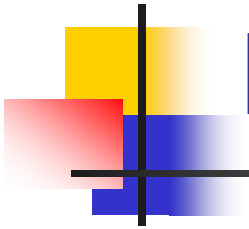
Digital and Analog Communication (EE-217-F)



BOOK

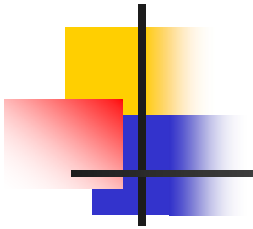
- **Text Book:**
  - Data Communications, Computer Networks and Open Systems Halsall Fred, (4thediton) 2000, Addison Wesley, Low Price edition
- **Reference Books:**
  - Business Data Communications, Fitzgerald Jerry, 7thEd. New York, 2001, JW&S,
  - Communication Systems, 4thEdi, by A. Bruce Carlson, Paul B. Crilly, Janet C. Rutledge, 2002, TMH.
  - Data Communications, Computer Networks and Open Systems, Halsall Fred, 1996, AW.

SectionA: Communication system components:

- Introduction to Communication: Definition & means of communications;
- Digital and analog signals: sign waves ,square waves;
- Properties of signals: amplitude, frequency ,phase;
- Theoretical basis for data communication: Fourier analysis: Fourier series and Fourier Transform (property, ESD, PSD and Raleigh) effect of limited band width on digital signal.

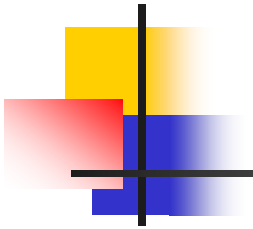
Introduction to Digital & Analog Communication

INTRODUCTION TO COMMUNICATION SYSTEM



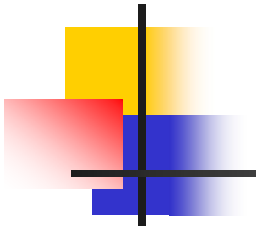
- Topics covered:
  - Communication model
  - Signal classification
  - Digital and Analog signals

What is Communication ?

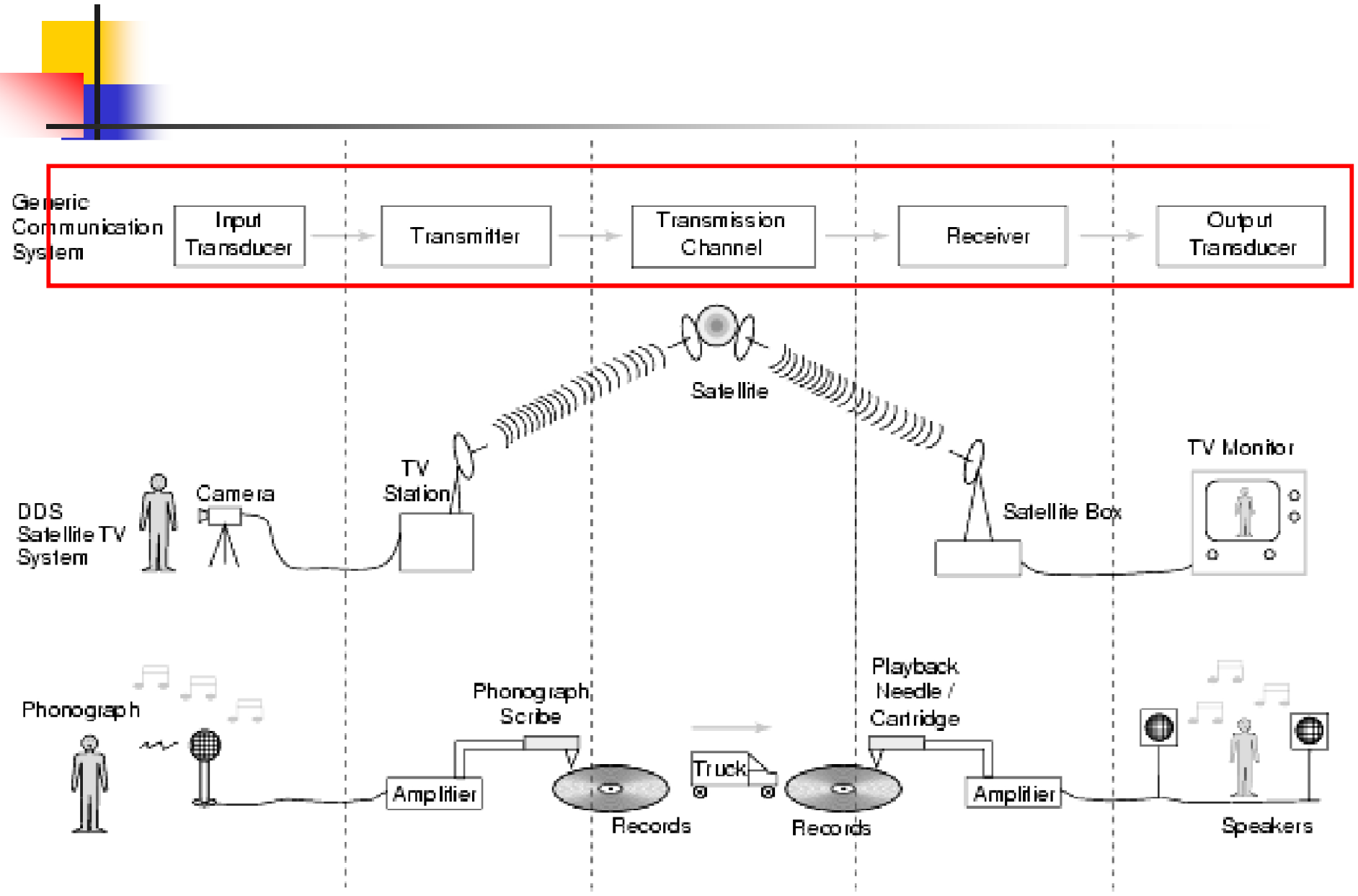


- Communication is the transfer of data or information between a source and a receiver.
- The source transmits the data and the receiver receives it.
- Communication deals with the transfer of data, the method of transfer and the preservation of the data during the transfer process.

