Chapter 1 Introduction

- What is digital design?
- Analog v. Digital
- Digital Devices
- Digital Abstraction

What is Digital Design?

Also referred to as logic design, digital design is concerned with designing digital circuits, devices or systems such as computers.

Analog Versus Digital

- Analog devices process signals that can assume any value across a continuous range and produce results that are also in continuous form. Examples of continuous signal include voltage, current, force, etc..
- Digital devices process signals that take on only two discrete values such as 0 and 1 and produces output that can be represented by 0 and 1.

Examples

- Analog Devices: solid-state devices TV (except for digital TV), telephone, etc.
Advantages of Digital Systems

• Reproducibility
• Easy of design via logic design
• Programmability - digital devices can be reprogrammed
• Robust to noise and perturbations

Digital Devices: Gates

The most fundamental building blocks of a digital system are gates. A digital system (a chip) consists of many, many gates. They have one or more digital inputs and one digital output. Gates are digital devices that perform various basic logic operations. See Figure 1-1

Gates (cont’d)

• AND gate
• OR gate
• NOT gate

AND gate

Performs the AND logic operation on its inputs and outputs its result.

Input \[ \rightarrow \] output
Characteristics of 2-Input AND gate
Four possible input combinations lead to two different outputs.

Characteristics of 2-Input OR gate
Four possible input combinations lead to two different outputs.

OR gate
Performs the OR logic operation on its inputs and outputs its result.

NOT gate
Also referred to as inverter, produces an output value that is the opposite of the input value.
**Flip-Flop**

A flip-flop (FF) is a device that stores a value of either 0 or 1. The state (stored value) of a flip-flop depends on its current clock input. Flip-flop can be constructed from gates. It is often used in sequential circuit since it remembers. Memory is made up of FFs.

---

**Digital Abstraction**

Digital circuit deals with analog voltages and currents. Digital abstraction allows analog behavior to be ignored. This can be accomplished by associating a range of voltages with each logic value. For example, the signals in a digital system might be restricted to two levels -5 and +5 volts, corresponding to two discrete values of 0 and 1. It is necessary to understand the operating environment (e.g., voltage, temperature, loading, ..) under which the digital abstraction can be guaranteed.

---

**Digital Abstraction**

Alternatively, high and low are often used to represent 1 and 0 while discussing electronic logic.

---

**Software for Digital Design**

Software is widely used in digital design. It can significantly reduce design time, design cost, and improve design quality. It has been mainly used for

- drawing schematic diagrams
- circuit simulation and modeling
- testing and debugging
- timing analysis

Software for simulation (e.g. LogicWorks) and programming language (e.g. VHDL) for programming logic devices.
Integrated Circuits

A collection of one or more gates fabricated on a single silicon chip to achieve a specific function is called an integrated circuit or IC for short.

Integrated Circuits (cont’d)

Based on the size (number of gates) of an IC, it can be classified as small-scale integration (SSI), medium-scale integration (MSI), large-scale integration (LSI), and very large-scale integration (VLSI). SSI usually contains less than 20 gates, MSI about 20-200 gates, LSI about 200 to 200,000 gates, and VLSI up to 1 million gates. The latest VLSI has 5 million gates.

Integrated Circuits (cont’d)

An IC usually consists of “legs”, referred to as pins or DIPs (Dual in line). Pins are input/output connectors. The functionality or purpose of each pin can be obtained from the pin diagram or data sheet.
Programmable Logic Devices
Most digital devices can be programmed or reprogrammed for different functionalities without physically replacing or rewiring the devices
- Programmable Logic Arrays (PLA)
- Programmable Array of Logic (PAL)
- Field Programmable Gate Array (FPGA)

Printed Circuit Boards
An IC is normally mounted on a breadboard, often referred to as printed circuit board (PCB), to connect it with other ICs on the board. IC components are attached to the PCB using surface mount technology (SMT).