University of Al-Mustaqbal
College of Science
Department of Medical Physics

Digital Electronic

Third stage

Introduction to Digital Electronics

Lecture One

Name of lecturer

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Introduction to Digital Electronics

What is the Digital Electronics?

Electronics:

It is the science concerned with studying the movement of electrons within materials and devices, and with designing circuits that control electrical signals, whether analog or digital.

Digital:

Derived from the word *Digit*, meaning "number," and here it specifically refers to the binary numbers (0 and 1).

Thus, digital means that signals or information are represented using binary numbers rather than continuous values as in analog.

Stages in the Development of Digital Electronics:

1. **Theoretical Foundation – Boolean Algebra (1854)**

   In 1854, George Boole laid the foundation of Boolean algebra.

   This algebra is the mathematical system upon which the logic circuits used in digital electronics are based.

   These ideas were not applied electronically until about 100 years later.

2. **Logic Circuits – 1930s**

   In 1937, the American scientist Claude Shannon presented the first practical application of Boolean algebra in designing electrical logic circuits.

   This work established the link between mathematics and electrical engineering.

3. **Vacuum Tubes – 1940s**

   The first digital electronic computers, such as the ENIAC in 1946, used vacuum tubes

to represent and operate digital signals.

 However, they were very large, slow, and consumed enormous amounts of power.

4. **Invention of the Transistor – 1947**

In 1947, scientists at Bell Labs invented the first transistor.

The transistor was revolutionary because it was:

- Smaller in size
- Faster
- More efficient than vacuum tubes

 The transistor is the cornerstone of modern digital electronics.

5. **Integrated Circuits (ICs) – 1960s**

Integrated circuits were developed, combining thousands of transistors into a single small chip.

Computers became smaller, more powerful, and more reliable.

6. **Microprocessors – 1970s**

In 1971, Intel launched the first microprocessor (Intel 4004).

This enabled the creation of personal computers and portable digital devices.

7. **The Digital Technology Era – From the 1980s to Today**

Digital electronics evolved to be part of everything, including:

- Smartphones
- Digital television
- Smart cars
- Cloud computing
- Artificial intelligence (AI)
- Internet of Things (IoT)

Digital Electronics:

A branch of electronics that deals with circuits and signals represented in binary form (0 or 1), and is used in processors, computers, digital devices, and smart systems.

There are two types of electronics, The first type is analog electronics, in which information is converted into an electrical signal in the form of a voltage or current that changes gradually and continuously over a certain range. In this case, the signal's shape represents the original information and is identical to it, which is why it is called an analog signal.

The second type is digital electronics, which we will focus on in the following lines.

digital electronics :These are circuits that handle data consisting of only two levels of voltages in their input and output. These two levels can be expressed in more than one way: high and low, zero or one, on or off, false or true, white or black, large or small. Whatever the expression, we are always expressing two contradictory states in a digital circuit.

Digital Electronics Components Digital electronics, or digital circuits, comprise various components that perform specific functions. These components are divided into two categories:

Active Components

Passive Components

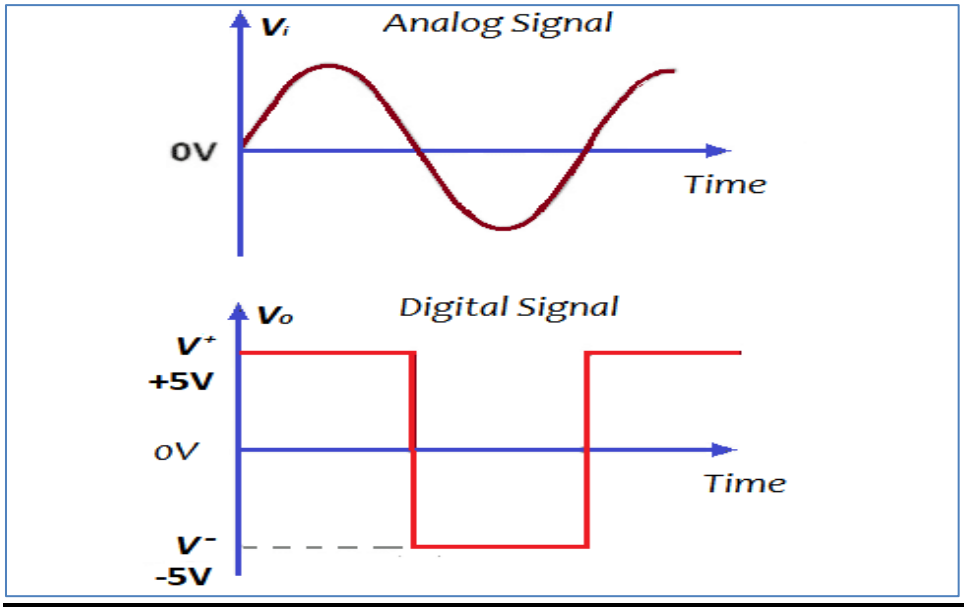
Active components are transistors and diodes, while passive components are capacitors, resistors, inductors, etc.

