# Introduction to Digital Signal

UNIT:- 1

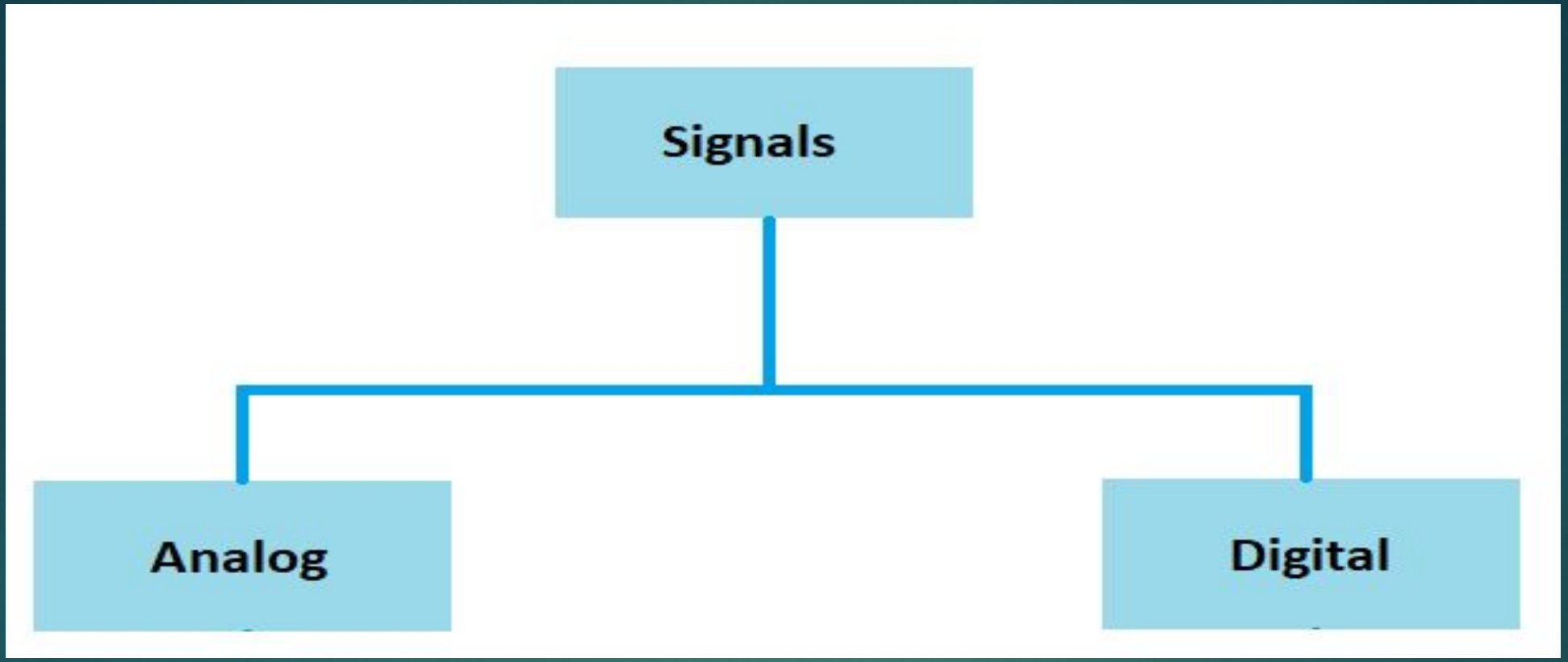
# Signal:-

**The signal is an electromagnetic wave that carries information from one point to another**.

It can travel through different mediums, such as air, vacuum, water, and solid.

In electronics, the signal is defined as a current, voltage, or wave carrying information and traveling long distances. The speed of a signal wave is equal to the speed of light.

Depending on their characteristics, signals are mainly classified into two types: Analog and Digital. Analog and Digital signals are further classified, as shown in the following figure.