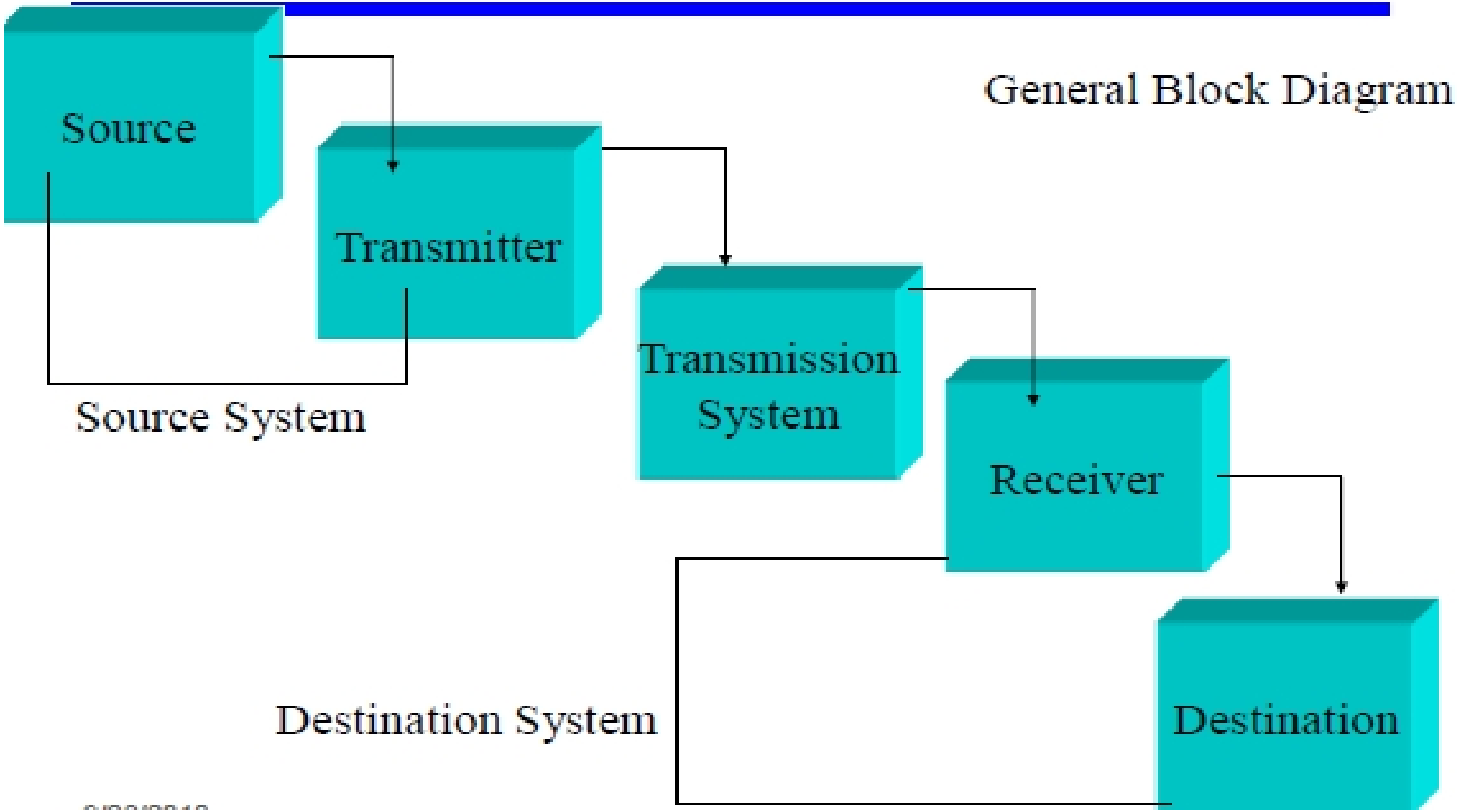
What is Communication ?

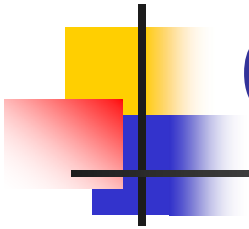


- Communication is a process by which information is exchanged between individuals through a common system of symbols, signs
- Communication systems are reliable, economical and efficient means of communications.
  - Public switched telephone network (PSTN), mobile telephone communication (GSM, 3G, ...), broadcast radio or television, navigation systems, ...


Generic Communication System
Input Transducer
Transmitter
Transmission Channel
Receiver
Output Transducer
Satellite
TV Station
DDS Satellite TV System
Camera
Satellite Box
TV Monitor
Phonograph
Phonograph Scribe
Amplifier
Records
Truck
Records
Playback Needle / Cartridge
Amplifier
Speakers

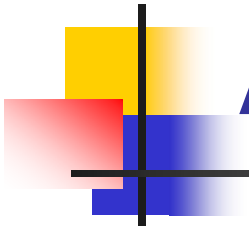
Simplified Communications Model - Diagram





Communication model

- Source
  - generates data to be transmitted
- Transmitter
  - Converts data into transmittable
- Transmission System
  - Carries data
- Receiver
  - Converts received signal
- Destination
  - Takes incoming data



A Communications Model

- Source:
  - This device originates message to be transmitted such as voice, picture and data.
  - The source is what or who is trying to send a message to the receiver

