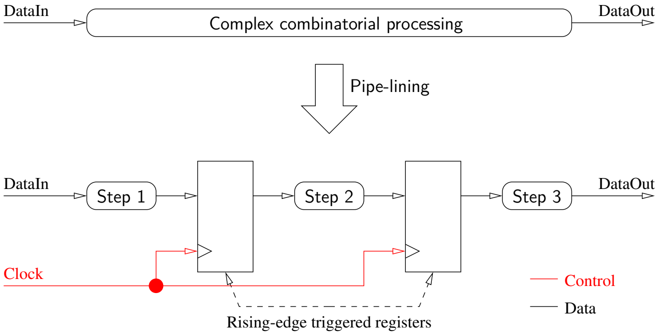
Example of a sequential circuit

Reusing the same hardware



Example of a sequential circuit

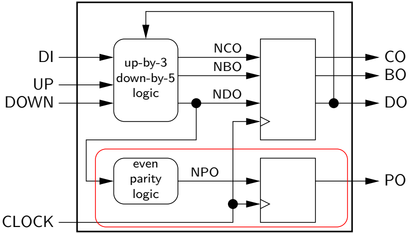
Pipelined circuit



Synchronous process

Output signals are register outputs

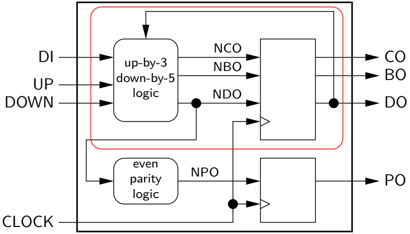
```
process(clock)
begin
  if rising_edge(clock) then
    o <= f(i);
  end if;
end process;
```



Synchronous process

Output signals cannot be combinatorial outputs

```
process(clock)
begin
  if rising_edge(clock) then
    o <= f(i);
  end if;
end process;
```


DI
UP
DOWN
CLOCK
up-by-3
down-by-5
logic
even
parity
logic
NCO
NBO
NDO
NPO
CO
BO
DO
PO