Title of the course: Applied Electronics

Credits : (3-0-3)

Objective: To understand the principle behind common digital and analog electronics devices.

Digital Electronics : Number systems, Binary, Decimal, Hexadecimal, Octal, Conversion of Number system, Binary algebra, addition, substraction, Division, Multiplication, 1's and 2's complement, parity, error detection and correction code, De-Morgans laws, Boolean Algebra: OR Gate, AND Gate, NOT Gate, Boolean Laws, Combinational Circuits: Adder, Subtraction, Decoder, Encoder, Multiplexers, Demultiplexers Sequential Circuits: Latch, Flipflops, Counters, Shift registers, Memory, Sampling, ADC, DAC.

Devices and basic circuits: Diodes, Clipping and Clamping, Rectification, Power-supply filtering, Zener diode regulator BJT and MOSFET Structure and operation,BJT and MOSFET switches, biasing, amplifiers (Common emitter, emitter follower, common source, source follower etc.). Basic logic design with transistors and diodes (TTL and CMOS)

Feedback and operational amplifiers : Introduction to feedback, Operational amplifiers (as a black box), the golden rules, Basic op-amp circuits: Inverting and Noninverting amplifier, Follower, Integrators, Differentiators, Precision rectifiers, Comparators, Schmitt trigger

Unit 4 : Measurement Transducers
Temperature, Light, Acceleration, Pressure, Force, velocity, magnetic field, particle detectors.

Unit 5 : PLC & Microcontroller : Application of Microcontrollers (Toys, Embedded systems etc), General Architecture, Interfacing, Bus Signals, Interrupts, Registers, Support chips. Case study: Compare the architectures of two popularly used microcontrollers, Programming of a microcontroller with examples. Basic operation of relays, PLC as relays, Application of PLC in process industries, Architecture of a typical PLC, Ladder logic programming, Case study: Writing Ladder logic for any process industry (Cement mills, Paper mills etc).

References:

1. P. Horowitz and Winfield Hill " The art of electroncics" Cambridge University
2. M. Morris Mano " Digtial logic design", Prentice Hall.
3. H. Roth "Digital System Design by Charles"
4. Adel S. Sedra & Kenneth C. Smith, "Microelectronics Circuits".
5. Ramakant A. Gayakward " Op-Amplifier"
6. Kenneth Ayala "The 8051 Micro controller"

Introduction to Digital Systems

Digital Systems

Logic circuits are the basis for modern digital computer systems. To appreciate how computer systems operate you will need to understand digital logic and Boolean algebra.

Digital Electronics

- Digital Electronics represents information (0, 1) with only two discrete values.
- Ideally
  - “no voltage” (e.g., 0V) represents a 0 and
  - “full source voltage” (e.g., 5V) represents a 1
- Realistically
  - “low voltage” (e.g., <1V) represents a 0 and
  - “high voltage” (e.g., >4V) represents a 1

- We achieve these discrete values by using switches.
- We use transistor switches, which operates at high speed, electronically, a small in size.

Analog versus Digital

The term digital refers to the fact that the signal is limited to only a few possible values.

- Analog systems process time-varying signals that can take on any value across a continuous range of voltages (in electrical/electronics systems).

- Digital systems process time-varying signals that can take on only one of two discrete values of voltages (in electrical/electronics systems).
  - Discrete values are called 1 and 0 (ON and OFF, HIGH and LOW, TRUE and FALSE, etc.)

**** More complicated signals can be constructed from 1s and 0s by stringing them end-to-end, like a necklace. If we put three binary digits end-to-end, we have eight possible combinations: 000, 001, 010, 011, 100, 101, 110 and 111.***

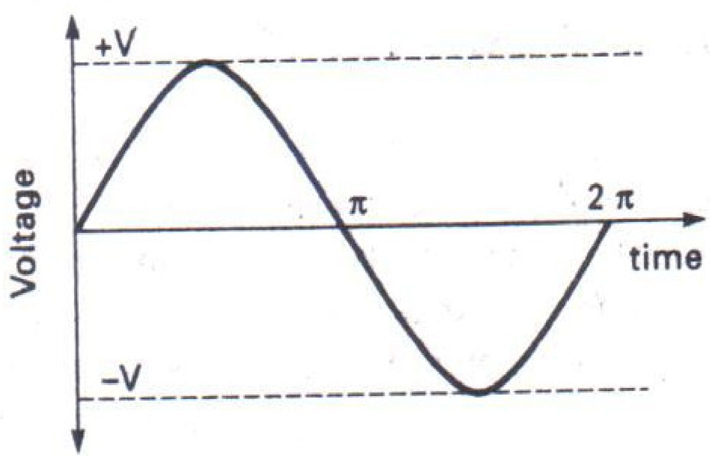
- ***In principle, there is no limit to how many binary digits we can use in a signal, so signals can be as complicated as you like. The figure below shows a typical digital signal, firstly represented as a series of voltage levels that change as time goes on, and then as a series of 1s and 0s.***