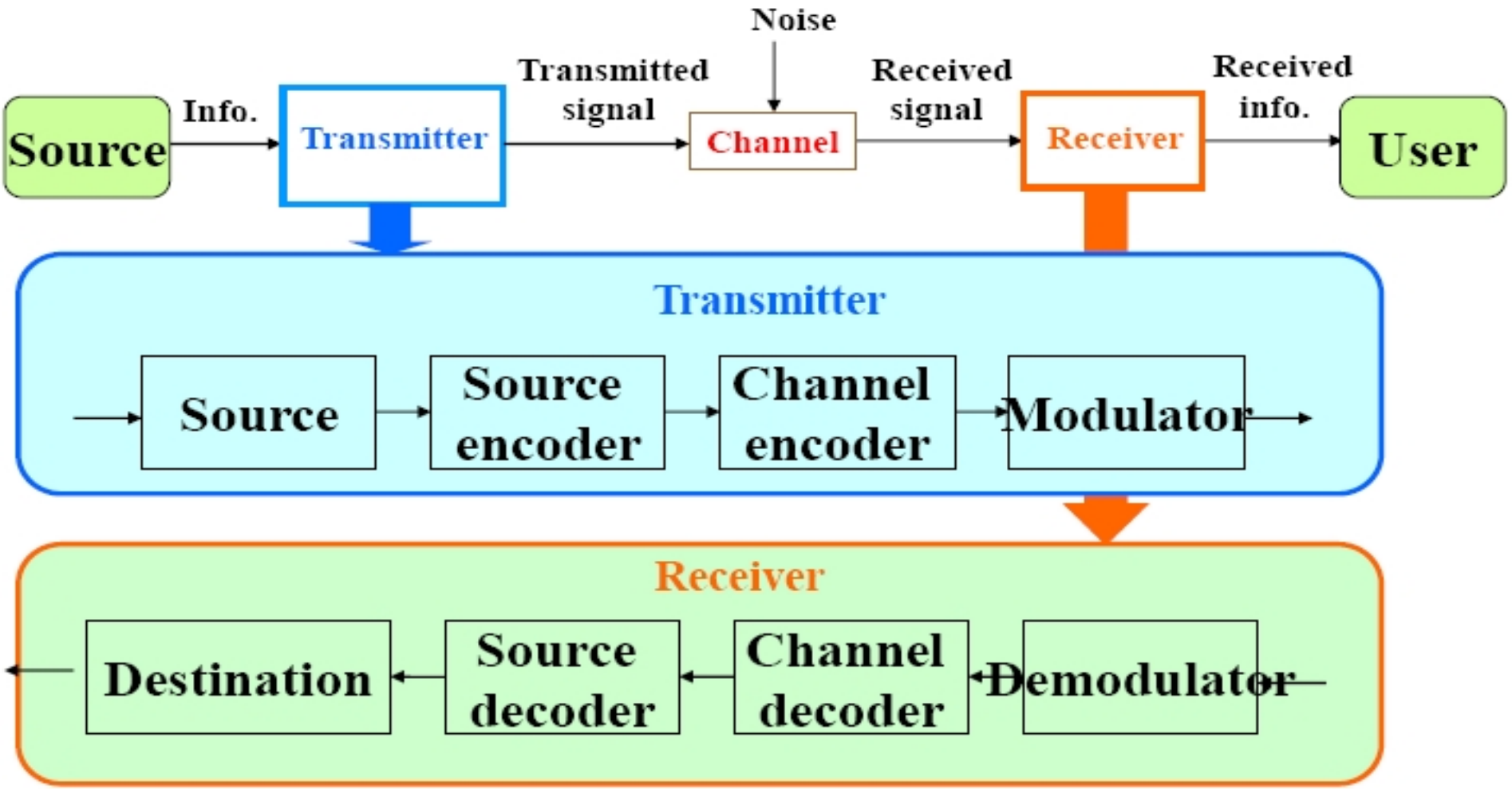
A Communications Model

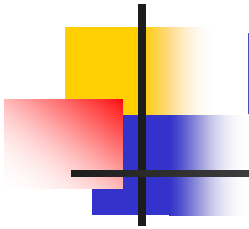
- Transmitter- Transmitter transforms and encodes the information in the form which can be transmitted.
- In the general case, it is not possible to directly insert the message on to the communications medium.
  - For instance, when you speak on the telephone, it is not possible to actually transmit sound (vibrations in matter) across the wire for any distance. In your phone is a microphone, which converts the sound in to electrical impulses, which *can be transmitted by wires*

A Communications Model

- Transmission System
  - This can be a single transmission line or a complex network
  - Connecting source and destination.
  - It may be a simple conducting wire, coaxial cable, optical fiber, air etc.
- Receiver
  - The receiver accepts the signals from the transmission system and converts in the form that can be handles by the destination device.
- Destination
  - Take the incoming data from the receiver.

General structure of a communication systems/Digital communication model





Digital communication system

- Important features of a DCS:
  - Transmitter sends a waveform from a finite set of possible waveforms during a limited time
  - Channel distorts, attenuates the transmitted signal and adds noise to it.
  - Receiver decides which waveform was transmitted from the noisy received signal
  - Probability of erroneous decision is an important measure for the system performance

Distortion and Noise

- When we transmit a signal, there is always a possibility of addition of noise into message.
- Noise may introduced at the transmitter or at the receiver or in channel. But on channel possibility is more.
- Signal is not only distorted by channel but it may be distorted by external signal called noise.

