UNIT-IV

Fundamentals of semiconductor devices and digital circuits

Lecture 23

Prepared By:
Krishan Arora
Assistant Professor and Head

What is Digital Signal

- A digital **signal** is a signal that can only have discrete values in time
  - Most common are **binary** digital signals, where only two values are allowed often designated as 0 and 1
- The opposite is analog signals that can take infinite values

Analog Signal

Digital Signal

What is Digital

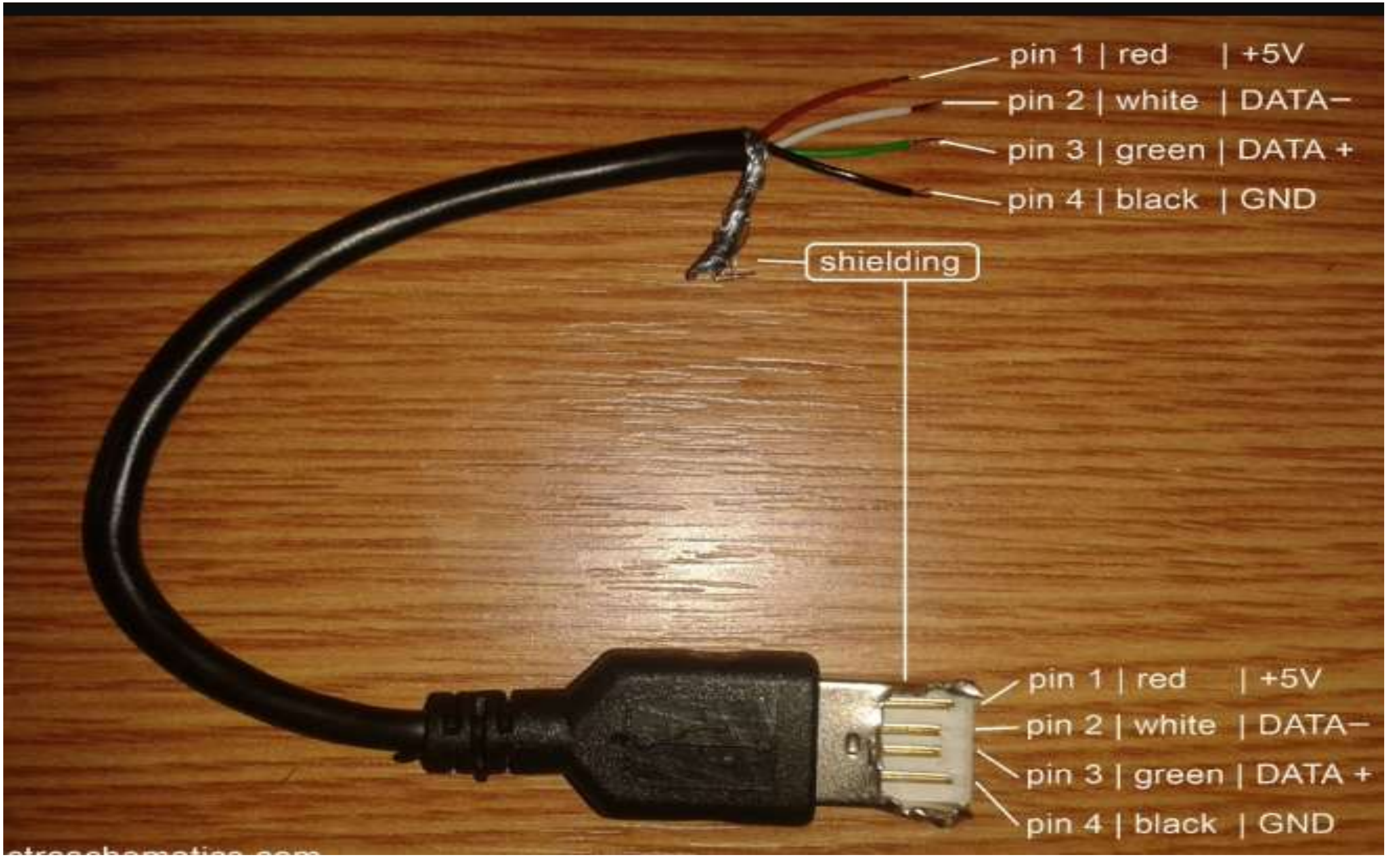
- A digital **system** processes digital signals

- Examples: computer, cellphone, DVD, digital camera, etc.

