Department of Electrical Engineering

EE313 - Analog Communication Systems I

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Outlines

- Introduction to Communication systems
- Block diagram of Communication system
- Review of Signal and Systems
- Review of Fourier transform and its properties.
- Fundamental Concepts: Mode of Communication
- SNR, Bandwidth, Rate of Communication, Frequency and Wavelength.
- Baseband and Carrier Communication,
- Modulation, Continuous Wave (CW) Modulation
- Basic Principles of Amplitude Modulation, AM DSB-SC Modulation
- AM Demodulation: synchronous or coherent detection
- AM-Double-sideband large (Full) Carrier (AM-DSBFC)
- AM Frequency Spectrum and Bandwidth and Sideband and Carrier Power
- AM-Single-sideband(AM-SSB- Generation and Demodulation of SSB-SC Signals
- Angle Modulation. Frequency Modulation(FM) and Phase Modulation(PM)
- Frequency Modulation(FM) and demodulation
- Phase Deviation and Modulation Index , FM Bandwidth and Deviation Ratio (DR)
- Noise in Communication System

References:

- Lecture Notes
- Modern Digital and Analog Communication Systems, 4th ed.; B.P. Lathi and Zhi Ding; Oxford University Press; 2009.
- Communication Systems Engineering 2nd Ed by John G. Proakis and Masoud Salehi 2002.
- Digital and Analog Communication Systems, 8th Edition by L.W. Couch II, Prentice Hall, 2013.

"How do you want to send data/information to someone who is far from you?"

"It's for you."

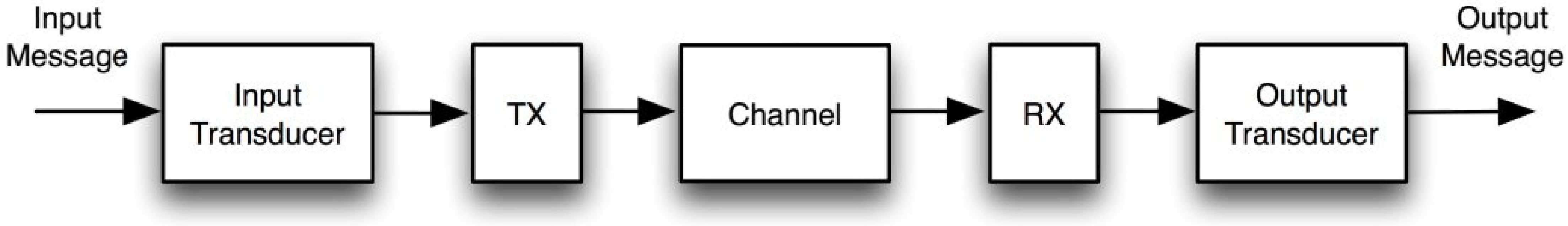
Nowadays, COMMUNICATION OVER LONG DISTANCES IS NO LONGER A PROBLEM.

"Thank you for calling. Please leave a message. In case I forget to check my messages, please send your message as an audio file to my e-mail, then send me a fax to remind me to check my e-mail, then call back to remind me to check my fax."

Communication

To transfer information from one place to another

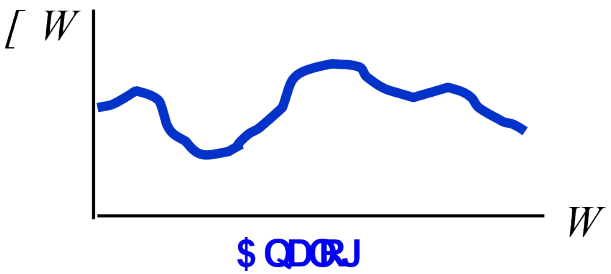
Electrical communication systems are designed to send messages or information from a source that generates the messages to one or more destinations. In general, a communication system can be represented by the functional block diagram shown in Figure 1. The heart of the communication system consists of three basic parts, namely, the **Transmitter TX,** the **Channel**, and the **Receiver RX**.