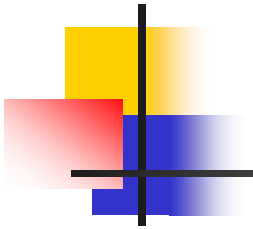
Definition

- **A Signal: is a function that specifies how a specific variable changes versus an independent variable such as time. Usually represented as an X-Y plot.**
- •Means by which data are propagated

Classification of Signals

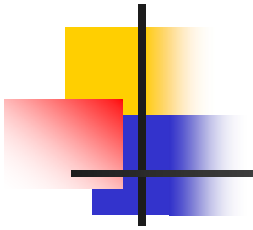
- Deterministic and Random Signal
- Periodic and Non Periodic Signal
- Analog and Digital Signal
- Energy and Power Signal

Deterministic and random signals



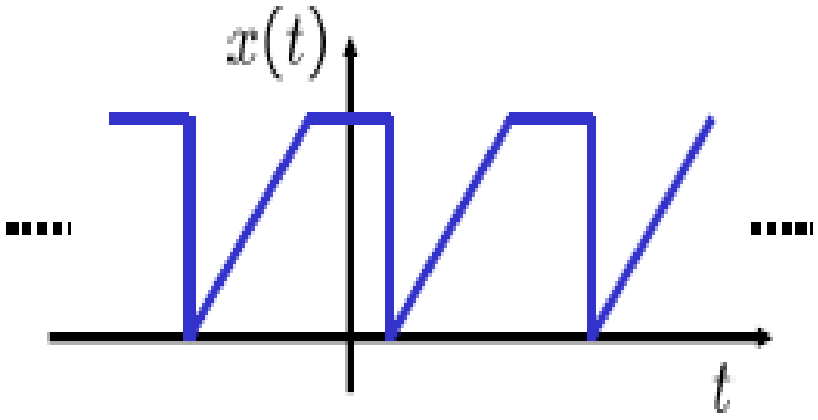
- **Deterministic signal: No uncertainty with respect to the signal value at any time.**
- **Random signal: Some degree of uncertainty in signal values before it actually occurs.**
  - Thermal noise in electronic circuits due to the random movement of electrons
  - Reflection of radio waves from different layers of ionosphere

Periodic vs. aperiodic signals:

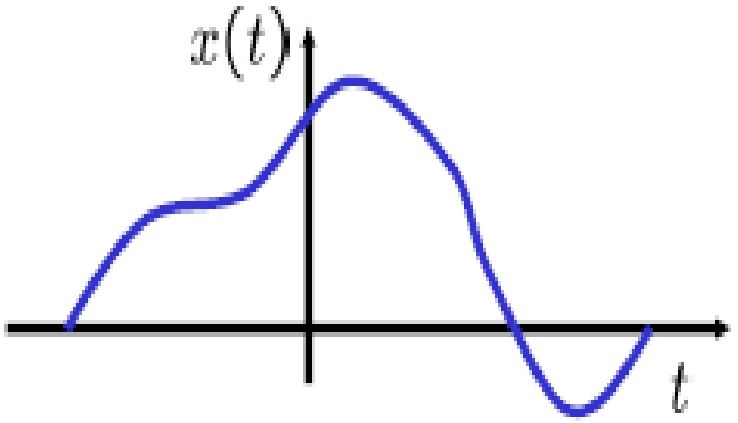


- Periodic signals are signals constructed from a shape that repeats itself regularly after a specific amount of time T0, that is:
  - f(t) = f(t+nT0) for all integer n.
- **Aperiodic signals do not repeat regularly.**