Okay, what is a signal then?

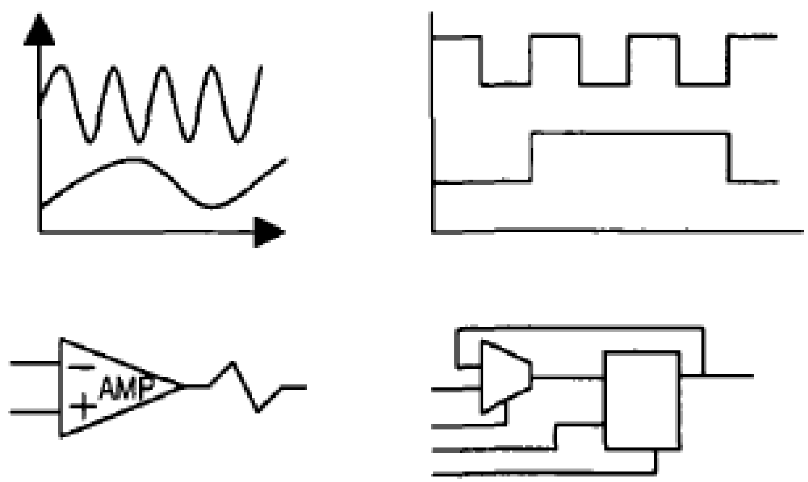
- A signal is a physical quantity (sound, light, voltage, current) that carries **information**
  - The power cable supplies power but no information (not a signal)
  - A USB cable carries information (files)
- Examples of quantities used as digital information signals
  - Voltage: 5V (logic 1), 0V (logic 0) in digital circuits
  - Magnetic field orientation in magnetic hard disks
  - Pits and lands on the CD surface reflect the light from the laser differently, and that difference is encoded as binary data

USB Cable Connections



ANALOG VS DIGITAL

- Analog devices and systems: Process analog signals (time-varying signals that can take any value across a continuous range known as dynamic range)
- Digital devices and systems: Process digital signals (analog signals that are modeled as having at any time one of two discrete values)



a. Analog Circuit. b. Digital Circuit.

Example of analog vs digital system

Digital advantages:

Battery life

Programmability

Accuracy

The world is analog

- Few systems like the watch can be completely digital
- Systems that interact with the environment, need to process analog information
- How? Analog signals must first be converted to digital

Example of analog vs digital system

Analog

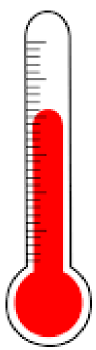
Digital

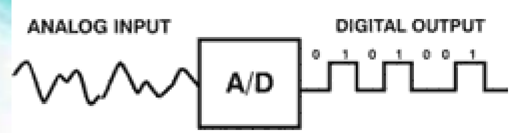
Temperature sensor (analog)

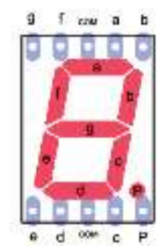
A/D

converter

Display







ANALOG GOES DIGITAL

- Photography
- Video
- Audio
- Automobile applications
- Telephony/Telecomunications
- Traffic lights
- Special effects

WHY DIGITAL?
ADVANTAGES OF DIGITAL PROCESSING

- Reproducibility of results
- Ease of design
- Programmability
- Speed
- Noise tolerance