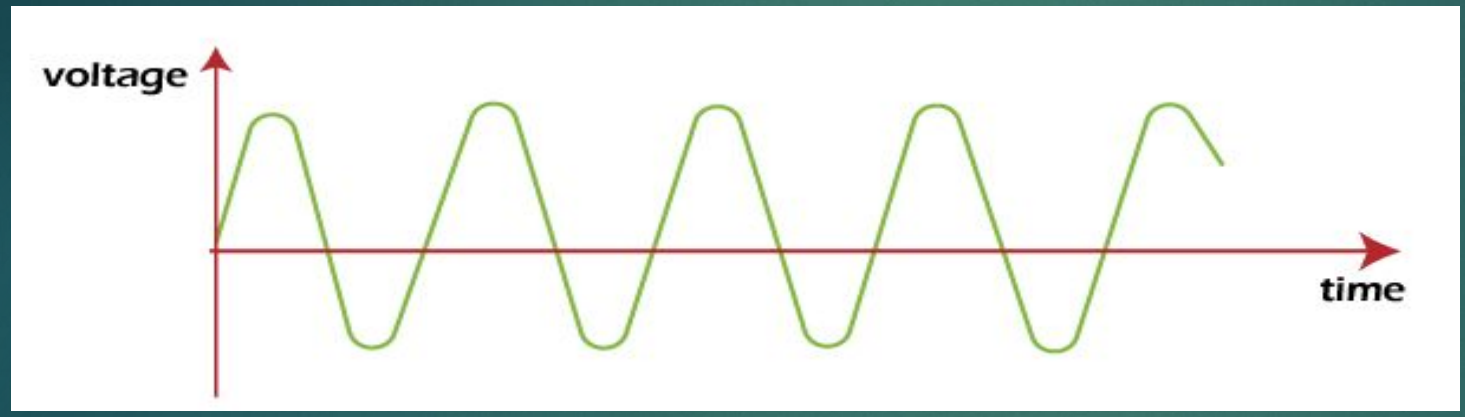



There are two types of signals, Analog and digital.
**Analog** refers to the data transmission in Analog or continuous form.
**Digital** refers to the data transmission in the form of bits. The bits are represented by **0 (LOW)** and **1 (HIGH).**

# Analog Signal

Analog signals are continuous time-varying signals. It means that these signals are the function of time. Or

An Analog signal is a signal whose characteristics, such as voltage, amplitude, or frequency, vary with time. The common shape of an Analog signal is the sinusoidal (having the form of a sine curve)wave. It is shown below:

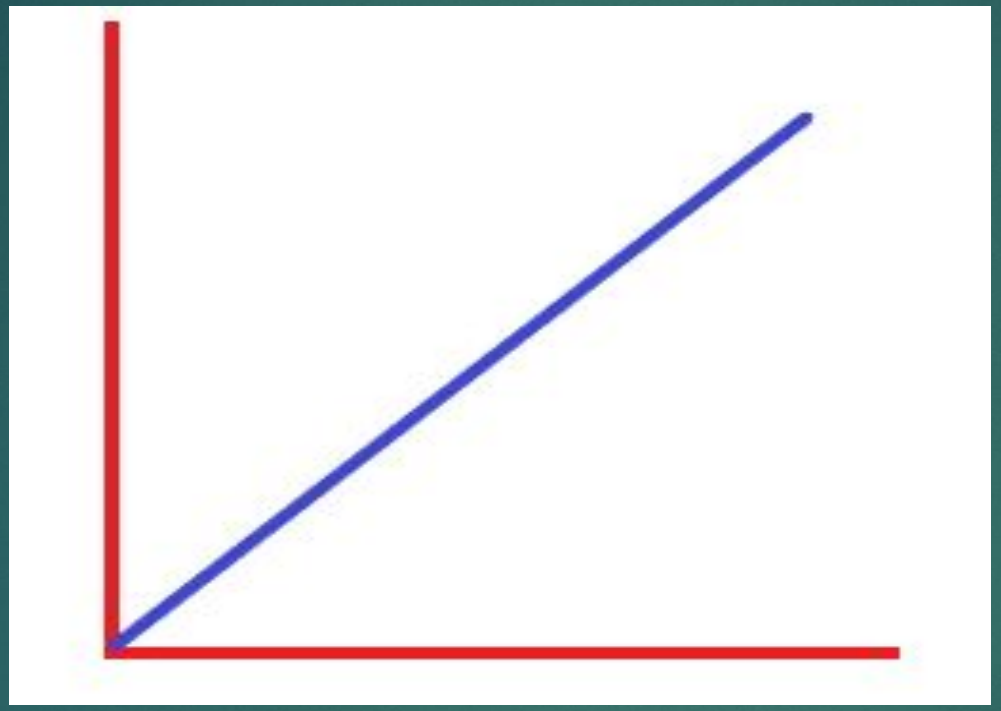



Examples of Analog signals are electrical signals, light signals, speech signals, etc. Radio signals are also categorized as Analog signals. Every signal requires a medium to propagation.

For example,

Electrical signals require cables to propagate from one place to another.