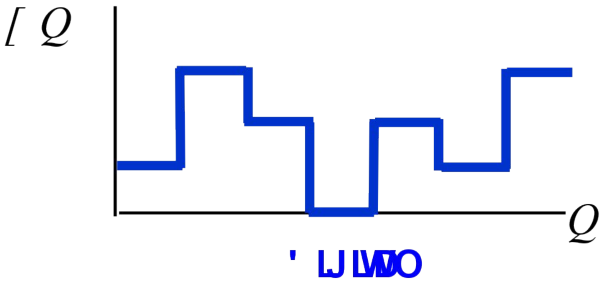


A **transducer** is usually required to convert the input message into an electrical signal that is suitable for transmission. For example, a microphone serves as the transducer that converts an acoustic speech signal into an electrical signal, and a video camera converts an image into an electrical signal. We will refer to the resulting signal as the **baseband / input / message** signal.

The information (input message) generated by the source may be of the form of **voice** (speech source), a **picture** (image source), or **plain text in** some particular language etc...

Input message can be **analogue or digital Waveforms.** An analogue waveform is a function of time that has a continuous range of values. A digital waveform is defined as a function of time that can have only a discrete set of values. If the digital waveform is binary waveform, only two values are allowed.





Analog Information Source:
An analogue information source produces messages which are defined on a continuum. (E.g.: Microphone)

Digital Information Source:
A digital information source produces a finite set of possible messages. (E.g.: Typewriter)

Deterministic and Random Waveforms
A deterministic waveform is completely specified function of time. For example,

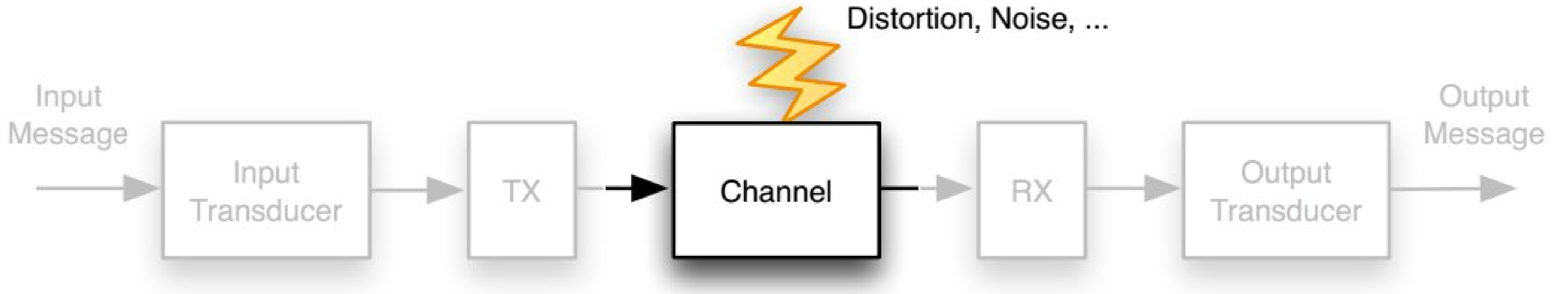
$$\mathbf{x(t) = A\ cos(}\boldsymbol{wt} + \boldsymbol{\phi}\mathbf{)}$$

If A, w, and ϕ are all known constants then the value of $\boldsymbol{x(t)}$ can be determined for every $\boldsymbol{t}$. A random signal cannot be determined completely as a function of time and hence must be modelled probabilistically.

The Transmitter (TX) : converts the electrical signal into a form that is suitable for transmission through the physical channel or transmission medium. It converts the input signal (electronically, mechanically, physically, ...) to a format that best matches the channel characteristics (**fibre optic cable**, **electronic wave guide**, **coaxial cable**, ...);

In general, the transmitter performs the matching of the message signal to the channel by a process called ***modulation*.** Usually, modulation involves the use of the information signal to systematically vary either the amplitude, frequency, or phase of a sinusoidal carrier. The choice of the type of modulation is based on several factors, such as the amount of **bandwidth** allocated, the types of **noise** and **interference** that the signal encounters in transmission over the channel, and the electronic devices that are available for signal amplification prior to transmission

In addition to modulation, other functions that are usually performed at the transmitter **are filtering** of the information-bearing signal, **amplification** of the modulated signal, and in the case of wireless transmission, **radiation** of the signal by means of a transmitting antenna.

