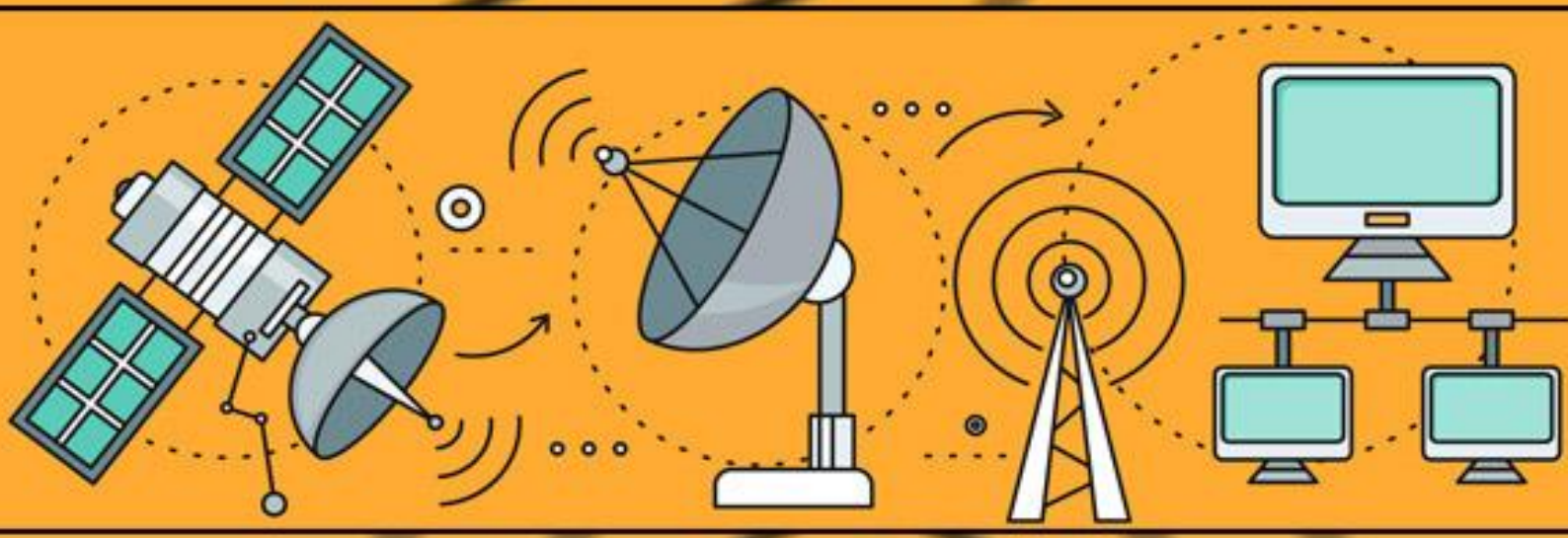
# Principles of Communication



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## About the Tutorial

In this tutorial, the basic concepts of communications along with the important concepts of analog and digital communications have been covered. This tutorial is helpful for a beginner who wants to acquire knowledge on the communication systems.

There are a few topics in this tutorial covering the concepts of digital communications, which are elaborately discussed in our Digital Communication tutorial.

## Audience

This tutorial is prepared for beginners who are interested in the basics of communications and who aspire to acquire knowledge regarding analog and digital communications.

## Prerequisites

To benefit from this tutorial, basic knowledge of the terms involved in Electronics and Communications would be an added advantage.

## Disclaimer & Copyright

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# 1. PoC – Introduction

The word communication arises from the Latin word "commūnicāre", which means "to share". Communication is the basic step for the exchange of information.

For example, a baby in a cradle, communicates with a cry that she needs her mother. A cow moos loudly when it is in danger. A person communicates with the help of a language. Communication is the bridge to share.

**Communication** can be defined as the process of exchange of information through means such as words, actions, signs, etc., between two or more individuals.

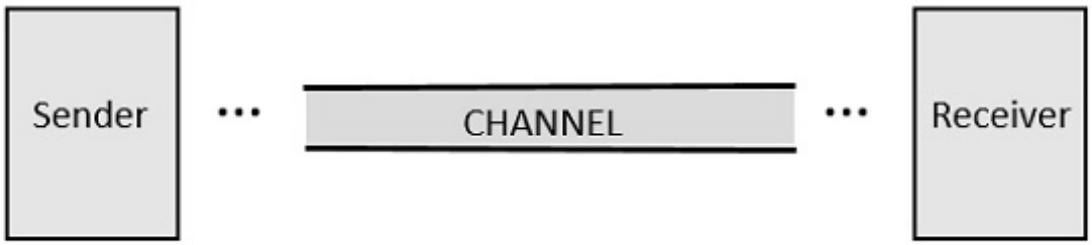
## Need for Communication

For any living being, while co-existing, there occurs the necessity of exchange of some information. Whenever a need for exchange of information arises, some means of communication should exist. While the means of communication, can be anything such as gestures, signs, symbols, or a language, the need for communication is inevitable.