Digital Circuits

Digital circuits take only one of two values: one (1) or zero (0). These are mathematical values that express the circuit's state. If the circuit is in the OFF state, it is expressed as zero (0), while if it is in the ON state, it is expressed as one (1).

In a digital system, there are not many options for potential difference. The voltage is zero (0) volts, and any value from zero to 0.8 volts is also expressed as zero (0). The value of 5 volts is expressed as one (1) volt, and any value from 2 volts to 5 volts is also expressed as one volt (1). For values between greater than 0.8 and less than 2 volts, some circuits give them a value of 1, while others give them a value of 0. This is the middle area called the gray zone. Using these values is not recommended and it is best to avoid them to avoid errors.

When the voltage value is zero (0) volts, the value for a digital circuit is zero (0), meaning the voltage is low. When the voltage is 5 volts, the value for a digital circuit is one (1), meaning the voltage is high. There is no ambiguity in a digital circuit; it is clearly either low or high. Digital circuits use digital gates, which are usually in the form of integrated circuits IC.



Advantages of Digital Systems over Analog Systems

1-Data is transmitted in digital systems without degradation due to noise, compared to analog systems.

2-Digital systems are immune to noise, making data storage easier, while analog systems are susceptible to wear and tear, which can lead to the degradation of stored information.

3-Digital systems interface with computers, facilitating data control. The system can be kept error-free by updating the software, a feature not available in analog systems.

Disadvantages of Digital Systems

Disadvantages of Digital Systems Although digital systems offer noise immunity and better storage, they also have disadvantages, including:

1-The power consumed by digital systems is greater than that of analog systems. This power is consumed in calculations and signal processing, which results in heat generation.

2-Digital systems are expensive.

3-If one digital data is misinterpreted, the final data will be completely altered.

Applications of Digital Circuits

Digital electronics, or digital circuits, are an integral part of electronic devices. Here are some uses of digital circuits:

-Digital clocks are designed based on digital circuits.

-Digital electronics are used in rocketry and computing.

-Automatic doors operate on the principle of digital electronics.

- Traffic lights rely on digital circuits.

Number systems and their properties

When we hear the word number, most of us think of the familiar decimal number system consisting of the prime decimal digits (**0, 1, 2, 3, 4, 5, 6, 7, 8, 9**). The commonly used numbering system uses ten digits from zero to nine and is called the **decimal system** because it contains ten digits. There are other systems (counting systems in computers) that are only known to those who specialize in studying electronics, computers and communications, including binary numbers, octal numbers and hexadecimal numbers.

Numbering System		
System	Base	Digits
Binary	2	0,1
Octal	8	0,1,2,3,4,5,6,7
Decimal	10	0,1,2,3,4,5,6,7,8,9
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

Decimal Number System

This system is one of the most widely used and convenient systems for humans. In everyday life, humans use the decimal system for various mathematical operations. The decimal system is so named because it consists of ten digits (0, 1, 2,…., 9).

The value of a digit depends on its position in the decimal number. This means that a digit can have more than one value, and its position within the number determines the value of that digit. The value of a digit increases as it is moved to the left, and its value decreases as it is moved to the right. Therefore, the digit located to the far right of the number is the least significant bit (LSB), and the digit located to the far left of the number is the most significant bit (MSB). The decimal system is a local counting system; the value of a digit depends on its position in the decimal number. A digit can be calculated based on what is known as the number's place value. The number can be expressed using the base 10 raised to the exponent so that it begins with (2,1,0...).

Decimal Number System (Base-10)

*Digits: 0 – 9

Each digit's place value is a power of 10

Example 1: Analyze the number according to the decimal system.