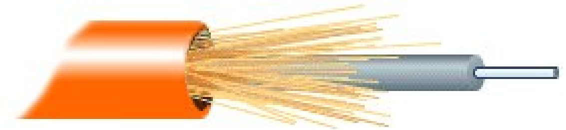


The communications **Channel** is the physical medium that is used to send the signal from the transmitter to the receiver.

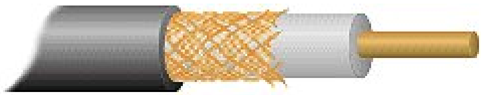
Divided into two basic groups:

- ❑ Guided Electromagnetic Wave Channel – eg. wire, coaxial cable, optical fiber
- ❑ Electromagnetic Wave Propagation Channel – eg. Wireless broadcast channel, mobile radio channel, satellite etc.

Channel introduces **distortion, noise and interference** – in the channel, transmitted signal is attenuated and distorted. Signal attenuation increase along with the length of channel. This results in corrupted transmitted signal received by receiver, Rx

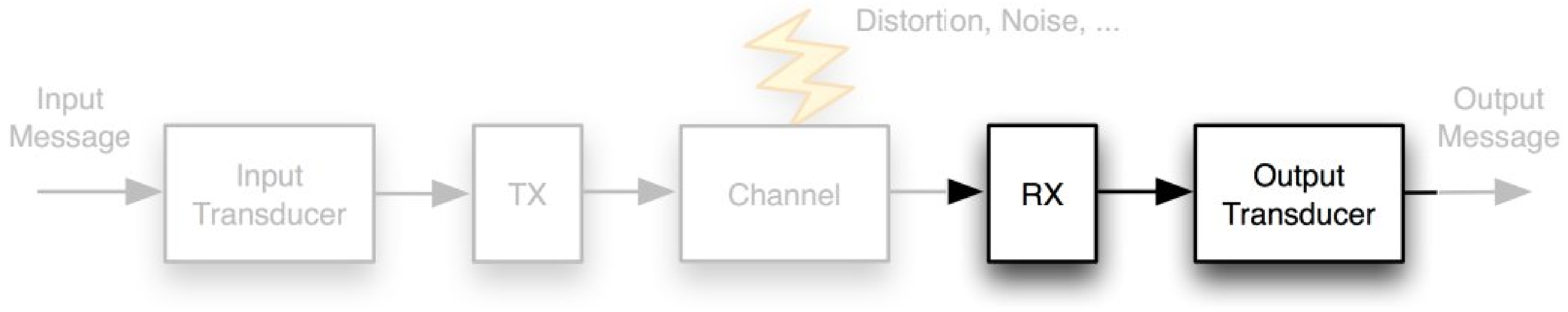


Fiber Optic



Coaxial

Waveguide



The **Receiver (RX)** : The function of the receiver is to recover the message signal contained in the received signal. If the message signal is transmitted by carrier modulation, the receiver performs carrier demodulation in order to extract the message from the sinusoidal carrier. Since the signal demodulation is performed in the presence of additive noise and possibly other signal distortion, the demodulated message signal is generally degraded to some extent by the presence of these distortions in the received signal. As we shall see, the fidelity of the received message signal is a function of the **type of modulation**, the strength of the additive **noise**, the type and strength of **interference** etc.… **Besides** performing the primary function of signal demodulation, the receiver also performs a number of peripheral functions, including signal filtering and noise suppression.

At the destination, a similar **transducer** is required t o convert the electrical signals that are received into a form that is suitable for the user; (output message) e.g., speech signals, images, etc.

Transceivers
A transceiver is an electronic unit that incorporates circuits that both send and receive signals.

