Integrated Circuit (IC)

• Definition:
  – Silicon Semiconductor, called a chip, containing the electronic component for constructing digital gates.
  – The chip is mounted in a ceramic or plastic container, and connections are welded to external pins to form an IC

• Level of Integration
  – Small-Scale Integration (SSI) Circuit: fewer than 10 gates
  – Medium-Scale Integration (MSI) Circuit: 10-100 gates
  – Large-Scale Integration (LSI) Circuit: Thousands of gates
  – Very large-Scale Integration (VLSI) Circuit: Hundreds of Thousand of gates

Integrated Circuit (IC)

• Digital Circuit Families
  – Classification based on the specific circuit technology
  – Basic gates are NAND, NOR and Inverter gates

• Most Popular Technologies
  – TTL (Transistor-Transistor Logic)
    • 7400, 74S86
  – ECL (Emitted-Coupled Logic)
    • High speed and also high power consumption
  – MOS (Metal-Oxide Semiconductor)
    • High density
  – CMOS (Complementary Metal-Oxide Semiconductor)
    • Low power consumption
Integrated Circuit (IC)

- Several Terms
  - Fan-out
    - Specify the number of standard loads that the output of the typical gates can drive without impairing its normal operation.
  - Fan-in
    - The number of inputs available in a gate
  - Power dissipation
    - Power consumed by the gate that must be available from the power supply.
  - Propagation delay
    - The average transition delay time for a signal to propagate from input to output
  - Noise margin
    - The Maximum external noise voltage added to an input signal that does not cause an undesirable change in the circuit output

Compute-Aided Design (CAD)

- or Electrical Design Automation (EDA)
  - Design is too large to be handled manually
  - Different level of tools exist
    - FloorPlan, Placement and Route
    - Synthesis
    - Simulation
  - Hardware Description language
    - Verilog
    - VHDL
    - System Verilog
  - Different between software and hardware
**HARDWARE DESCRIPTION LANGUAGES (HDLs)**

- **Textual Representation of Digital Circuit**
  - Yet Another Way (truth tables, equations, circuit diagrams, etc.)

- **Why Have HDLs?**
  - Documentation
    - First common HDL (VHDL) Documentation Language
  - Simulation
    - First common HDL for Simulation (Verilog)
  - Synthesis
    - Both VHDL and Verilog used for this
    - Currently, more emphasis on SystemC, SystemVerilog

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**HARDWARE DESCRIPTION LANGUAGES (HDLs)**

- **Why are HDLs Important?**
  - Easy way to Describe Large Circuits
  - Large Teams of Designers can Work Concurrently
    - Using Software Engineering Techniques
  - The Specification can be Simulated
  - The Specification can be Synthesized
  - HDLs Support Multiple Levels of Abstraction
Definitions

• Specification
  – Description of the Desired Functionality

• Simulation
  – Given a Model and Inputs, Predict the Output

• Synthesis
  – Transform One Model into Another

Why Another Language?

• Sequential Languages
  – Programming Languages are Sequential
  – Each Statement is Executed in Order of Appearance

• Hardware is a Parallel Instance
  – Model in Terms of Events
  – More Natural Way to Describe and Simulate

• HDLs can be tricky because:
  – We are used to Sequential Execution
  – Different “bugs” Occur due to Parallel Behavior
  – Parallel Behavior Modeled Using Event Driven Methods