Representing Information Electronically

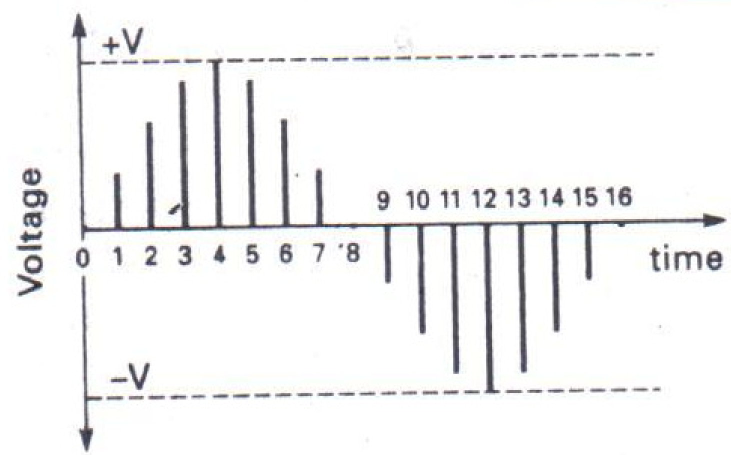
- “Analog electronics” deals with non-discrete values
- “Digital electronics” deals with discrete values

Degrees	v_c volts	Time interval
00.0	0.00	0
22.5	3.83	1
45.0	7.07	2
67.5	9.23	3
90.0	10.0	4
112.5	9.23	5
135.0	7.07	6
157.5	3.83	7
180.0	0.00	8
202.5	−3.83	9
225.0	−7.07	10
247.5	−9.23	11
270.0	−10.0	12
292.5	−9.23	13
315.0	−7.07	14
337.5	−3.83	15
360.0	0.00	16

Analog and Digital Representation



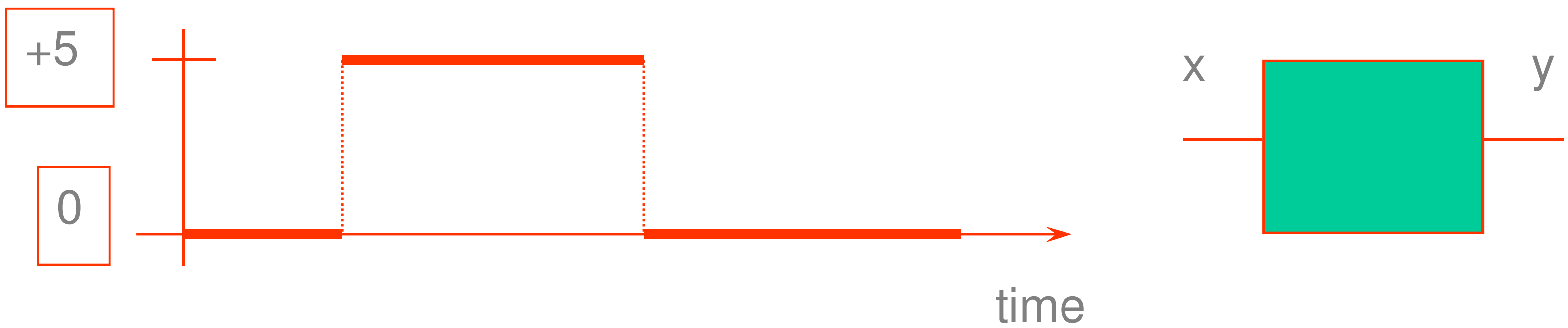
(a) Analog representation



(b) Discrete representation

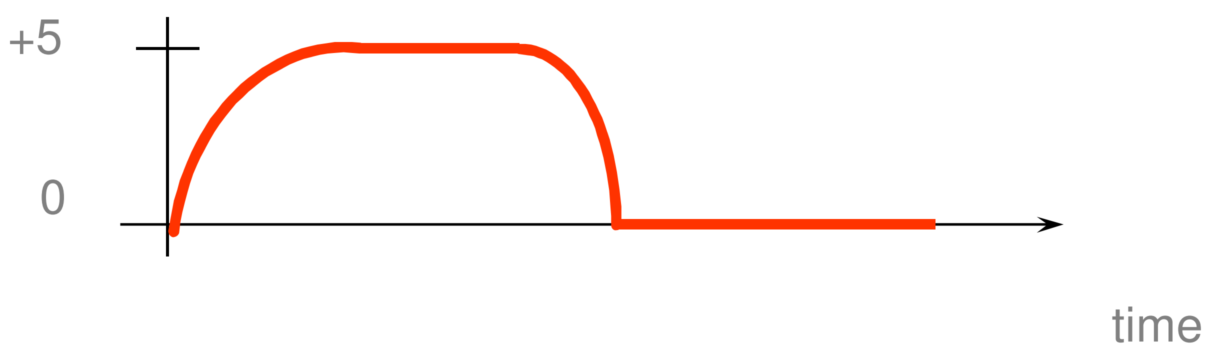
Digital versus Analog

- **Digital systems** have inputs and outputs that are represented by discrete values