Language and gestures play an important role in human communication, while sounds and actions are important for animal communication. However, when some message has to be conveyed, a communication has to be established.

## Parts of Communication System

Any system which provides communication, consists of the three important and basic parts as shown in the following figure.



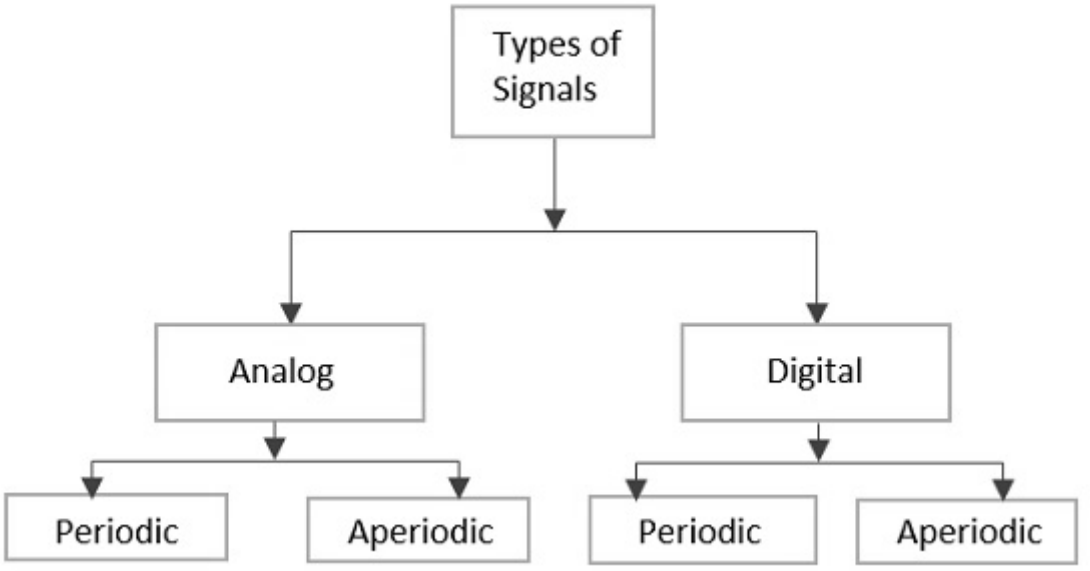

- The **Sender** is the person who sends a message. It could be a transmitting station from where the signal is transmitted.
- The **Channel** is the medium through which the message signals travel to reach the destination.
- The **Receiver** is the person who receives the message. It could be a receiving station where the signal transmitted is received.

## What is a Signal?

Conveying an information by some means such as gestures, sounds, actions, etc., can be termed as **signaling**. Hence, a signal can be a **source of energy which transmits some information**. This signal helps to establish communication between a sender and a receiver.

An electrical impulse or an electromagnetic wave which travels a distance to convey a message, can be termed as a **signal** in communication systems.

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.