Quick Quiz (Poll 1)

- **Is this digital or analog?**

A Digital
B Analog

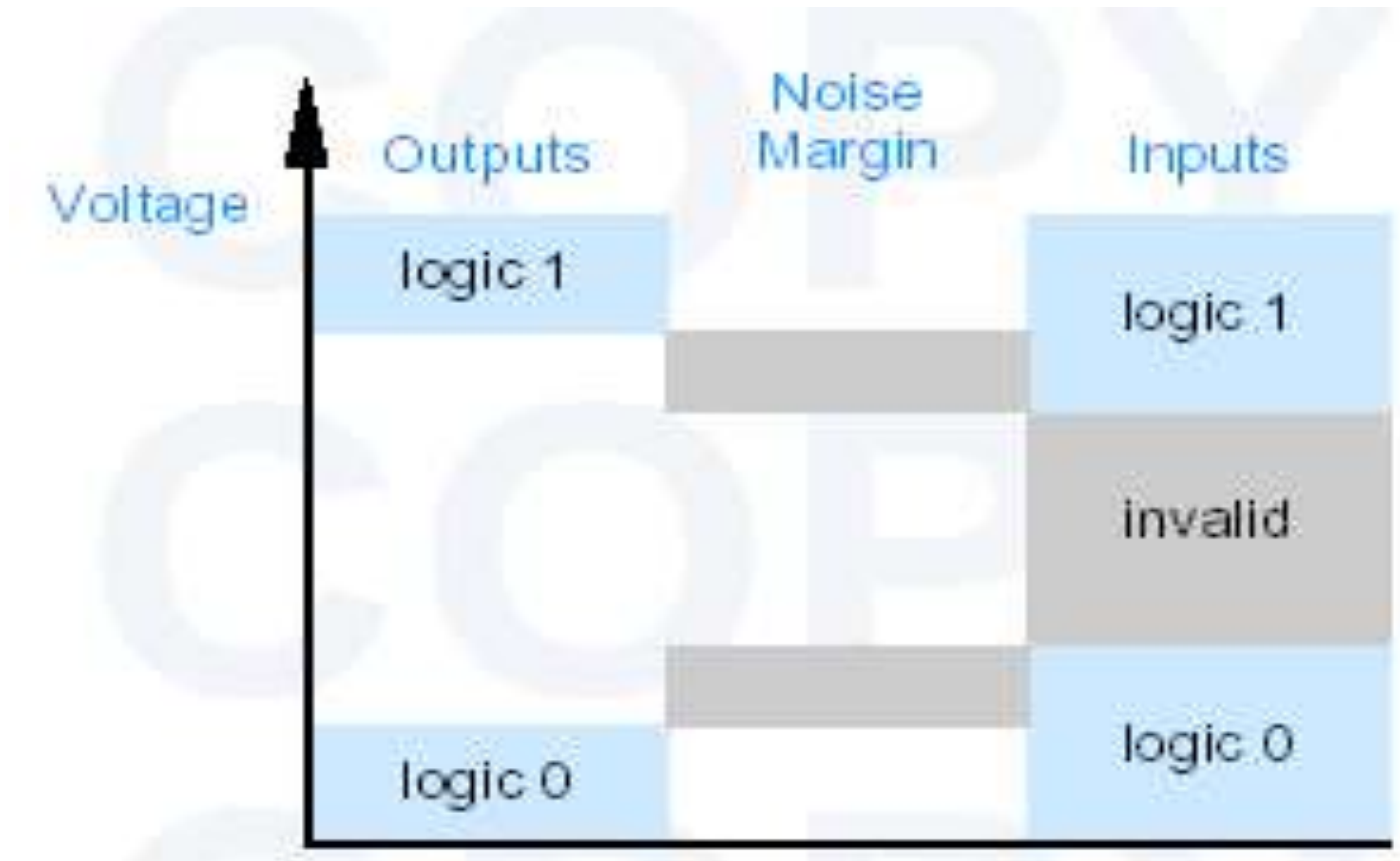
Quick Quiz (Poll 2)