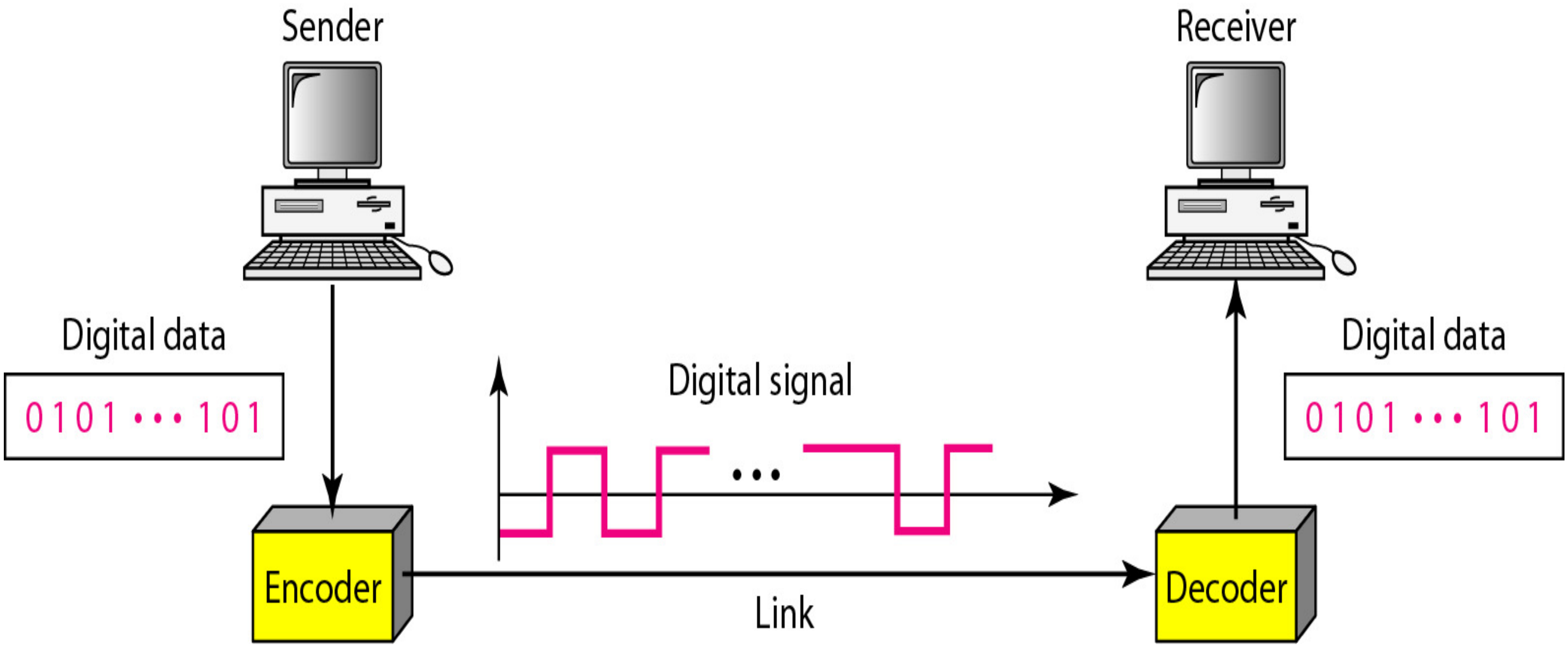


Binary digital systems have exactly two possible input / output values, i.e., 0 or +5 V.

Analog systems have inputs and outputs that take on a continuous range of values

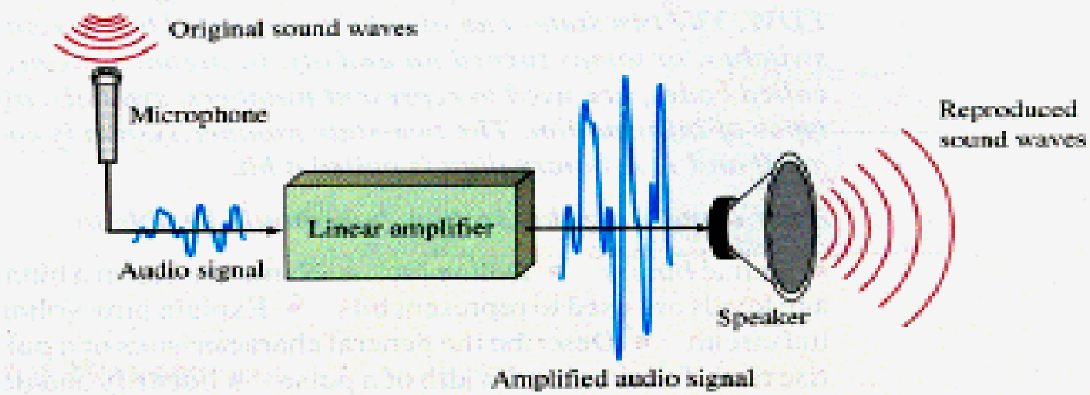


Line coding and decoding

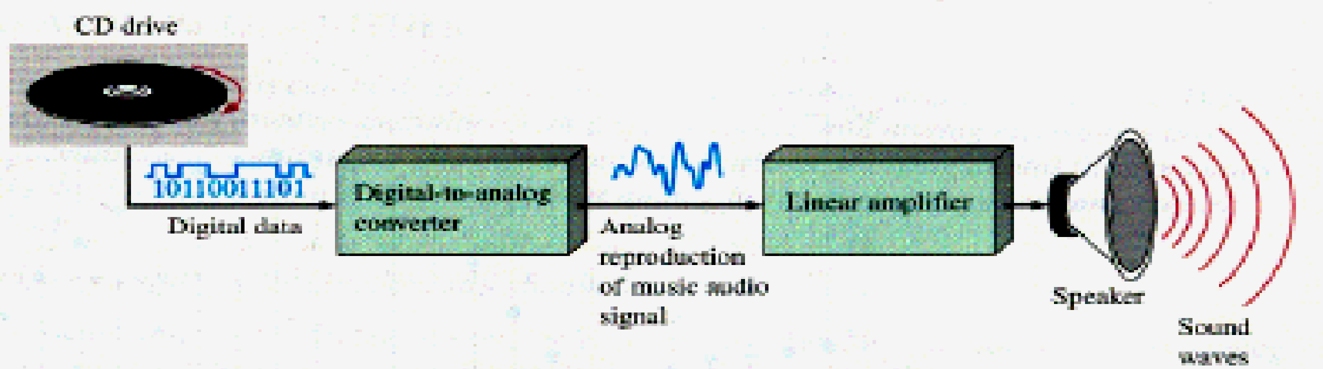


Analog & Mixed System

- ## Analog System



- ## Digital and Analog System



Cont….

