Progettazione e sintesi di circuiti digitali

Course introduction – part2

VLSI circuits: key concepts
VLSI circuits and PSCD

• Review of the concept of integrated circuit
  – from semiconductor device to monolithic circuit
  – from small-scale (SSI) to very-large-scale (VLSI) integrated circuit

• VLSI circuit design problem
  – taming complexity and design goals
  – design methodology
  – computer-aided design (CAD) tools
From device to circuit

device (MOSFET)

logic gate

logic circuit
From circuit to system

Put a few million of logic gates together

⇒ Very Large Scale Integrated Circuit

printed circuit board (PCB)

complete system

packaged chip
Different kinds of design involved

• Technology development
  – design a process that allows the fabrication of complementary MOSFET devices
  – decreasing minimum feature size $\Rightarrow$ new process roughly every two years
Different kinds of design involved

• Circuit design
  – starts from specifications and ends with a set of geometrical masks (layout) used for circuit fabrication
  – procedure that follows an ordered set of steps (design flow)

SPECIFICATIONS
• design a circuit for MP3 compression
  • power ≤ 250 mW
  • area ≤ 12 mm²
  • ...

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Different kinds of design involved

• System design
  – assemble different parts (sub-systems) to realize the final product

  touchscreen

  VLSI circuits

  loudspeaker, microphone, sensors, …

  PCB

  full system
VLSI ingredients and recipe

specifications

SPECIFICATIONS
• design a circuit for MP3 compression
• ...

VLSI design procedure (flow)

silicon wafers

CMOS fabrication process

circuit layout

VLSI/ULSI chip

wafer with fabricated dies

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What this class is about

• How to transform a product idea into a VLSI circuit

• Study a design methodology to guide the designer
  – from product specification
  – to physical design tape-out

• Learn to use the CAD tools that make the design flow a semi-automated process
Key concepts of the course 1/3

• A design methodology is required to:
  – control design complexity (millions of gates)
  – obtain predictable results
  – fit time-to-market requirements
  – reduce non-recurrent costs

• CAD tools amplify the designer’s capability to:
  – create a circuit description ⇒ capture
  – move to a lower abstraction level ⇒ synthesis
  – test the correctness of a design ⇒ verification
Key concepts of the course 2/3

• Abstraction levels:

same circuit described with increasing level of detail

• Domains of representation:

\[ S = A \oplus B \oplus C_i \]
\[ C_o = (A \oplus B)C_i + AB \]

behavioral  structural  physical
• Hardware Description Language (HDL):
  – captures the description of a circuit at different abstraction levels and representation domains
  – backbone of the digital design flow

```vhdl
entity FULL_ADDER is
  port (A, B, CI: in Bit;
       CO, S: out Bit);
end FULL_ADDER;
architecture BHV of FULL_ADDER is
  signal P: Bit;
begin
  P  <= A xor B;
  S  <= P xor CI;
  CO <= P and CI or A and B;
end BHV;
```
Course plan

• Review of basic digital design flow
  – combinational and sequential gates, synchronous FSM, binary arithmetics

• Hardware Description Languages
  – VHDL syntax and coding style

• CAD tools for VLSI design
  – theory and lab experience with CAD tools for design capture, simulation and synthesis

• Examples of circuits for digital signal processing