Introduction

- Design Representation
- Levels of Abstraction
- Design Tasks and Design Processes
- CAD Tools
Design Representation

- Behavioral or functional representation
  - Specifies the behavior or the function of a design without any implementation information

- Structural representation
  - Specifies the implementation of a design in terms of components and their interconnections

- Physical representation
  - Specifies the physical characteristics of the design
    - Blueprint for manufacturing
Alarm Clock (Behavioral Representation)

- **Pulse**: 
  - yes: \( \text{Seconds} = \text{Seconds} + 1 \)
  - no: \( \text{Seconds} = 0? \)

- **Seconds display**: \( \text{Seconds} \)

- **Minutes**: 
  - no: \( \text{Minutes} = \text{Minutes} + 1 \)
  - yes: \( \text{Minutes} = 0? \)

- **Minutes display**: \( \text{Minutes} \)

- **Hours**: 
  - no: \( \text{Hours} = \text{Hours} + 1 \)
  - yes: \( \text{Hours} = 0? \)

- **Hours display**: \( \text{Hours} \)

Clock Process
Alarm Clock (Behavioral Representation)

Setup Process

- If $S_1$ closed? no
- $S_3$ closed? yes
  - $S_4$ closed? yes
    - $H_{wakeup} = H_{wakeup} + 1$
    - $H_{display} = H_{wakeup}$
  - $S_4$ closed? no
    - $M_{wakeup} = M_{wakeup} + 1$
    - $M_{display} = M_{wakeup}$
- $S_3$ closed? no
  - $S_4$ closed? yes
    - $H_{wakeup} = H_{wakeup} + 1$
    - $H_{display} = H_{wakeup}$
  - $S_4$ closed? no
- $S_2$ closed? yes
  - $M_{wakeup} = M_{wakeup} + 1$
  - $M_{display} = M_{wakeup}$
- $S_2$ closed? no
  - $S_3$ closed? yes
    - $M_{wakeup} = M_{wakeup} + 1$
    - $M_{display} = M_{wakeup}$
  - $S_3$ closed? no
- $M_{wakeup} = M_{wakeup} + 1$
- $M_{display} = M_{wakeup}$
Alarm Clock (Behavioral Representation)

- Minutes = Mwakeup?
  - no
  -Minutes = Mwakeup?
  -yes
    - Hours = Hwakeup?
      - no
        - no
      - yes
        - yes
          - S₅ closed?
            - no
              - no
            - yes
              - Buzz = 1
- yes
  - yes
    - yes
      - Buzz = 1
- yes
  - yes
    - yes
      - Alarm Process
Alarm Clock (Structural Representation)

Oscillator

Pulse generator

Pulse

S cnt

M cnt

H cnt

M reg

H reg

S display

M display

H display

Minute comparator

Hour comparator

Sound generator

Buzz

S1 (Time set)

S3 (M advance)

S4 (H advance)

S2 (Alarm set)

S2

S2

S2

S3

S4
Alarm Clock (Pulse Wave)

Generated by Oscillator

(a) Sine wave

(b) Pulse wave

Generated by Pulse generator
**Alarm Clock (Physical Representation)**

- **Oscillator**
- **Pulse generator**
- **Sound generator**
- **Liquid display**
- **Hour advance switch**
- **Minute advance switch**
- **Battery holder**
- **Set and alarm switches**

**Printed circuit board**

**Front view**
# Levels of Abstraction

<table>
<thead>
<tr>
<th>Levels</th>
<th>Behavioral forms</th>
<th>Structural components</th>
<th>Physical objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transistor</td>
<td>Differential equ., current-voltage diagrams</td>
<td>Transistors, resistors, capacitors</td>
<td>Analog &amp; digital cells</td>
</tr>
<tr>
<td>Logic</td>
<td>Boolean equations, finite-state machines</td>
<td>Gates, flip-flops</td>
<td>Modules or units</td>
</tr>
<tr>
<td>Processor</td>
<td>Algorithms, flowcharts, instruction sets, generalized FSM</td>
<td>Adders, comparators, registers, counters, register files, queues</td>
<td>Microchips</td>
</tr>
<tr>
<td>System</td>
<td>Executable specification, programs</td>
<td>Processors, controllers, memories, ASICS, ASIPs, IPs</td>
<td>Printed-circuit boards or System-on-chip</td>
</tr>
</tbody>
</table>
Design Methodologies

- Top-down
- Bottom-up
- Meet-in-the-middle
Design Process

- Design Specification
- Library Development
- Design Synthesis
  - System synthesis
  - Architecture synthesis
  - Sequential synthesis
- Logic synthesis
- Circuit design
- Layout generation
- Design Analysis
  - Property verification
  - Constraint satisfaction for cost, performance, power, testability manufacturing, and other metrics
- Documentation
- Manufacturing
CAD Tools

- Design Capture and Modeling
  - Schematic capture
  - Modeling in a hardware-description language
- Synthesis Tools
  - Logic synthesis
  - Sequential synthesis
  - Behavioral or high-level synthesis
  - System synthesis
- Verification and Simulation
- Physical Design
  - Placement
  - Routing
- Testing
Typical Design Process

- Market Analysis
- Product Requirements
- Product Specification
- Product Architecture
- Product Design
- Verification or Simulation
- Physical Design
- Test Generation
- Documentation
- Manufacturing
- Testing
Road Map of Digital Design

- Transistors, resistors, capacitors
- Electronics
- Digital circuit design
- Analog circuit design
- Boolean algebra
- Finite-state machine
- Logic gates and flip-flops
- Logical design techniques
- Sequential design techniques
- Combinational components
- Storage components
- Interface components
- Generalized finite-state machines
- Algorithm synthesis
- Processor components
- Computer design
- Software design and engineering
- Hardware, software, and mechanical codesign
- Embedded system design
- VLSI design

Material covered in book
Chapter Summary

- Three Design Representations
  - Behavioral
  - Structural
  - Physical

- Four Levels of Abstraction
  - System
  - Processor
  - Register
  - Gate

- CAD Tools
  - Capture and Modeling
  - Verification and Simulation
  - Synthesis and Analysis
  - Placement and Routing
  - Test Generation

- Road Map