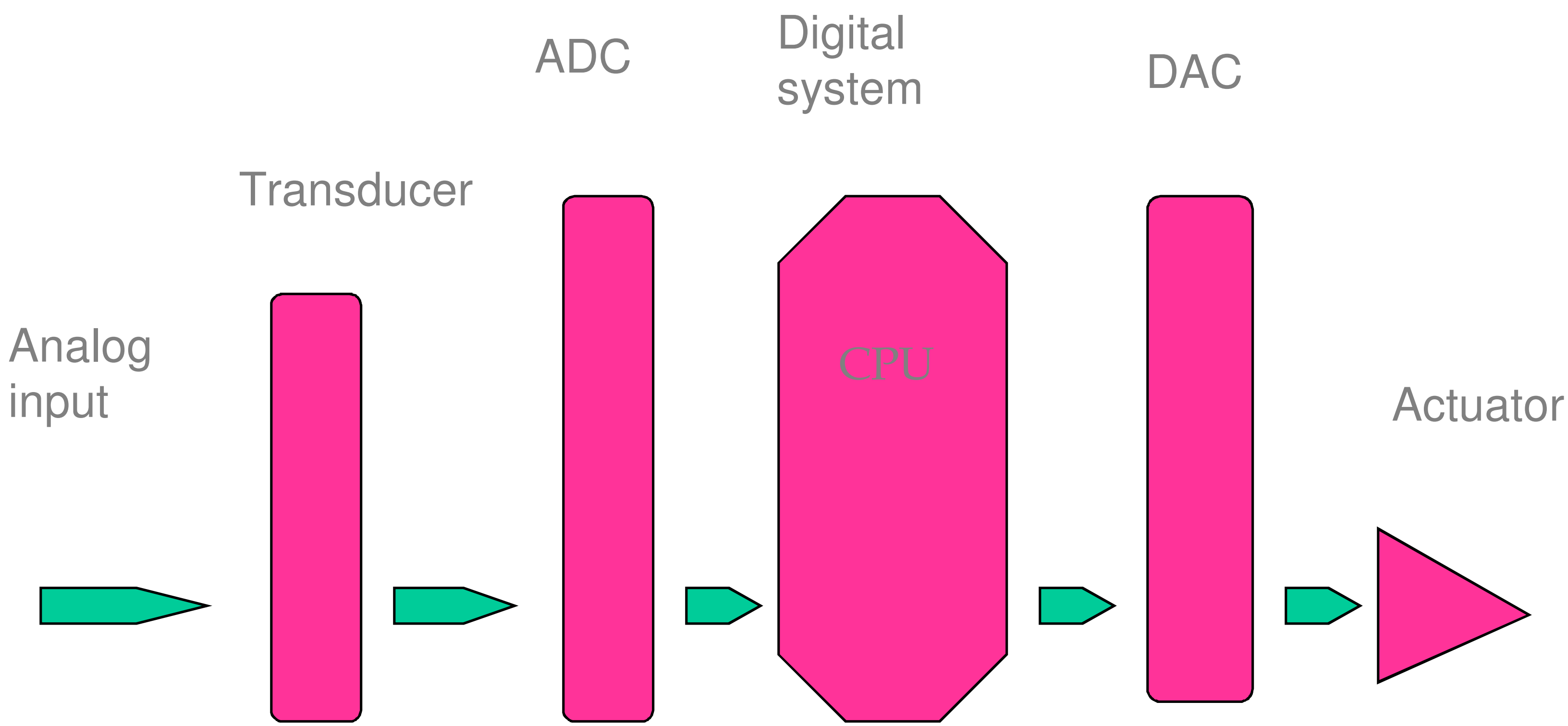
- Digital systems have inherent ability to deal with electrical signals that have been **degraded** by transmission through circuits

- The real world operates in an analog fashion-that is continuously;
  - thus digital systems need interface devices (sensor, actuators, converters) to control analog devices

Advantages of Digital Techniques

1. Easy storage of information
2. Accuracy and precision
3. Easier to design
4. Programmability
5. Less affected by noise
6. Easier fabrication processes

Interfacing with Analog World



Benefits of Digital over Analog

- Reproducibility
- Not effected by noise means quality
- Ease of design
- Data protection
- Programmable
- Speed
- Economy

Digital Revolution

- Digital systems started back in 1940s.
- Digital systems cover all areas of life:

  still pictures
  digital video
  digital audio
  telephone
  traffic lights

  Animation

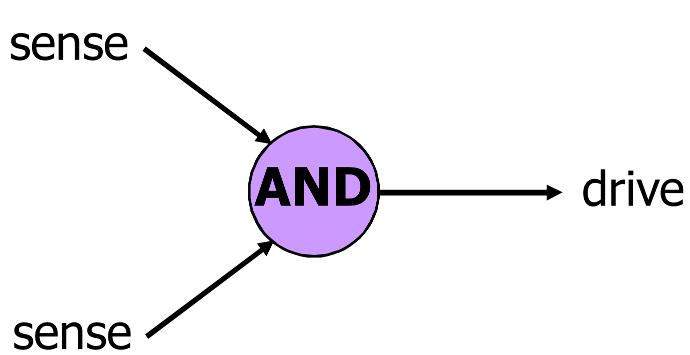
What is logic design?