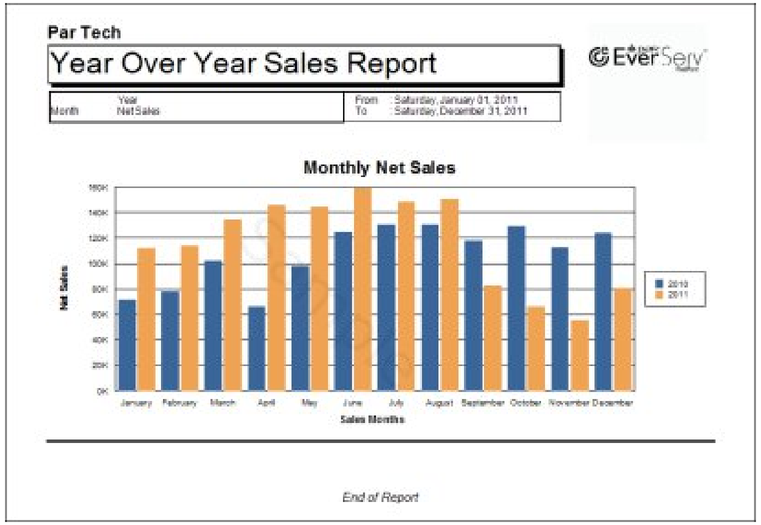
Examples are:

- Telephones 
- Fax machines 
- Cell phones 
- Computer modems 
- Handheld Citizen's Band (CB) radios 

Objective : Transmit the information contained within the input signal to the destination such that the information contained in the output message is either identical (ideally) or closely resembles the information in the input signal. Do this most **efficiently, economically** and **effectively**.

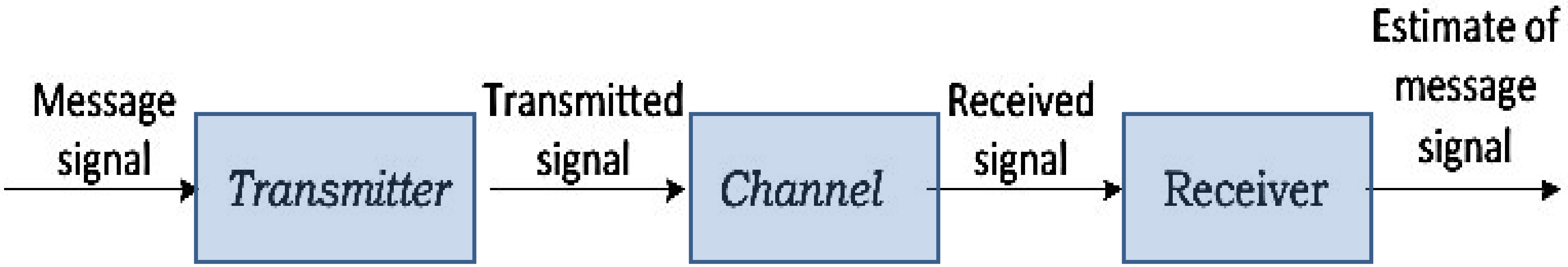
The concept and theory of signals and systems are needed in almost all electrical engineering fields and in many other engineering and scientific disciplines as well. In this course, the mathematical description and representation of signals and systems and their classifications are introduced and defined.

A signal is a set of data or information and can be defined as a function of one or more variables that conveys information on the nature of a physical phenomenon. Examples include a **telephon**e or a **television signal,** monthly sales of a corporation. Signals can either be one dimension e.g. speech or multidimensional e.g. image. For instance, in a RC circuit the signal may represent the voltage across the capacitor or the current flowing in the resistor. Mathematically, a signal is represented as a function of an independent variable ***t***. Usually ***t*** represents time. Thus, a signal is denoted by ***x(t).***



A system is defined as an entity that manipulates one or more signals to accomplish a function, thereby yielding new signals. It is a physical device that performs an operation on a signal and it is characterized by the type of operation that performs on the signal. Such operations are referred to as signal processing.