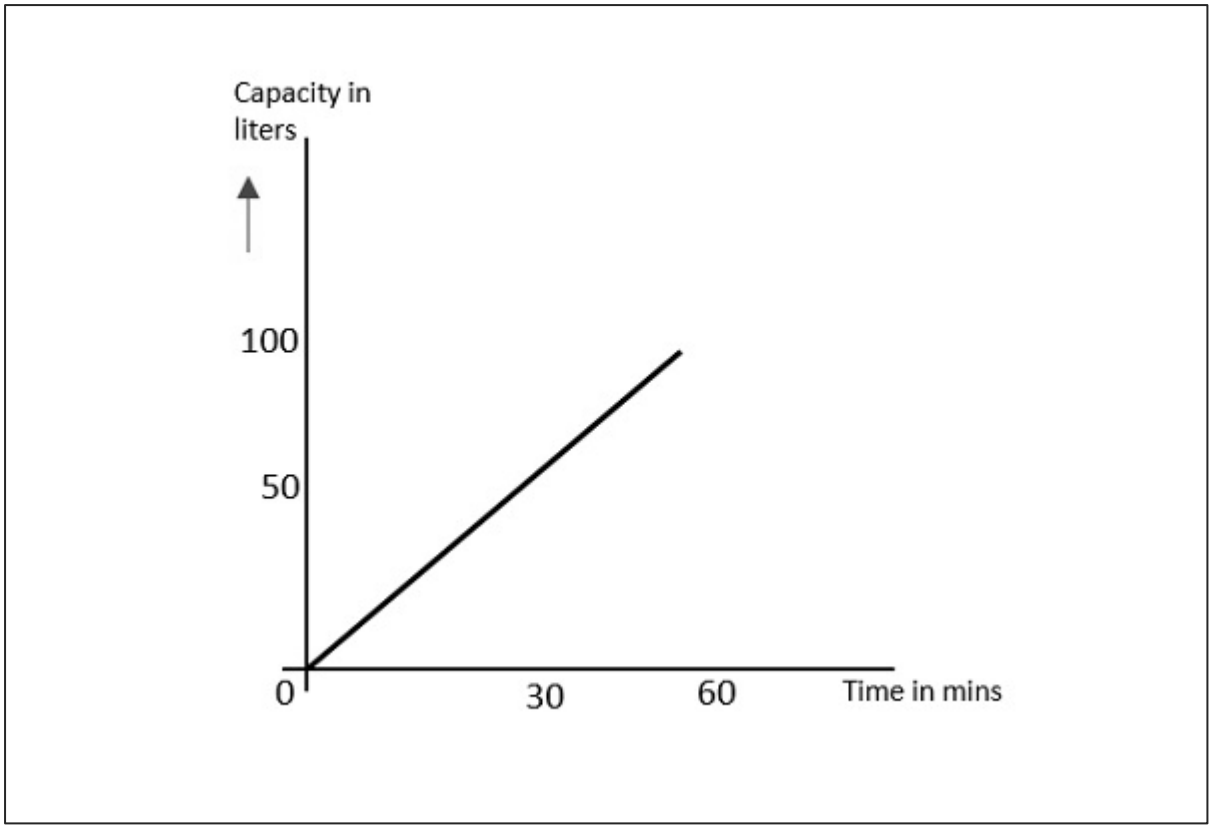

## Analog Signal

A continuous time varying signal, which represents a time varying quantity can be termed as an **Analog Signal**. This signal keeps on varying with respect to time, according to the instantaneous values of the quantity, which represents it.

### Example

Let us consider, a tap that fills a tank of 100 liters capacity in an hour (6 am to 7 am). The portion of filling the tank is varied by the varying time. Which means, after 15 mins (6:15 am) the quarter portion of the tank gets filled, whereas at 6:45 am, $3/4^{th}$ of the tank is filled.

If you try to plot the varying portions of water in the tank, according to the varying time, it would look like the following figure.