- **An analog signal is sent in discrete pulses in two states, on= 1 or off= 0.**

a) True

b) False

DIGITAL ABSTRACTION



Introduction

Value discretization forms the basis of the *digital abstraction*. The idea is to lump signal values that fall within some interval into a single value (see in Figure) where a voltage signal was discretized into two levels:

- voltage value between 0 volts and 2.5 volts is treated as a ‘‘0,’’ and
- a value between 2.5 volts and 5 volts as a ‘‘1.’’

Correspondingly, to transmit the logical value ‘‘0’’ over a wire, we place the nominal voltage level of 1.25 on the wire. Similarly, to transmit the logical ‘‘1,’’ we place the nominal voltage level of 3.75 volts on the wire (see in Figure)

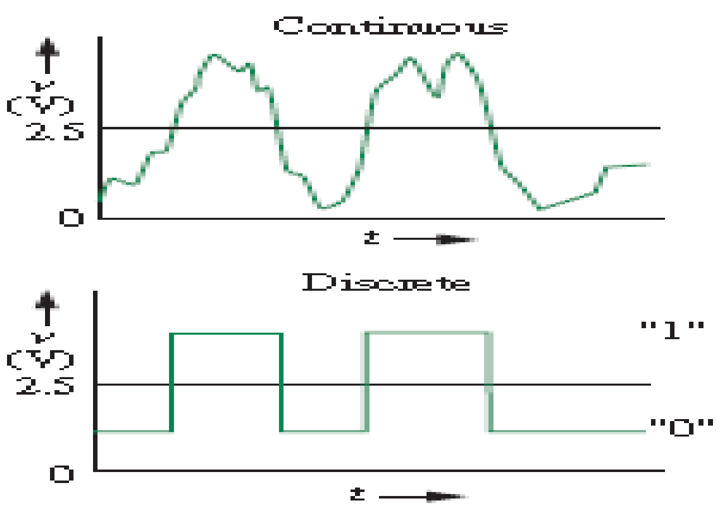


FIGURE Value discretization into two levels.

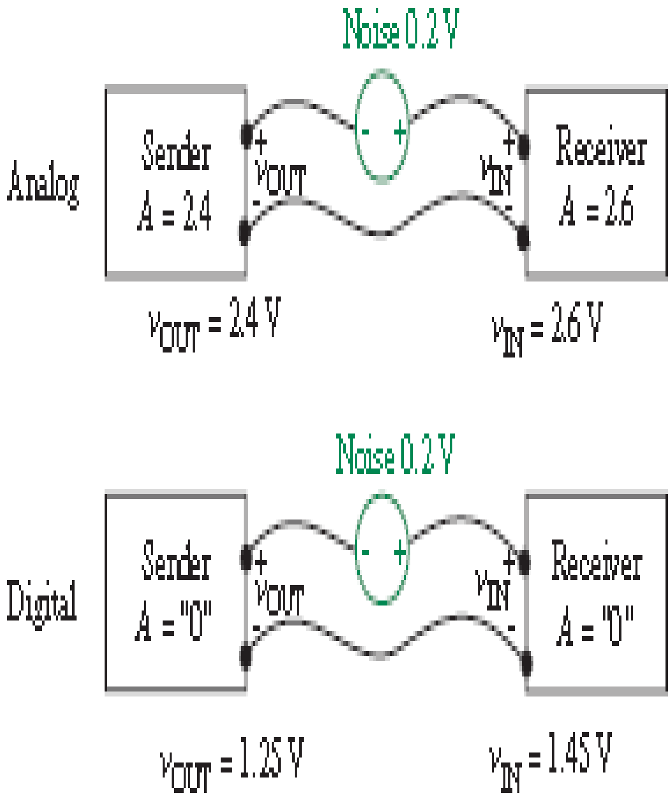


FIGURE 9.2 Signal transmission in the presence of noise. The noise is represented as a series voltage source.