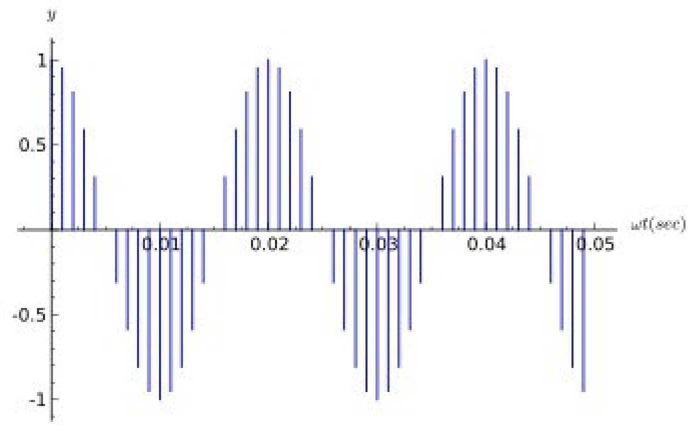
For example, in communication system, the input signal could be a speech signal or computer data, the system is made up of a transmitter, channel, and receiver, and the output is an estimate of the information contained in the original message as illustrate below.

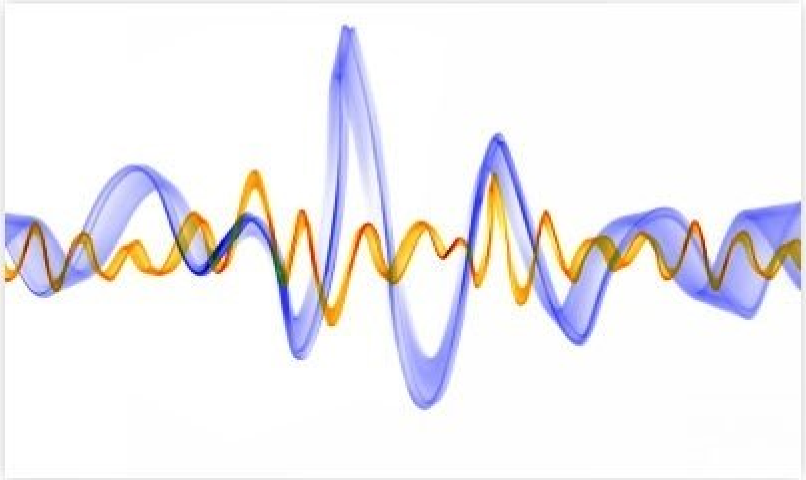


Communication System

Signals are classified according to their characteristics

1. Continuous time and discrete time signals
2. Analog and Digital Signals:
3. Real and Complex Signals:
4. Deterministic and random signals
5. Even and odd signals
6. Periodic and non periodic signals
7. Energy and power signals





Continuous-Time and Discrete-Time Signals:

A signal ***x(t)*** is a continuous-time signal if ***t*** is a continuous variable. By the term continuous signal we mean a real or complex function of time ***x(t),*** where the independent variable ***t*** is continuous. Several particularly important continuous signals are introduced later. These signals serve as basic building blocks from which other signals can be constructed. Therefore, the use of these signals allows us to examine the properties of systems.

If ***t*** is a discrete variable, that is, ***x(t)*** is defined at discrete times, then ***x(t)*** is a discrete-time signal. Since a discrete-time signal is defined at discrete times, a discrete-time signal is often identified as a sequence of numbers, denoted by {***x***,) or ***x[n],*** where ***n*** = integer. Illustrations of a continuous-time signal ***x(t)*** and of a discrete-time signal ***x[n]*** are shown in Fig. 1-1.