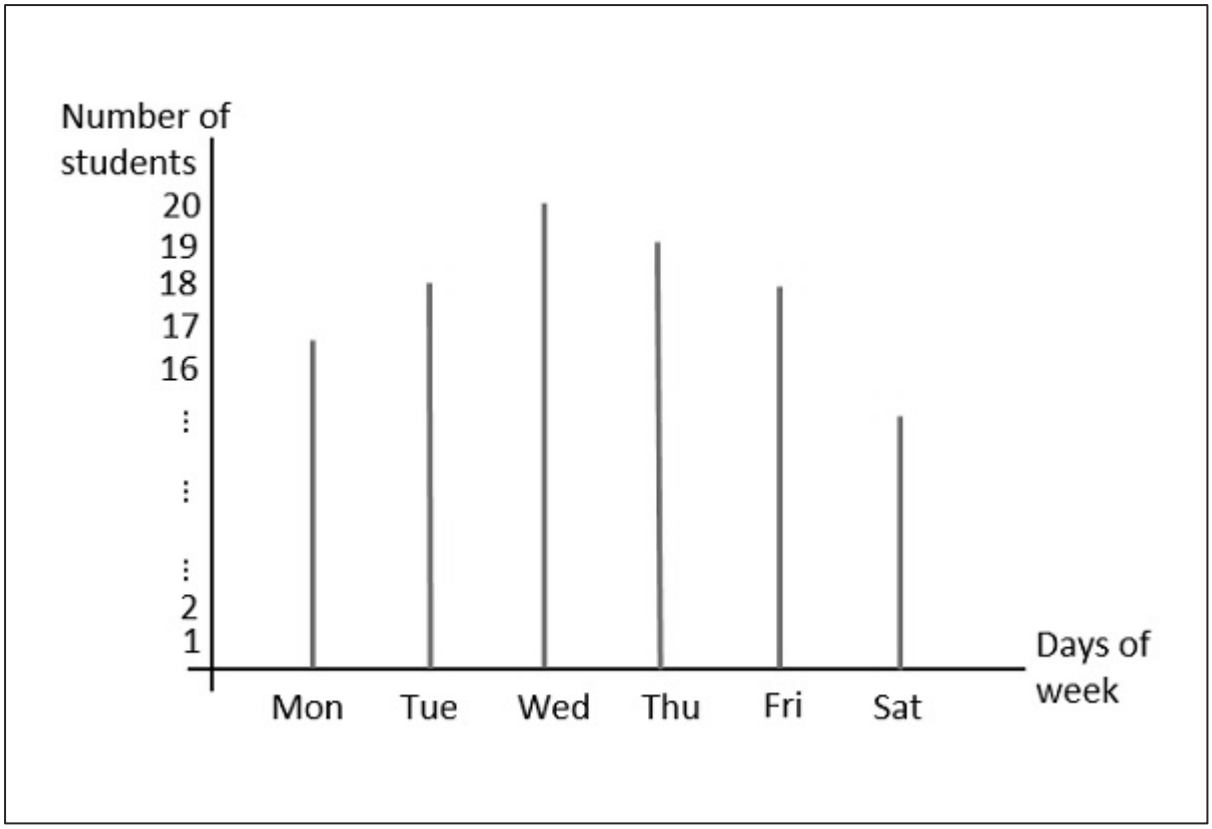

As the resultant shown in this image varies (increases) according to time, this **time varying quantity** can be understood as Analog quantity. The signal which represents this condition with an inclined line in the figure, is an **Analog Signal**. The communication based on analog signals and analog values is called as **Analog Communication**.

## Digital Signal

A signal which is discrete in nature or which is non-continuous in form can be termed as a **Digital signal**. This signal has individual values, denoted separately, which are not based on the previous values, as if they are derived at that particular instant of time.

### Example

Let us consider a classroom having 20 students. If their attendance in a week is plotted, it would look like the following figure.




In this figure, the values are separately stated. For instance, the attendance of the class on Wednesday is 20 whereas on Saturday is 15. These values can be considered individually and separately or discretely, hence they are called as **discrete values**.

The binary digits which has only 1s and 0s are mostly termed as **digital values**. Hence, the signals which represent 1s and 0s are also called as **digital signals**. The communication based on digital signals and digital values is called as **Digital Communication**.