- **What is design?**
  - given a specification of a problem, come up with a way of solving it choosing appropriately from a collection of available components
  - while meeting some criteria for size, cost, power, beauty, elegance, etc.

- **What is logic design?**
  - determining the collection of digital logic components to perform a specified control and/or data manipulation and/or communication function and the interconnections between them
  - which logic components to choose? – there are many implementation technologies (e.g., off-the-shelf fixed-function components, programmable devices, transistors on a chip, etc.)
  - the design may need to be optimized and/or transformed to meet design constraints

What is digital hardware?

- Collection of devices that sense and/or control wires that carry a digital value (i.e., a physical quantity that can be interpreted as a “0” or “1”)
  - example: digital logic where voltage < 0.8v is a “0” and > 2.0v is a “1”
  - example: pair of transmission wires where a “0” or “1” is distinguished by which wire has a higher voltage (differential)
  - example: orientation of magnetization signifies a “0” or a “1”
- Primitive digital hardware devices
  - logic computation devices (sense and drive)
    - are two wires both “1” - make another be “1” (AND)
    - is at least one of two wires “1” - make another be “1” (OR)
    - is a wire “1” - then make another be “0” (NOT)
  - memory devices (store)
    - store a value
    - recall a previously stored value



Digital Devices

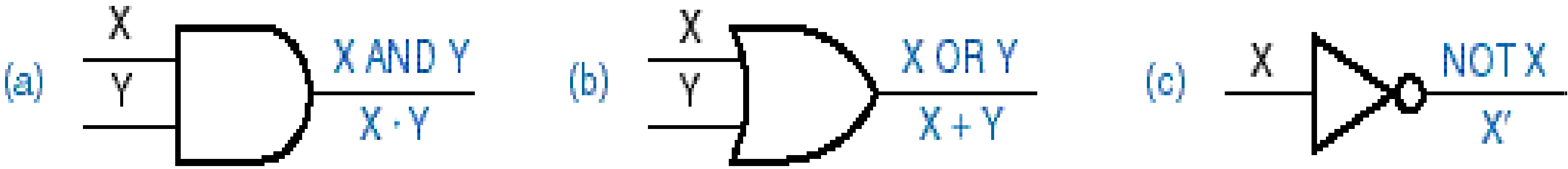
- Gates
- Flip-Flops
- PLDs
- FPGAs

Gates

- The most basic digital devices are called gates.
- Gates got their name from their function of allowing or blocking (gating) the flow of digital information.
- A gate has one or more inputs and produces an output depending on the input(s).
- A gate is called a combinational circuit.
- Three most important gates are: AND, OR, NOT

Digital Logic

- Binary system -- 0 & 1, LOW & HIGH, negated and asserted.
- Basic building blocks -- AND, OR, NOT