Periodic and non-periodic signals

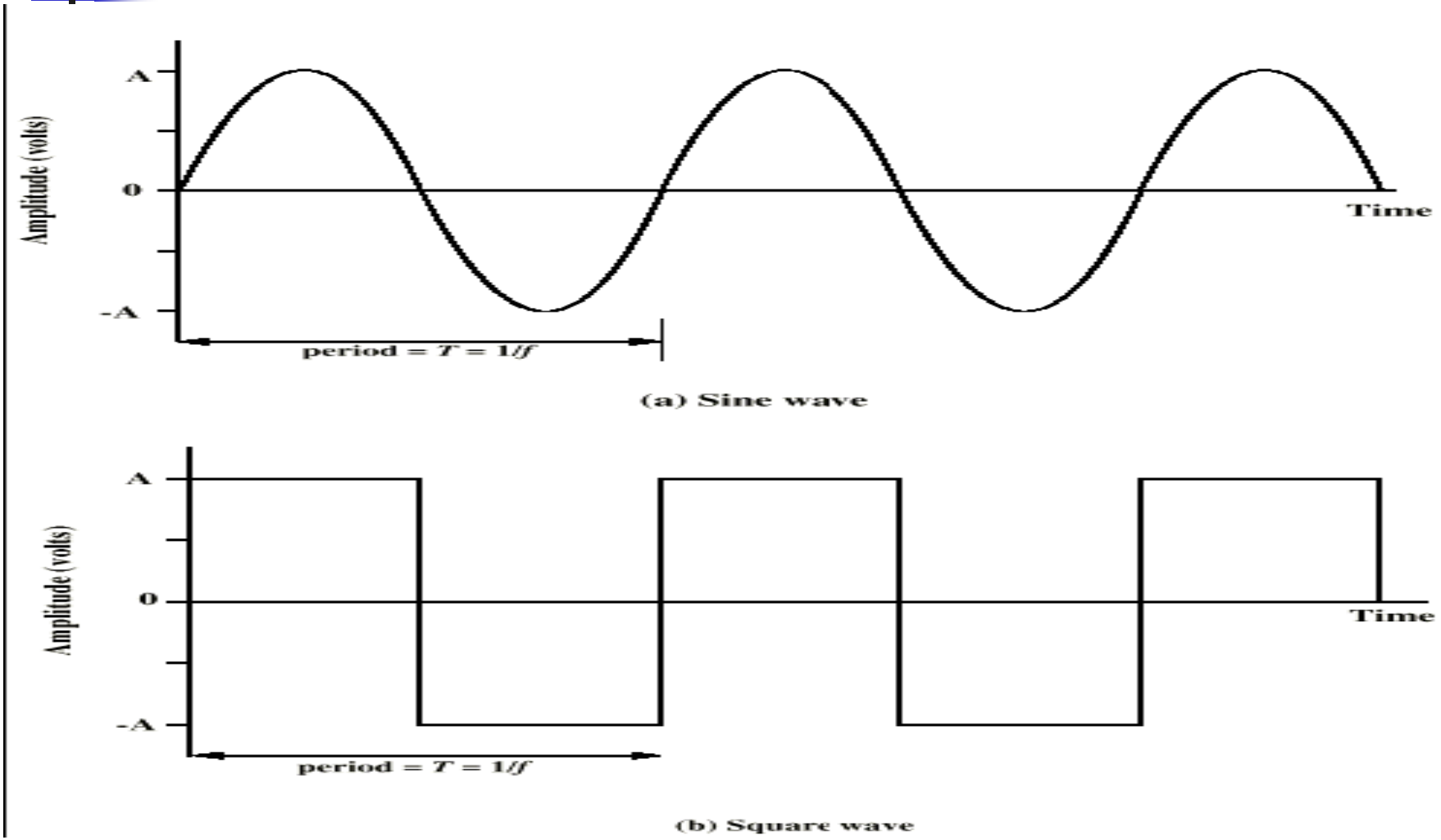


A periodic signal



A non-periodic signal

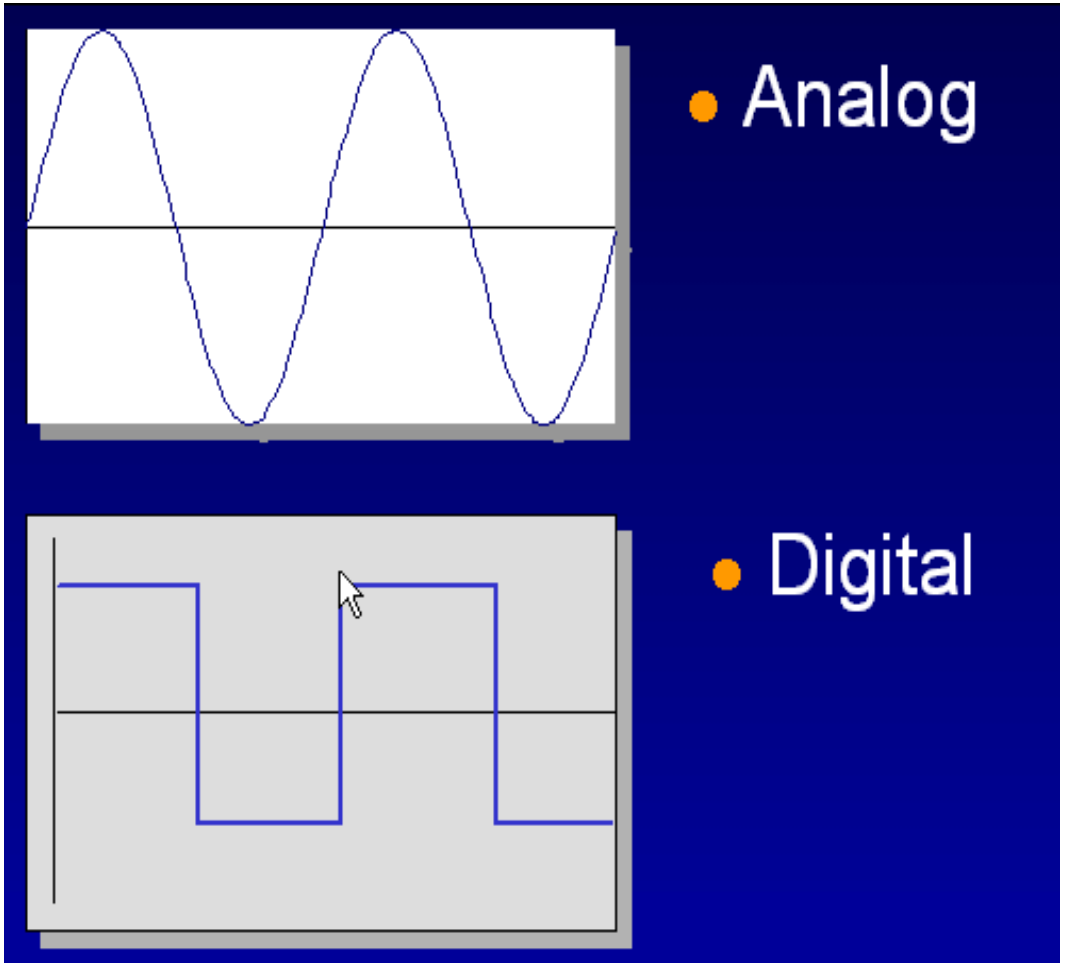
Periodic Signals



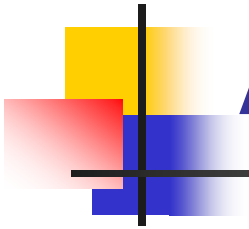
Analog and digital signal

- Analog
  - Continuously variable
  - Various media
  - wire, fiber optic, space
  - Speech bandwidth 100Hz to 7kHz
  - Telephone bandwidth 300Hz to 3400Hz
  - Video bandwidth 4MHz
- Digital
  - Use two Discrete components

- Continuous/Analog signals take on all possible values of amplitude
- Digital or Discrete Signals take on finite set of voltage levels