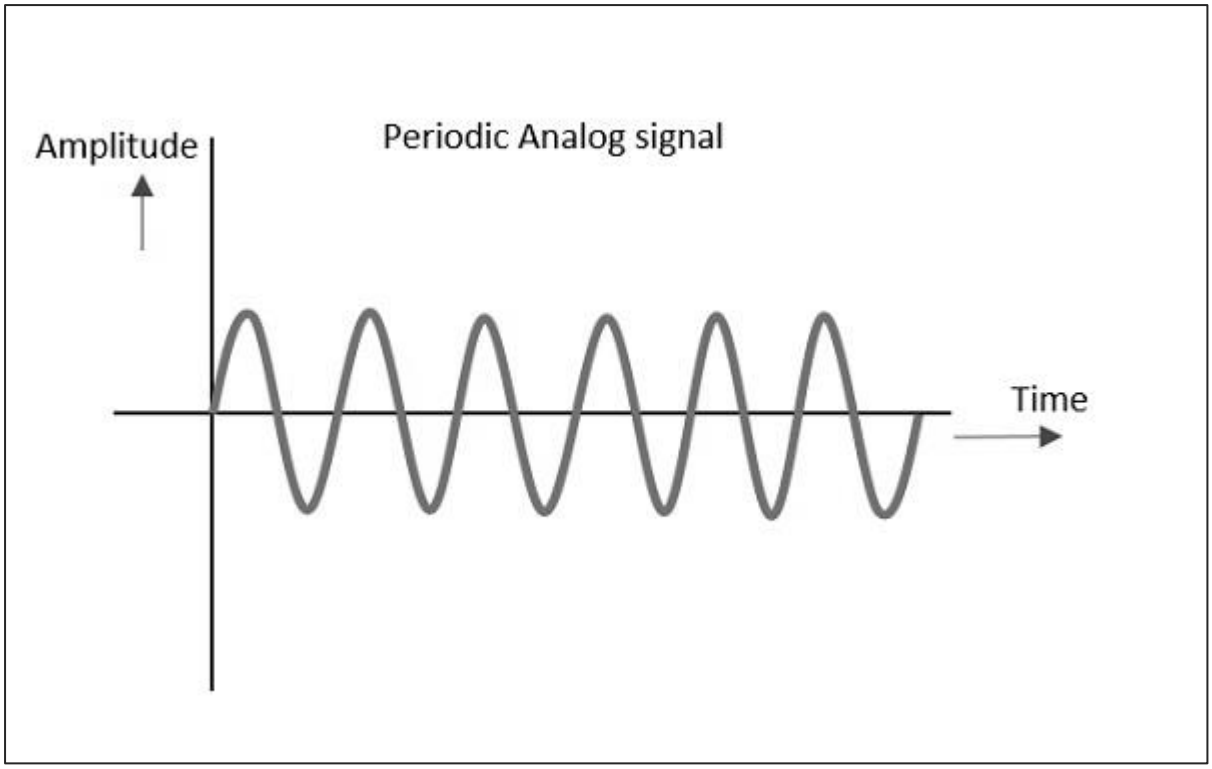
## Periodic Signal

Any analog or digital signal, that repeats its pattern over a period of time, is called as a **Periodic Signal**. This signal has its pattern continued repeatedly and is easy to be assumed or to be calculated.

### Example

If we consider a machinery in an industry, the process that takes place one after the other is a continuous and repeat procedure. For example, procuring and grading the raw material, processing the material in batches, packing a load of products one after the other etc., follow a certain procedure repeatedly.

Such a process whether considered analog or digital, can be graphically represented as follows.