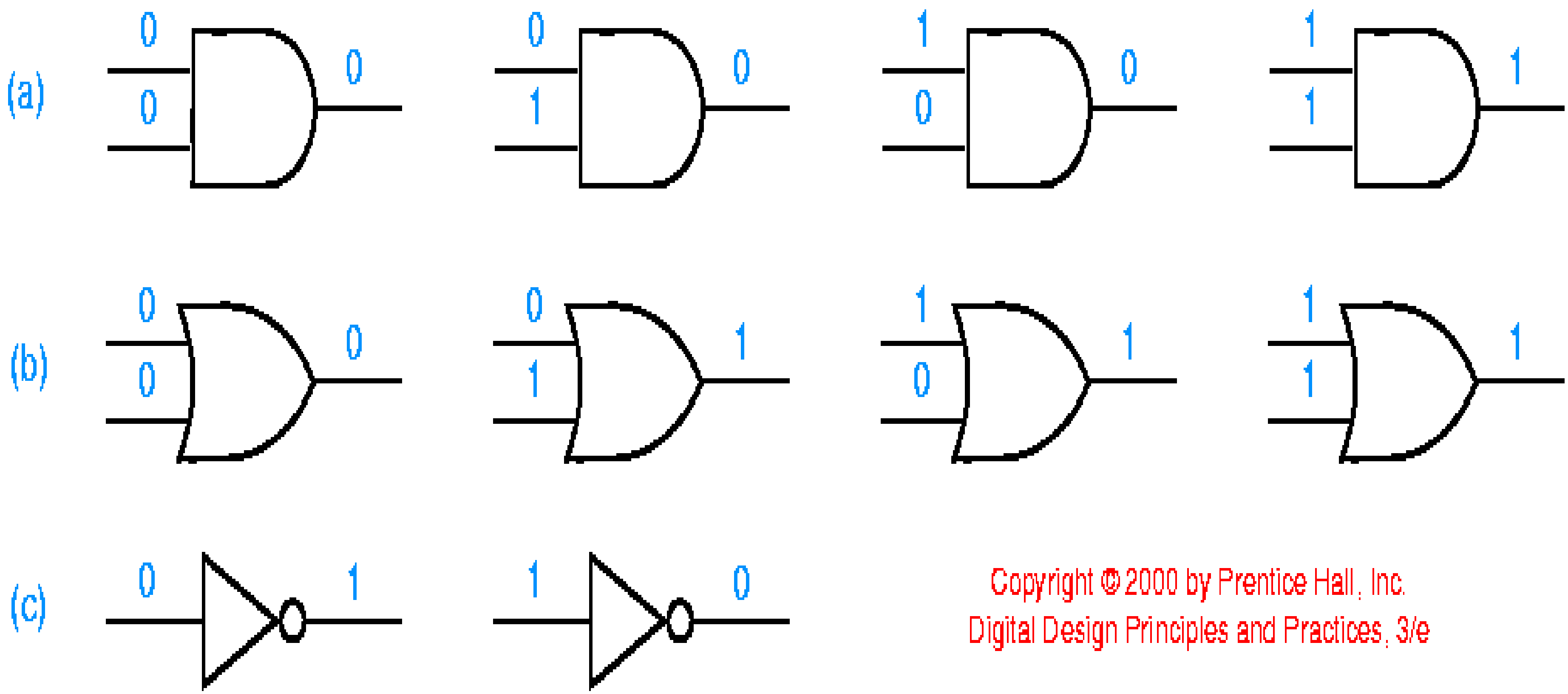


X	Y	X AND Y
0	0	0
0	1	0
1	0	0
1	1	1

X	Y	X OR Y
0	0	0
0	1	1
1	0	1
1	1	1

X	NOT X
0	1
1	0

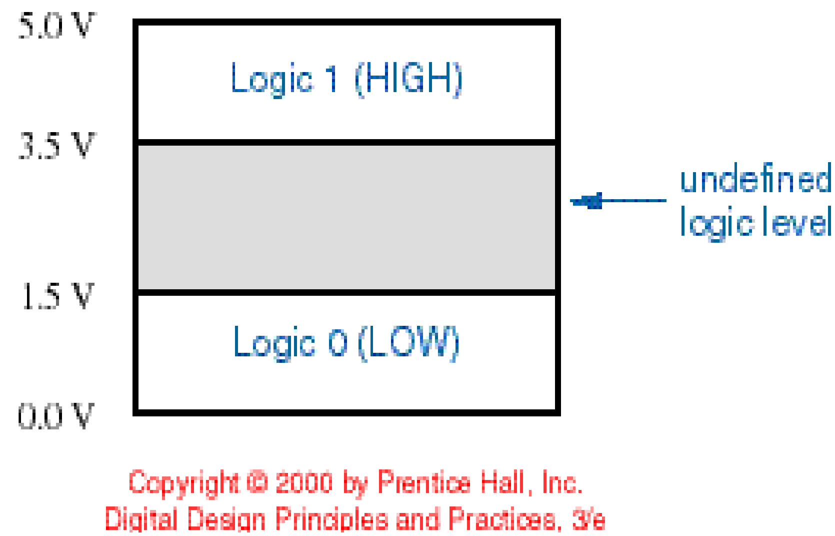
AND, OR, NOT Gates



Digital Abstraction

- It is difficult to make ideal switches means a switch is completely ON or completely OFF.
- So, we impose some rules that allow analog behavior to be ignored in most cases, so circuits can be modeled as if they really did process 0s and 1s, known as digital abstraction.
- Digital abstraction allows us to associate a noise margin with each logic values (0 and 1).

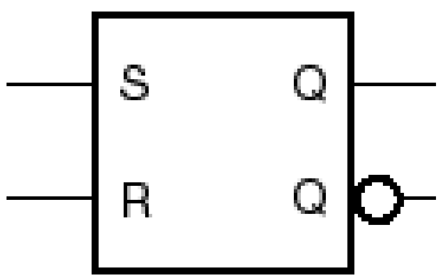
Logic levels



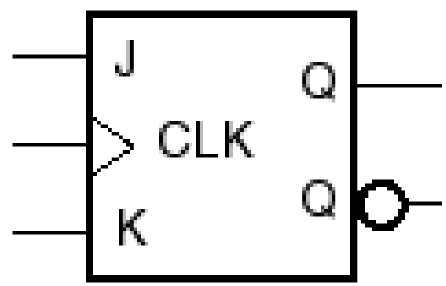
- Undefined region is inherent : digital, not analog
- Switching threshold varies with voltage, temp, process: need "noise margin"
- Logic voltage levels decreasing with new processors.
  5 -> 3.3 -> 2.5 -> 1.8 V

Flip-flops

- A device that stores either a 0 or 1.
- Stored value can be changed only at certain times determined by a clock input.
- New value depend on the current state and it's control inputs
- A digital circuit that contains filp-flops is called a sequential circuit