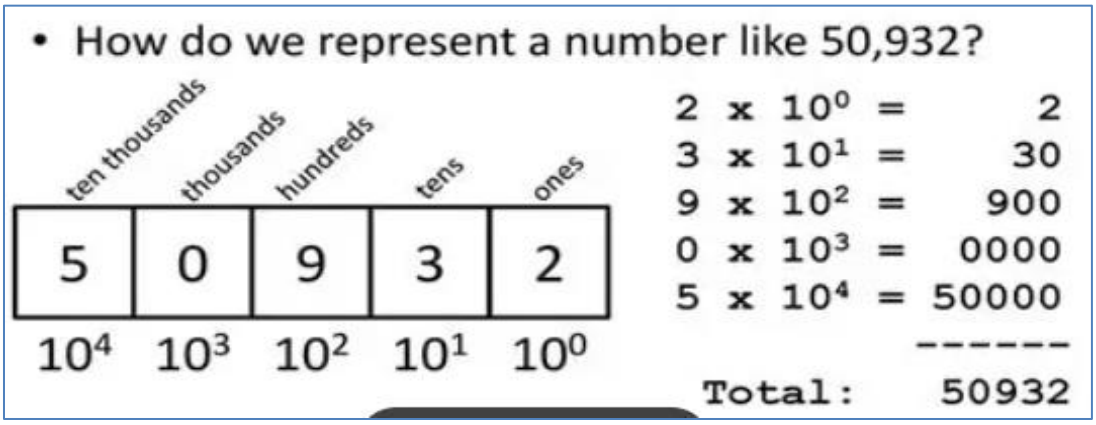
The number 354

354 = 4 ones + 5 tens + 3 hundreds = 4 +5x10 + 3x100

$= 3 \times 10^2 + 5 \times 10^1 + 4 \times 10^0 = 300 + 50 + 4 = (354)_{10}$

Note You can determine which number system this number belongs to by looking at the number written under the parentheses surrounding it. For example, (354)10 indicates that this number belongs to the decimal system. (354)2 belongs to the binary system. (354)8 belongs to the octal system. (354)16 belongs to the hexadecimal system.

Example 2: **Analyze the number (**50.932) **according to the decimal system**



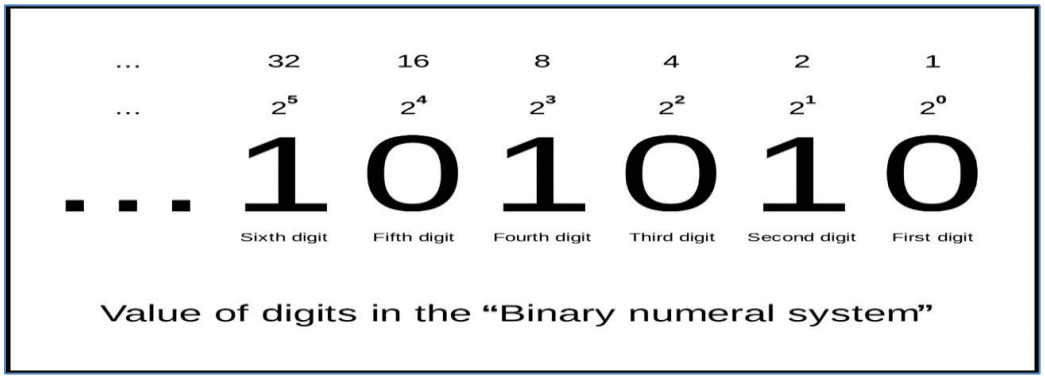
Binary Number System

The **Binary Number System**, also known as the **base-2** system, uses only two digits, '**0**' and '**1**', to represent numbers. It forms the fundamental basis for how computers process and store data. This base-2 system is the backbone of how computers process and store information, representing everything from text to images as sequences of 0s and 1s.

*The binary number $(11001)_2$ corresponds to the decimal number **25**.*

The word binary is derived from the word "bi," which is Latin for "two". But what makes it so essential, and how does it work? This article will dive deep into **binary numbers**, binary decimal number conversion and vice versa, 1's and 2's complements, and how they are used in **computer systems**.

Binary Number Table



Questions

Q1. What is the main difference between analog and digital electronics?
A) Analog uses discrete signals, while digital uses continuous signals
B) Analog uses continuous signals, while digital uses discrete signals
C) Both use only binary signals
D) Both deal with sinusoidal signals only
E) Analog systems are always more accurate than digital
✔ **Answer: B**

Q2. In digital electronics, signals are usually represented by:
A) Multiple voltage levels
B) Only zero volts
C) Two distinct levels, such as 0 and 1
D) Continuous waveforms
E) Random voltage values
✔ **Answer: C**

Q3. Which of the following is an **active component** in digital electronics?
A) Resistor
B) Capacitor
C) Inductor
D) Transistor
E) Fuse
✔ **Answer: D**

Q4. If a digital circuit is OFF, its value is represented by:
A) 1
B) High
C) 0
D) Floating
E) Undefined
✔ **Answer: C**

Q5. What is the "gray zone" in digital electronics?
A) The area of maximum voltage
B) A range of voltages between 0.8V and 2V that may cause uncertainty
C) A short circuit condition
D) A faulty transistor operation
E) A logic gate malfunction
✔ **Answer: B**

Q6. Which of the following is an **advantage of digital systems** over analog systems?
A) Higher susceptibility to noise
B) Easier data storage without degradation
C) Less power consumption

D) Always cheaper than analog
E) No need for software updates
✔ **Answer: B**

Q7. Which of the following is a **disadvantage of digital systems**?
A) They are completely immune to noise
B) They consume more power and generate heat
C) Stored data always degrades over time
D) They cannot interact with computers
E) They can only be used in clocks
✔ **Answer: B**

Q8. Which application is **not** directly based on digital circuits?
A) Digital clocks
B) Automatic doors
C) Traffic lights
D) Rocketry systems
E) Mercury thermometer
✔ **Answer: E**

Q9. In the decimal number system, the digit on the far **right** is called:
A) MSB (Most Significant Bit)
B) LSB (Least Significant Bit)
C) Binary digit
D) Floating digit
E) Weighted digit
✔ **Answer: B**

Q10. What is the decimal value of the number 57310573_{10}57310?
A) 357
B) 735
C) 573
D) 753
E) 537
✔ **Answer: C**