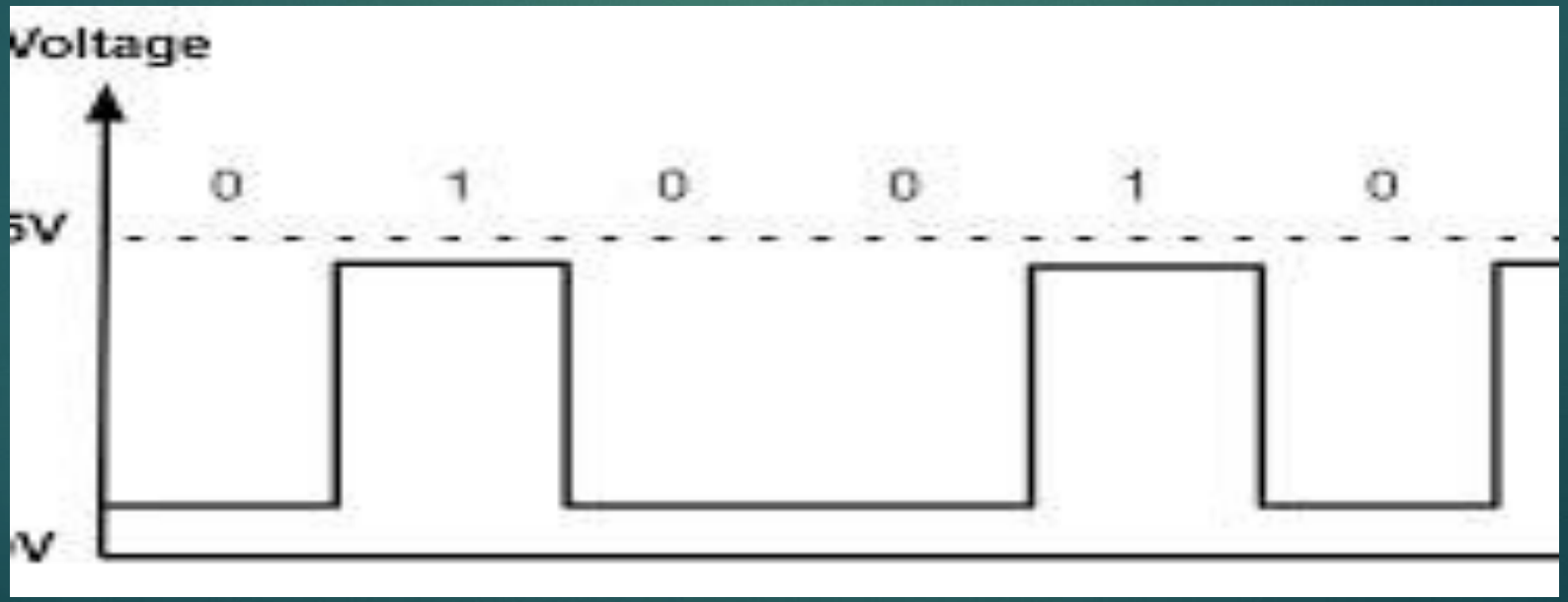
Example: The distance of a car travelling with constant time with a specific time can be considered as an example of an Analog signal. The graph representing will be an inclined line, as shown below:



It is continuous in nature.

# Digital signal

A **digital signal** is a type of signal used in electronics and computing to represent data as a series of discrete values, typically as binary numbers (0s and 1s). Unlike analog signals, which are continuous and can take on any value within a range, digital signals have defined, finite states, making them especially useful in computer systems and digital communications.



# Characteristics of Digital Signals

1. **Discrete Values**: Digital signals represent information in binary form, using distinct voltage levels to signify the two states (often "high" for 1 and "low" for 0). For example, in a digital circuit, 5 volts might represent a "high" signal (1), and 0 volts might represent a "low" signal (0).
2. **Square Waveforms**: Digital signals are usually represented by square waveforms, where the signal rapidly switches between two voltage levels. This contrasts with the smooth, continuous waveform of an analog signal, like a sine wave.
3. **Noise Resistance**: Digital signals are more resilient to noise compared to analog signals. Even if there's some interference, digital signals can often be "cleaned" or reconstructed based on the high and low values, minimizing errors.
4. **Synchronization**: Digital signals are typically transmitted with a clock signal to ensure the data is received at the correct times. The clock determines the rate at which the signal switches between states, ensuring that each bit of data is correctly interpreted.

# Digital Signals Transmission

Digital signals can be transmitted over various media, including cables, fiber optics, and wireless networks. They are highly efficient for transmitting data over long distances and are less prone to distortion. Unlike analog signals, digital data can be encoded with error-detection and error-correction algorithms, allowing for high fidelity in data transmission.