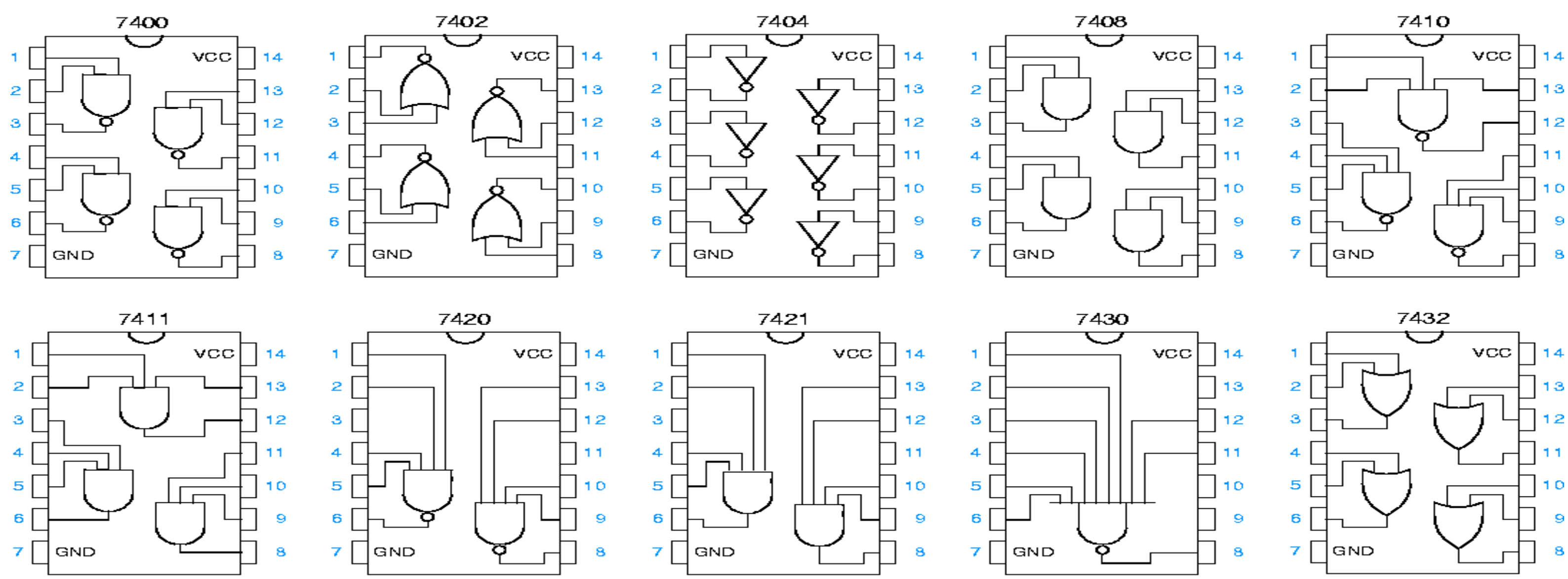
S-R latch symbols



J-K flip-flops

Integrated Circuits

- A collection of one or more gates fabricated on a single silicon chip is called an integrated circuit (IC).
- ICs were classified by size:
  - SSI - small scale integration - 1~20 gates
  - MSI - medium scale integration - 20~200 gates
  - LSI - large scale integration - 200~200,000 gates
  - VLSI - very large scale integration - over 1M transistors
- Pentium-III - 40 million transistors