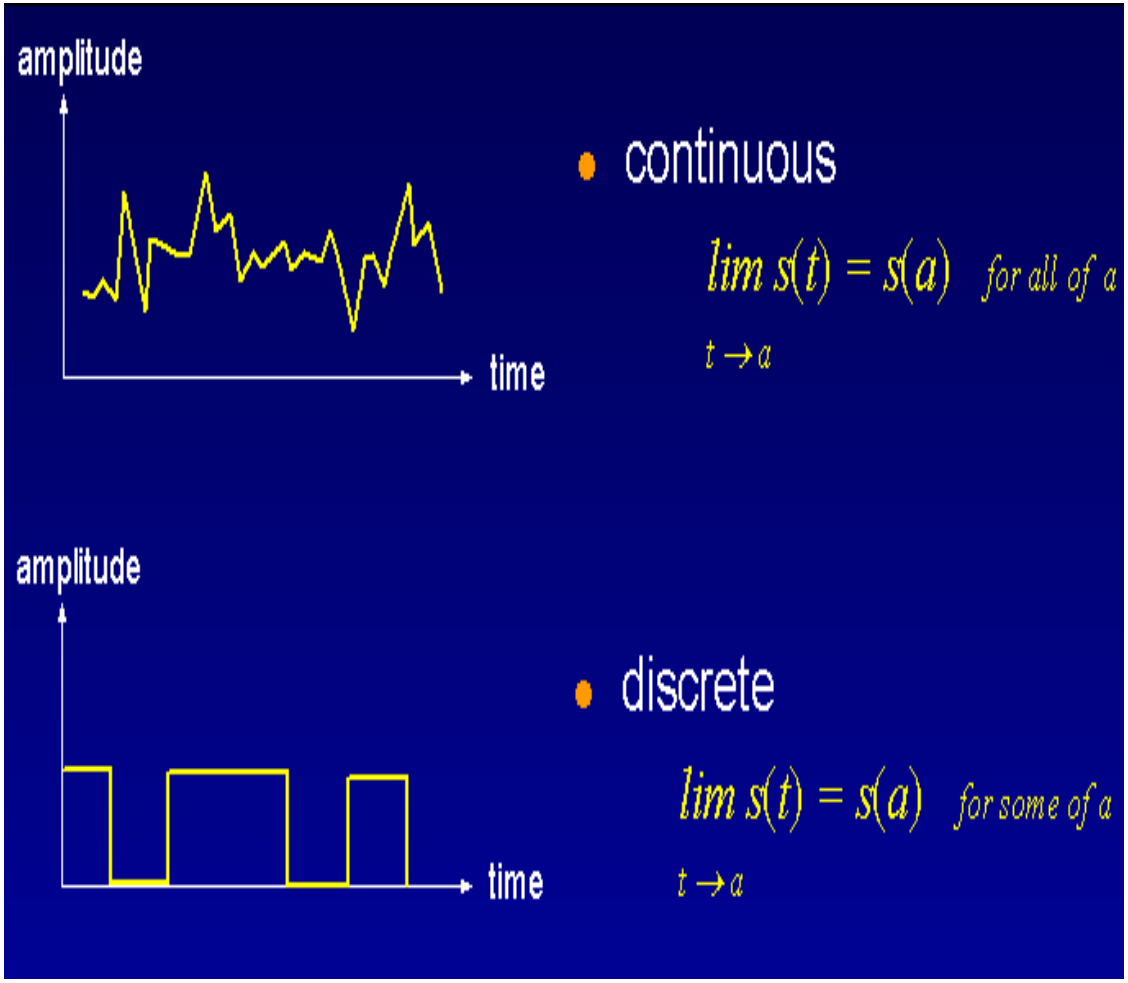
Which Signal/Data is Better Analog or Digital?



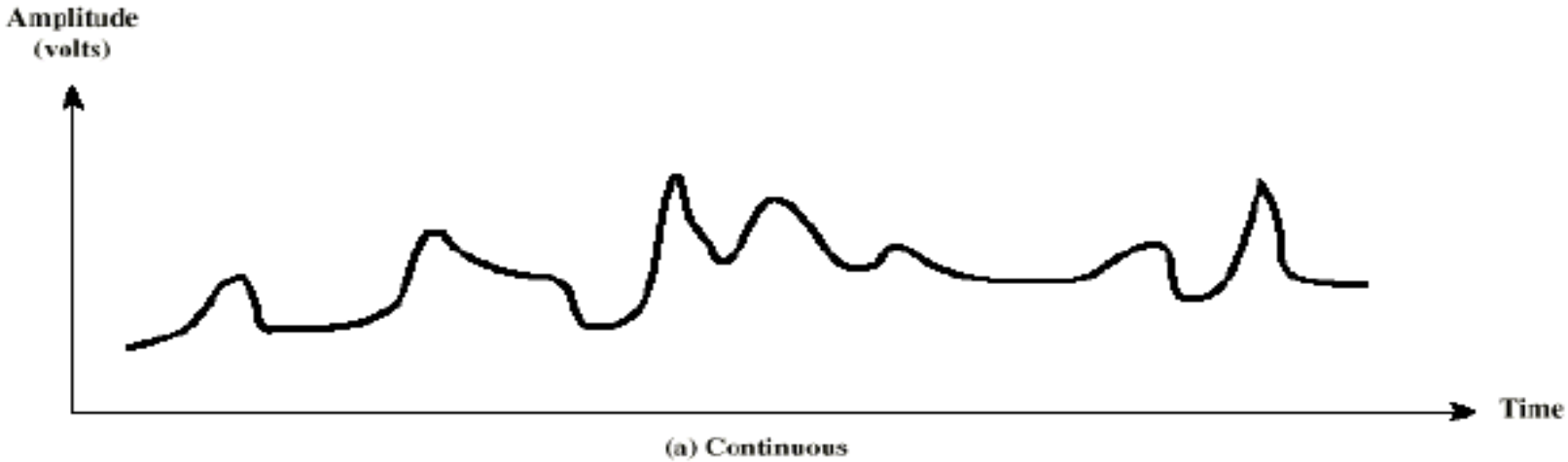
- Digital is better
- Even Analog data can be converted into digital data and transmitted as digital data
- Digital data provide the following advantages:
  - Digital technology
  - Data integrity through EDC and ECC
  - Capacity utilization through TDM
  - Security and privacy through encryption
  - Integration of all forms of information