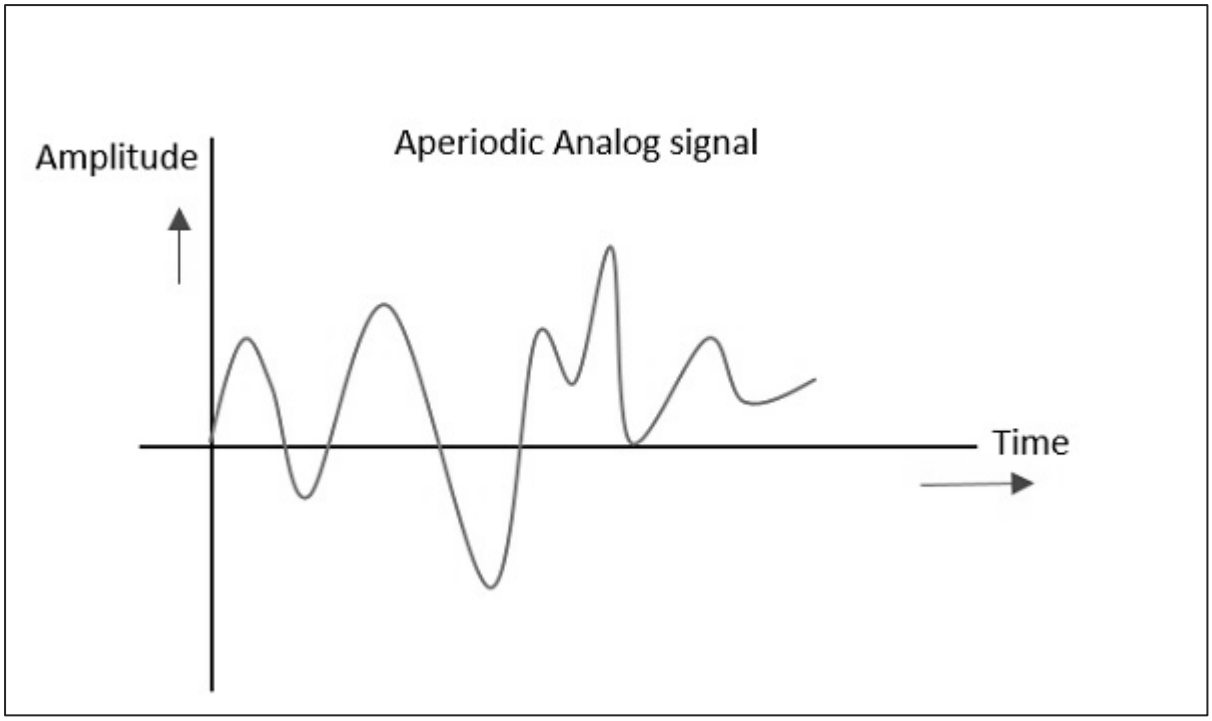

## Aperiodic Signal

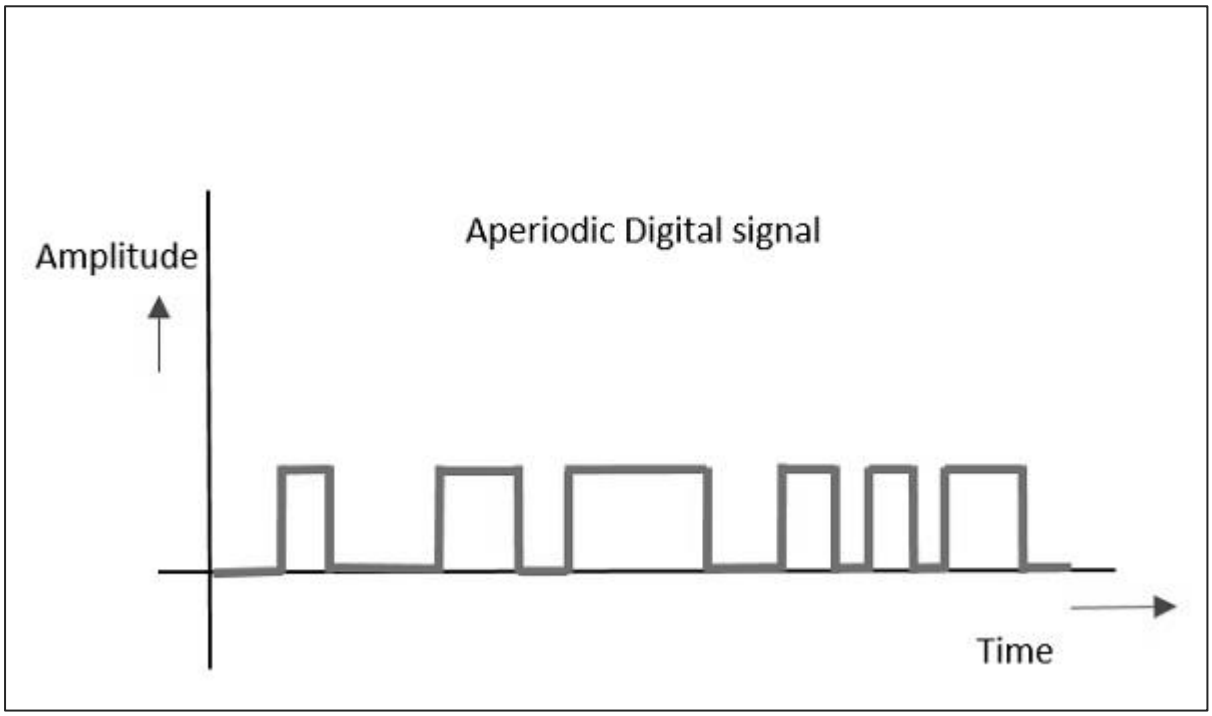
Any analog or digital signal, that doesn't repeat its pattern over a period of time, is called as **Aperiodic Signal**. This signal has its pattern continued but the pattern is not repeated and is not so easy to be assumed or to be calculated.

### Example

The daily routine of a person, if considered, consists of many types of works which take different time intervals for different works. The time interval or the work doesn't continuously repeat. For example, a person will not continuously brush his teeth from morning to night, that too with the same time period.

Such a process whether considered analog or digital, can be graphically represented as follows.




In general, the signals which are used in communication systems are analog in nature, which are transmitted in analog or converted to digital and then transmitted, depending upon the requirement.

But for a signal to get transmitted to a distance, without the effect of any external interferences or noise addition and without getting faded away, it has to undergo a process called as **Modulation**, which is discussed in the next chapter.

# 2. PoC – Modulation

A signal can be anything like a sound wave which comes out when you shout. This shout can be heard only up to a certain distance. But for the same wave to travel over a long distance, you'll need a technique which adds strength to this signal, without disturbing the parameters of the original signal.

## What is Signal Modulation?

A message carrying signal has to get transmitted over a distance and for it to establish a reliable communication, it needs to take the help of a high frequency signal which should not affect the original characteristics of the message signal.

The characteristics of the message signal, if changed, the message contained in it also alters. Hence it is a must to take care of the message signal. A high frequency signal can travel up to a longer distance, without getting affected by external disturbances. We take the help of such high frequency signal which is called as a **carrier signal** to transmit our message signal. Such a process is simply called as Modulation.

**Modulation** is the process of changing the parameters of the carrier signal, in accordance with the instantaneous values of the modulating signal.