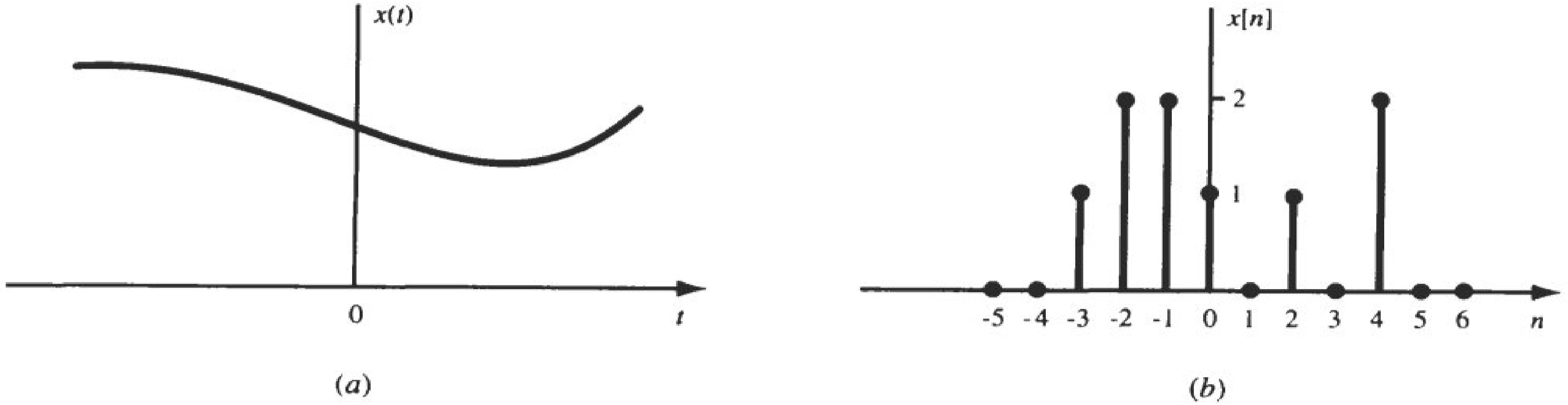


Fig. 1-1 Graphical representation of (a) continuous-time and (b)discrete-time signals.

Continuous-Time and Discrete-Time Signals:

A discrete-time signal ***x[n]*** may represent a phenomenon for which the independent variable is inherently discrete. For example, the weekly peak value of a particular economic indicator. On the other hand a discrete-time signal ***x[n]*** may be obtained by sampling a continuous-time signal ***x(t)*** such as

$$x(t_o),\ x(t_1),\ x(t_2),\ \ldots\ldots\ x(t_n),\ = x[0],\ x[1],\ x[2], \ldots.\ x[n] = x_0,\ x_1,\ x_2,\ \ldots\ldots\ x_n$$

$$\therefore\quad x_n = x[n] = x(t_n)$$

and x_n's are called samples and the time interval between them is called the sampling interval T_s. When the sampling intervals are equal (uniform sampling), then (See Fig. 1- 2)

$$x_n = x[n] = x(nT_s)$$

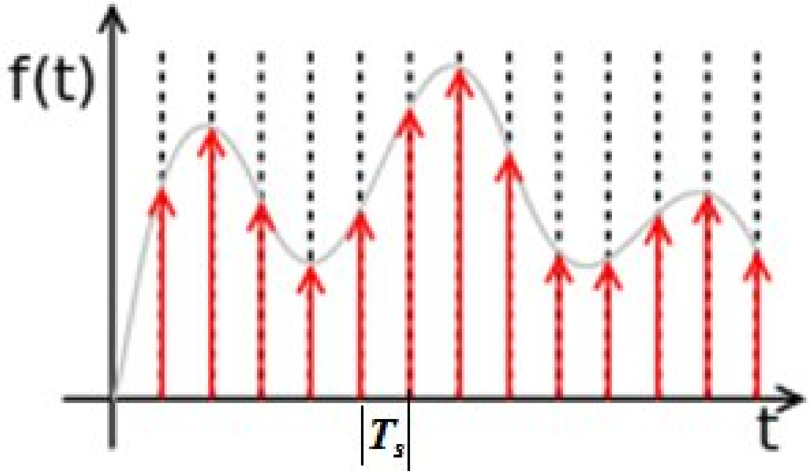


Fig. 1-2 Discrete sampled signal