Although the digital approach seems wasteful of signal dynamic range, it has a significant advantage over analog transmission in the presence of noise. Notice, this representation is immune to symmetric noise with a peak to peak value less than 2.5 V. To illustrate, consider the situation depicted in Figure in which a sender desires to transmit a value *A* to a receiver.

In the digital case, suppose that the value *A* is a logical "0." The sender transmits this value of *A* by representing it as a voltage level of 1.25 V on the wire, which is received as a voltage level of 1.45 by the receiver because of the series noise source. In this situation, since the received voltage falls below the 2.5-V threshold, the receiver interprets it correctly as a logical "0." Thus, the sender and receiver were able to communicate without error in the digital case.

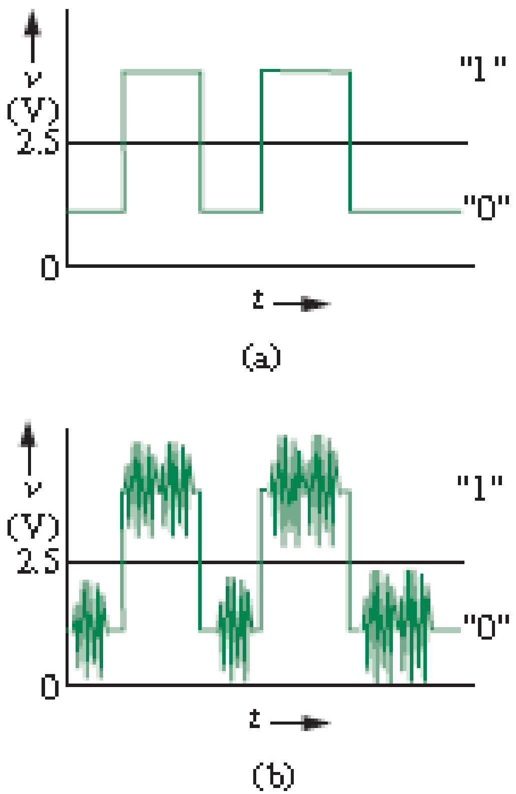


FIGURE 9.3 Noise immunity for discretized signals: (a) a digital signal produced by a sender; (b) the signal received by a receiver following transmission through a noisy environment.

To illustrate further, consider the waveforms in Figure 9.3. Figure 9.3a shows a discretized signal waveform produced by a sender corresponding to a “0,” “1,” “0,” “1,” “0” sequence. Figure 9.3b shows the same signal with the superposition of some amount of noise, possibly during transmission through a noisy environment.

Two levels of signal precision are sufficient for many applications. As one example, logic computations involve signals that commonly take on one of two values: TRUE or FALSE.

There are other applications that require more levels of precision:

A speech signal processing application might involve speech signals with 256 or more levels of precision.

One approach to achieving more precision is to use coding to create multi-digit numbers. When each digit takes on one of two values, the digit is called a *binary digit*, or bit.

Much as the familiar decimal system uses multiple digits to represent numbers other than 0 through 9, the binary system uses multiple bits to represent numbers other than 0 or 1.

Multi-bit signals are commonly transmitted by allocating multiple wires one for each bit, or occasionally, by time multiplexing multiple bits on a single wire.

The two-level representation is commonly known as the *binary representation*. Virtually all digital circuits use the binary representation because two-level circuits are much easier to build than multilevel circuits. The two levels in the binary representation are variously called

(a) TRUE or FALSE,

(b) ON or OFF,

(c) 1 or 0,

(d) HIGH or LOW.

Quick Quiz (Poll 3)

A signal is a way to transmit ___________________ by means of gesture, action, sound, or other means.

a) money
b) information
c) time
d) light