### Need for Modulation

The baseband signals are incompatible for direct transmission. For such a signal, to travel longer distances, its strength has to be increased by modulating with a high frequency carrier wave, which doesn't affect the parameters of the modulating signal.

### Advantages of Modulation

The antenna used for transmission, had to be very large, if modulation was not introduced. The range of communication gets limited as the wave cannot travel to a distance without getting distorted.

Following are some of the advantages for implementing modulation in the communication systems.

- Antenna size gets reduced.
- No signal mixing occurs.
- Communication range increases.
- Multiplexing of signals occur.
- Adjustments in the bandwidth is allowed.
- Reception quality improves.

## Signals in the Modulation Process

Following are the three types of signals in the modulation process.

### Message or Modulating Signal

The signal which contains a message to be transmitted, is called as a **message signal**. It is a baseband signal, which has to undergo the process of modulation, to get transmitted. Hence, it is also called as the **modulating signal**.

### Carrier Signal

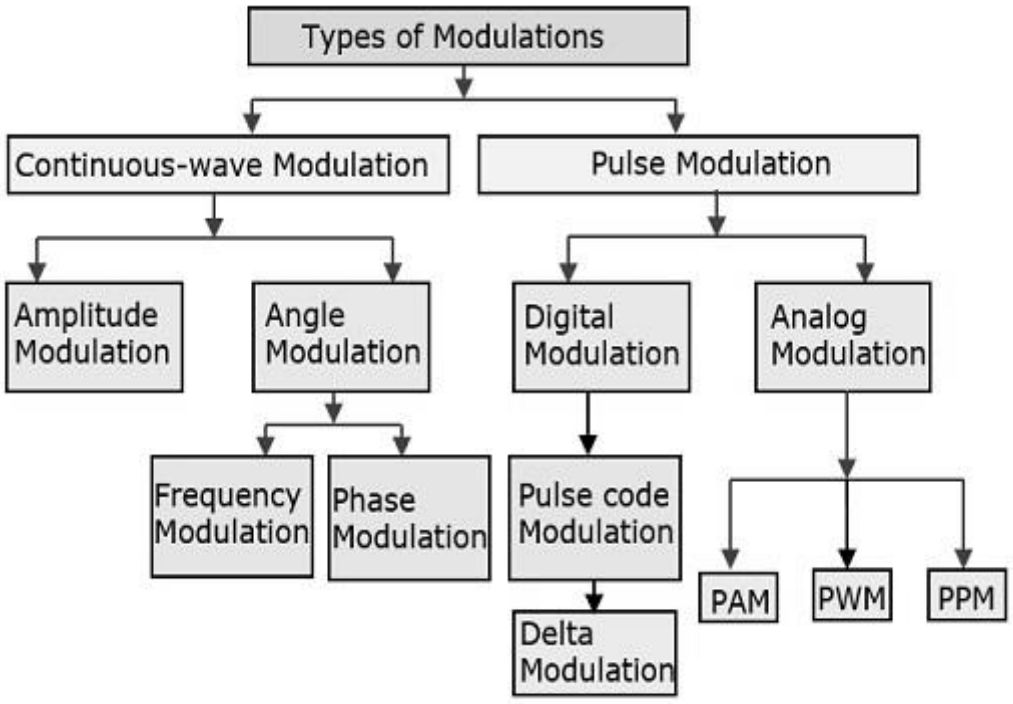
The high frequency signal which has a certain phase, frequency, and amplitude but contains no information, is called a **carrier signal**. It is an empty signal. It is just used to carry the signal to the receiver after modulation.

### Modulated Signal

The resultant signal after the process of modulation, is called as the **modulated signal**. This signal is a combination of the modulating signal and the carrier signal.

## Types of Modulation

There are many types of modulations. Depending upon the modulation techniques used, they are classified as shown in the following figure.




The types of modulations are broadly classified into continuous-wave modulation and pulse modulation.

## Continuous-wave Modulation

In the continuous-wave modulation, a high frequency sine wave is used as a carrier wave. This is further divided into amplitude and angle modulation.

- If the amplitude of the high frequency carrier wave is varied in accordance with the instantaneous amplitude of the modulating signal, then such a technique is called as **Amplitude Modulation**.

- If the angle of the carrier wave is varied, in accordance with the instantaneous value of the modulating signal, then such a technique is called as **Angle Modulation**.

  The angle modulation is further divided into frequency and phase modulation.

  - If the frequency of the carrier wave is varied, in accordance with the instantaneous value of the modulating signal, then such a technique is called as **Frequency Modulation**.