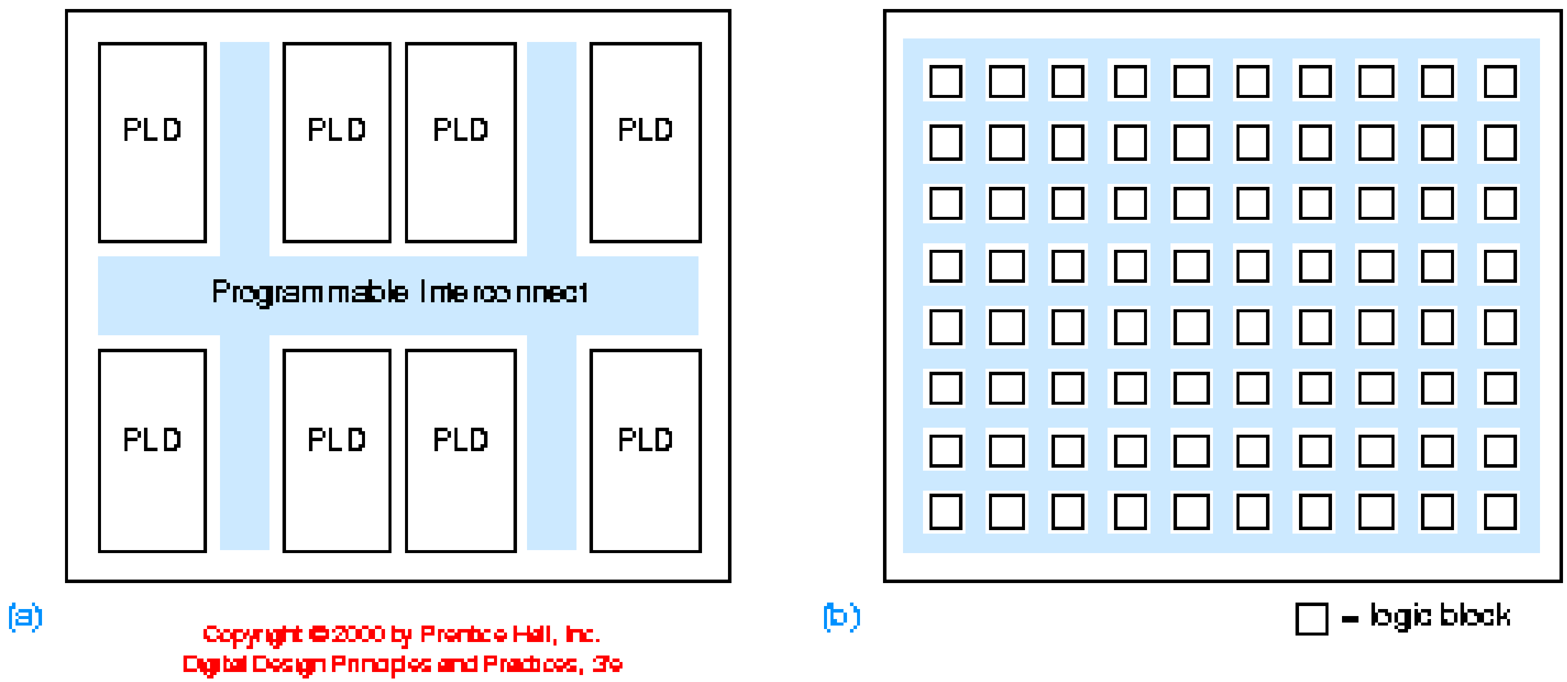


Programmable Logic Devices

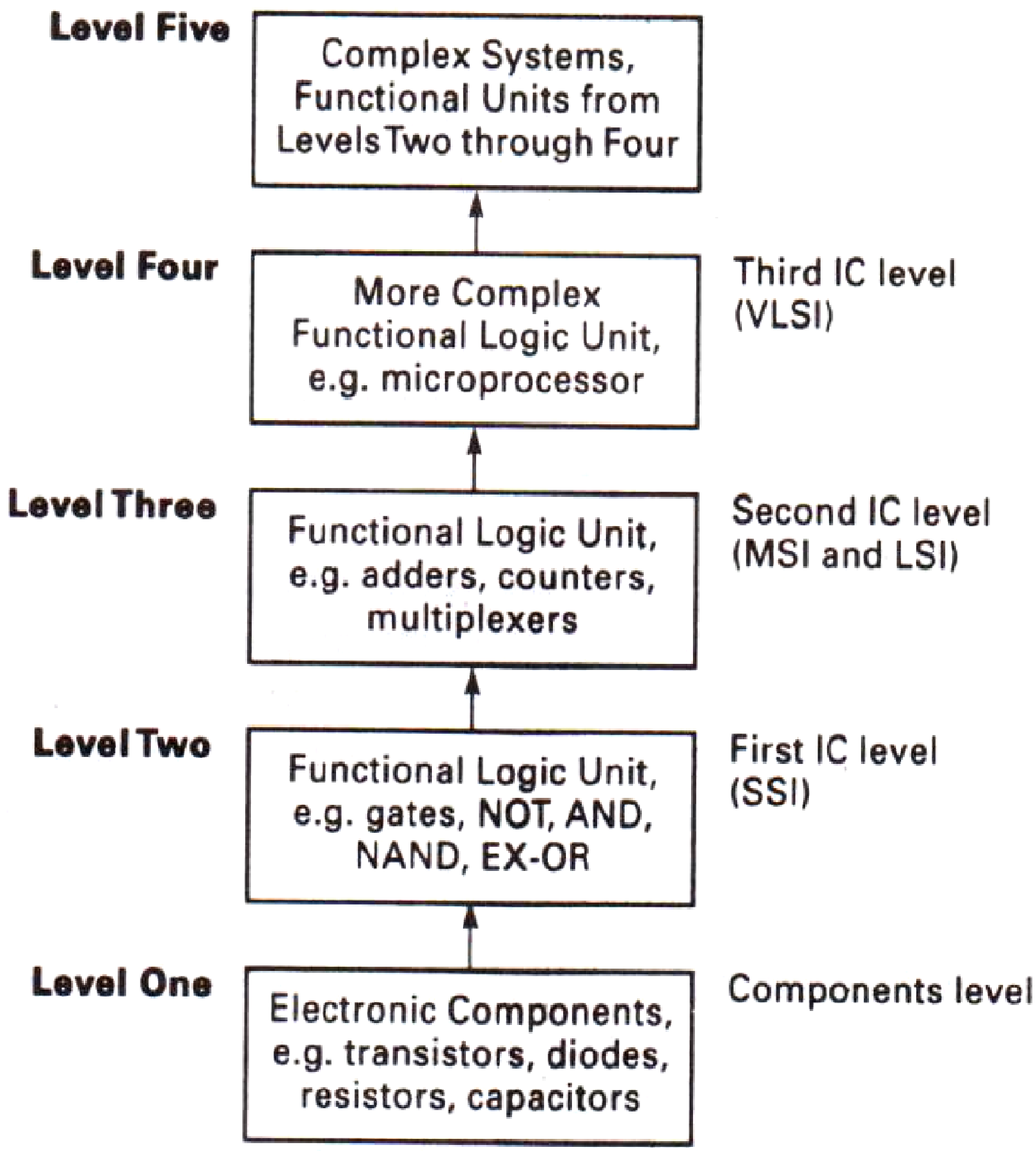
- PLDs allow the function to be programmed into them after they are manufactured.
- Complex PLDs (CPLD) are a collection of PLDs on the same chip.

- Another programmable logic chip is FPGA - field-programmable gate arrays.

CPLD **FPGA**



Simple Digital Hierarchy



Applications of logic design

- Conventional computer design
  - CPUs, busses, peripherals
- Networking and communications
  - phones, modems, routers
- Embedded products
  - in cars, toys, appliances, entertainment devices
- Scientific equipment
  - testing, sensing, reporting
- The world of computing is much much bigger than just PCs!

What is happening now in digital design?

- Important trends in how industry does hardware design
  - larger and larger designs
  - shorter and shorter time to market
  - cheaper and cheaper product

- Scale
  - pervasive use of computer-aided design tools over hand methods
  - multiple levels of design representation

- Time
  - emphasis on abstract design representations
  - programmable rather than fixed function components
  - automatic synthesis techniques
  - importance of sound design methodologies

- Cost
  - higher levels of integration
  - use of simulation to debug designs
  - simulate and verify before you build

Summery

- Design to minimize cost.
- Rule of thumb is to minimize the number of ICs.
- Though PLDs costs more but uses less PCB area.
- Design to solve real life problems.