# Application of Digital Signals

1. **Computing**: All computer operations are based on digital signals, with processors and memory interpreting binary data to perform tasks.
2. **Digital Communication**: Cellular networks, Wi-Fi, Bluetooth, and other communication technologies rely on digital signals for clear, reliable communication.
3. **Data Storage**: Digital signals are the foundation of data storage, with information stored in binary format on hard drives, SSDs, and memory chips.
4. **Broadcasting**: Digital signals are used in digital television (DTV) and radio broadcasting, including HD radio and satellite radio. They allow for higher quality and additional content to be transmitted, like subtitles, multiple audio tracks, and metadata.
5. **Security and Surveillance**: Digital signals are used in security systems, such as CCTV, biometric scanning, and alarm systems. Video footage, access logs, and other data are stored digitally for analysis and record-keeping.

# Advantages of Digital Signals over analog signals

1. **Noise Resistance**: Digital signals are less susceptible to noise and interference, as they represent data in discrete binary values (0s and 1s). This makes them more stable and reliable over long distances.
2. **Error Detection and Correction**:Digital systems can use error-detection and error-correction codes to identify and fix errors in the data, improving accuracy in communication and data storage.
3. **High Signal Quality over Distance**:Unlike analog signals, digital signals don't degrade easily as they travel. Amplification and regeneration of digital signals maintain their integrity, even over long distances.
4. **Efficient Storage and Compression**:Digital data can be stored in compact formats and compressed, reducing storage space requirements and enabling faster transmission.
5. **Easier to Process**: Digital signals can be processed using algorithms, making complex operations, such as filtering, transformation, and analysis, faster and more accurate.

# Advantages of Digital Signals over analog signals

6. **Multiplexing Capability**:Digital signals can be multiplexed, allowing multiple signals to be combined and transmitted over a single channel, which is highly efficient in communication systems.
7. **Security and Encryption**: Digital data can be easily encrypted, providing greater security in transmission and storage, making it ideal for sensitive information like financial and personal data.
8. **Consistency and Reproducibility**:Digital signals can be exactly replicated without quality loss, making them ideal for copying and distributing high-fidelity audio, video, and data files.
9. **Lower Power Consumption**: Digital circuits generally require less power than analog circuits, especially in applications like mobile devices and portable electronics, making them more energy-efficient.
10. **Integration with Computers and Digital Systems:** Digital signals are compatible with computers and digital systems, enabling integration across modern devices, networks, and the internet, leading to more functionality and **interconnectivity.**

# Representation of Digital Signal over analog signals

Digital signals can be represented in several ways, primarily through waveforms, binary code, and graphical or numerical models that illustrate their discrete, binary nature. Here are some common methods for representing digital signals:

1. **Binary Code (0s and 1s)**
   - Digital signals are most often represented as sequences of binary digits, or bits, where each bit is either 0 or 1.
   - Each bit represents one of the two voltage levels, with 0 often corresponding to a lower voltage (like 0V) and 1 to a higher voltage (like 5V or 3.3V).
   - For example, a digital signal transmitting "1101" might look like a pattern of high and low voltages in a square waveform.

# Representation of Digital Signal over analog signals

**2. Square Waveforms**

- A digital signal is commonly visualized as a square waveform that alternates between two levels (high and low).
- The waveform has distinct, sharp transitions between these levels, representing the binary states.
- The height of each "step" in the square wave represents the signal's amplitude, while the length of each step (horizontal distance) represents the duration of each bit.

3. **Logic Levels**

- Logic levels are voltage thresholds used to define the binary states in digital circuits (e.g., 0-0.8V as low, 2-5V as high).
- These levels are especially common in digital electronics, where they are represented on circuit diagrams to show binary states of signals passing through logic gates.

# Representation of Digital Signal over analog signals

**4. Truth Tables**

- Truth tables are a tabular method to represent all possible states of a digital signal or a digital circuit. They list all possible combinations of input signals and their corresponding output, often used in logic design.

**5. Data Packets in Communication Protocols**

- In digital communication systems, signals are often grouped into packets, each containing a header, payload, and footer.
- Each part of the packet represents specific information, like the destination address and message content, and is structured for error-checking and synchronization.

# Difference between analog signals and digital signals

| Analog Signals | Digital Signals |
| --- | --- |
| Analog signals are continuous signals that represents the physical measurement. | Digital signals are the time separated signals which are generated using digital modulation. |
| It is denoted by sine wave | It is denoted by square wave |
| It is continuous range of value that help you to represent information. | Digital signals uses discrete 0 and 1 to represent information. |
| The analog signals bandwidth is low | The digital signals bandwidth is high |
| It is suited for audio and video transmission | It is suited for computing and digital electronics. |
| Analog signals does not offer any fixes range | Digital signals has finite number, i e 0 and 1 |

# Thank you