  - If the phase of the high frequency carrier wave is varied in accordance with the instantaneous value of the modulating signal, then such a technique is called as **Phase Modulation**.

## Pulse Modulation

In Pulse modulation, a periodic sequence of rectangular pulses, is used as a carrier wave. This is further divided into analog and digital modulation.

In **analog modulation** technique, if the amplitude, duration or position of a pulse is varied in accordance with the instantaneous values of the baseband modulating signal, then such a technique is called as **Pulse Amplitude Modulation (PAM)** or **Pulse Duration/Width Modulation (PDM/PWM)**, or **Pulse Position Modulation (PPM)**.

In **digital modulation**, the modulation technique used is **Pulse Code Modulation (PCM)** where the analog signal is converted into digital form of 1s and 0s. As the resultant is a coded pulse train, this is called as PCM. This is further developed as **Delta Modulation (DM)**, which will be discussed in subsequent chapters. Hence, PCM is a technique where the analog signals are converted into a digital form.

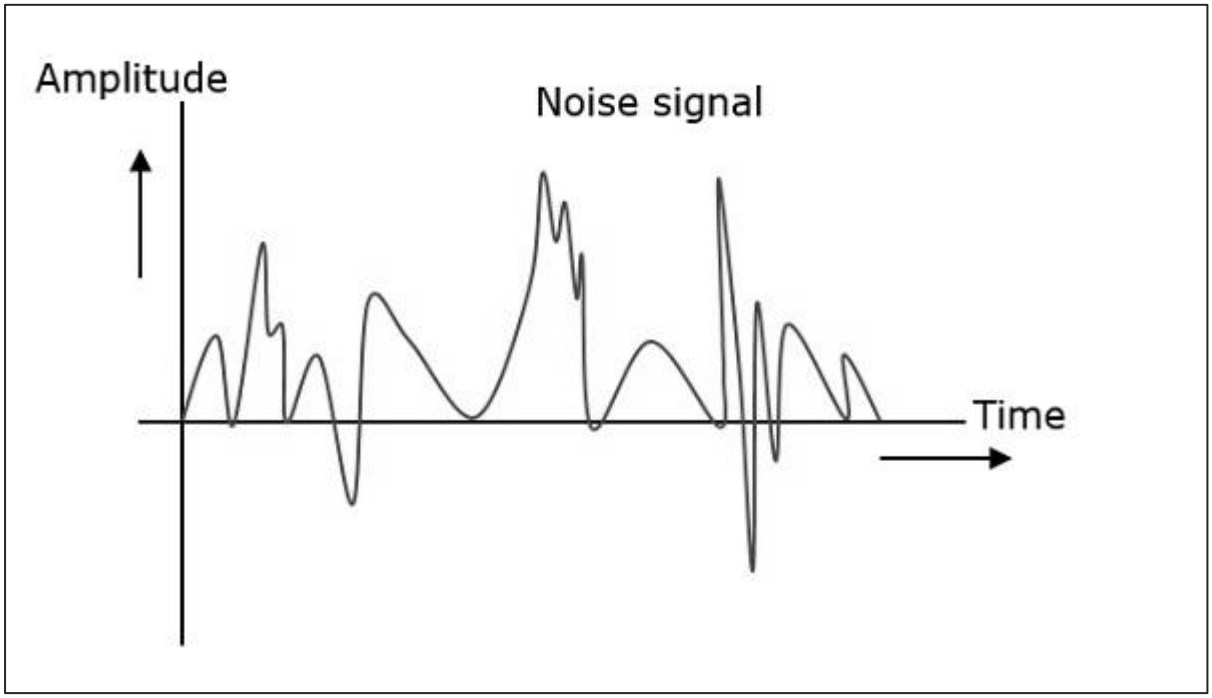
# 3. PoC – Noise

In any communication system, during the transmission of the signal, or while receiving the signal, some unwanted signal gets introduced into the communication, making it unpleasant for the receiver, questioning the quality of the communication. Such a disturbance is called as **Noise**.

## What is Noise?

Noise is an **unwanted signal** which interferes with the original message signal and corrupts the parameters of the message signal. This alteration in the communication process, leads to the message getting altered. It is most likely to be entered at the channel or the receiver.

The noise signal can be understood by taking a look at the following example.




Hence, it is understood that noise is some signal which has no pattern and no constant frequency or amplitude. It is quite random and unpredictable. Measures are usually taken to reduce it, though it can't be completely eliminated.

Most common examples of noise are:

- **Hiss** sound in radio receivers
- **Buzz** sound amidst of telephone conversations
- **Flicker** in television receivers, etc.

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