Continuous-time vs. discrete-time:

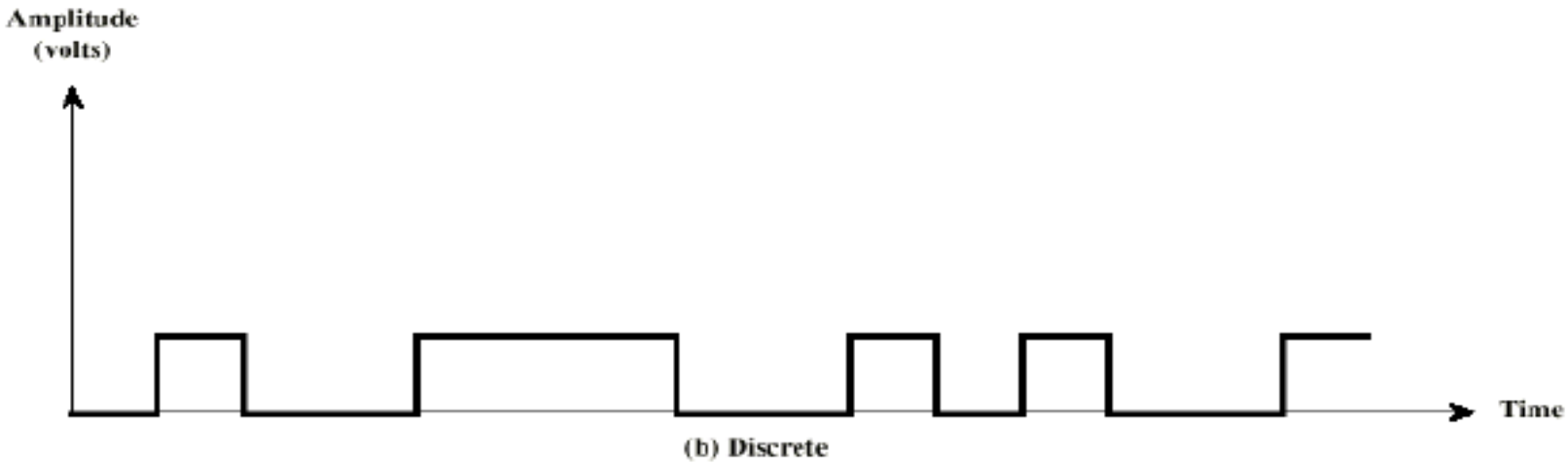
- Continuous or Analog signals take on all possible values of amplitude
- Digital or Discrete Signals take on finite set of voltage levels



Continuous-time vs. discrete-time:

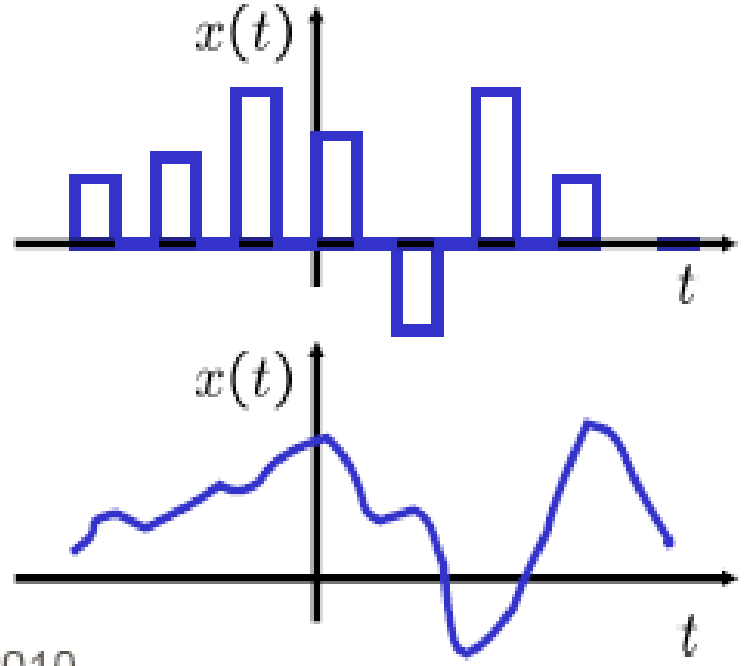


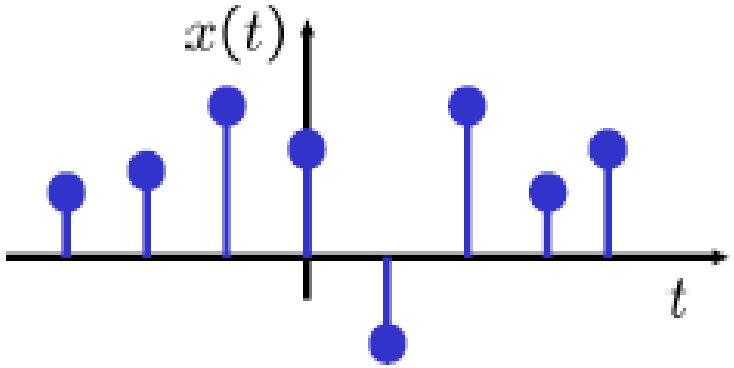
(a) Continuous



(b) Discrete

Continuous and discrete signals



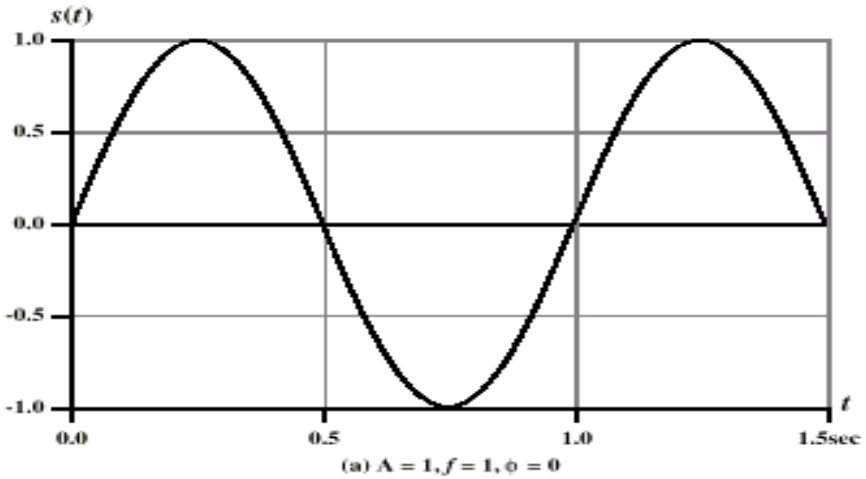


A discrete signal

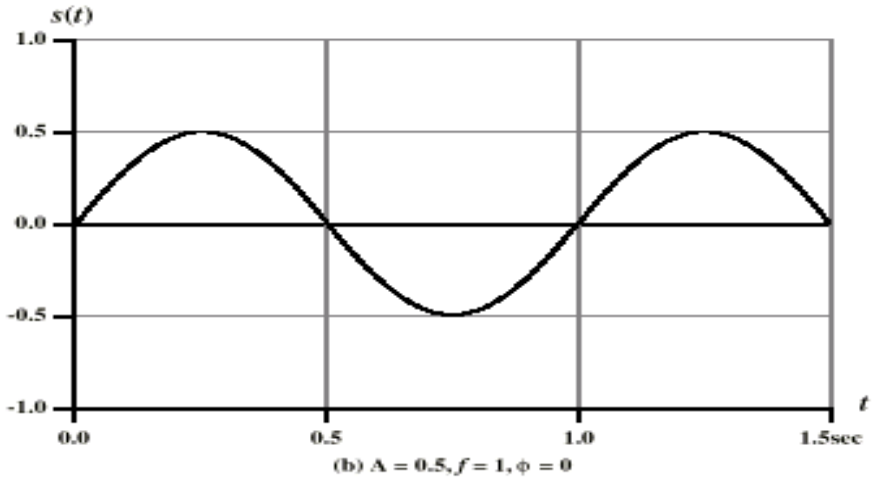
Sine wave

- The **sine wave** or **sinusoid** is a mathematical function that describes a smooth repetitive oscillation

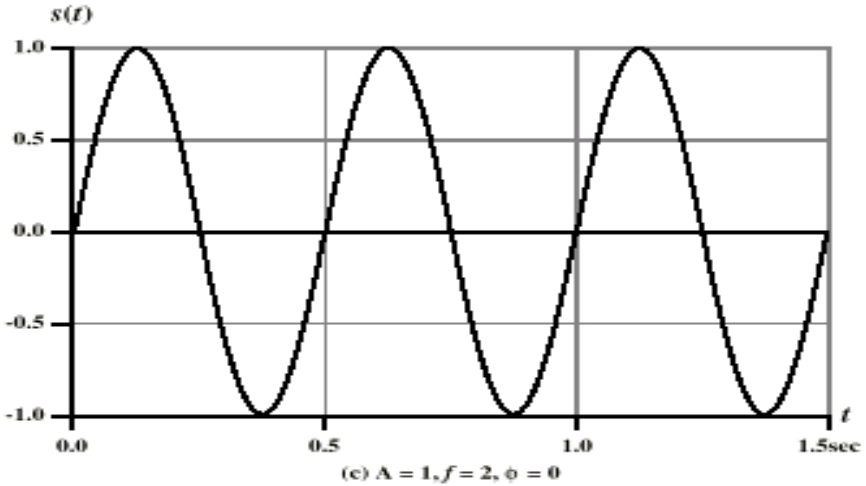
Varying Sine Wave



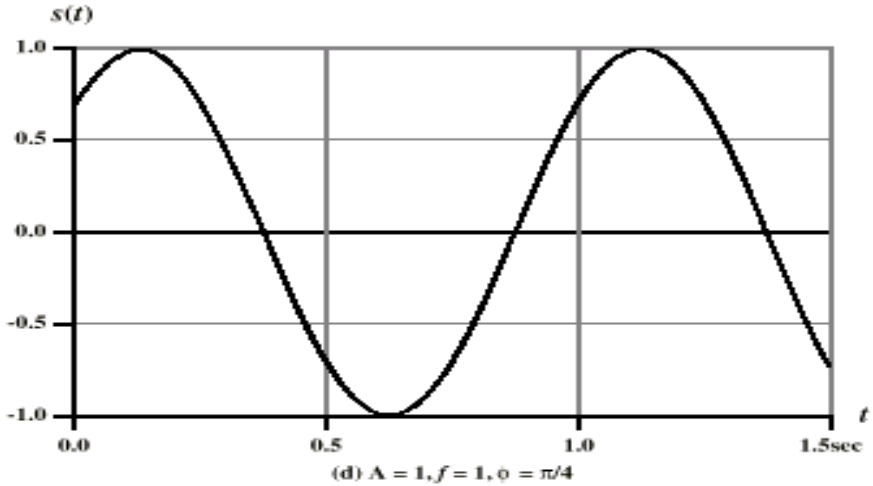
(a) A = 1, f = 1, ϕ = 0



(b) A = 0.5, f = 1, ϕ = 0



(c) A = 1, f = 2, ϕ = 0

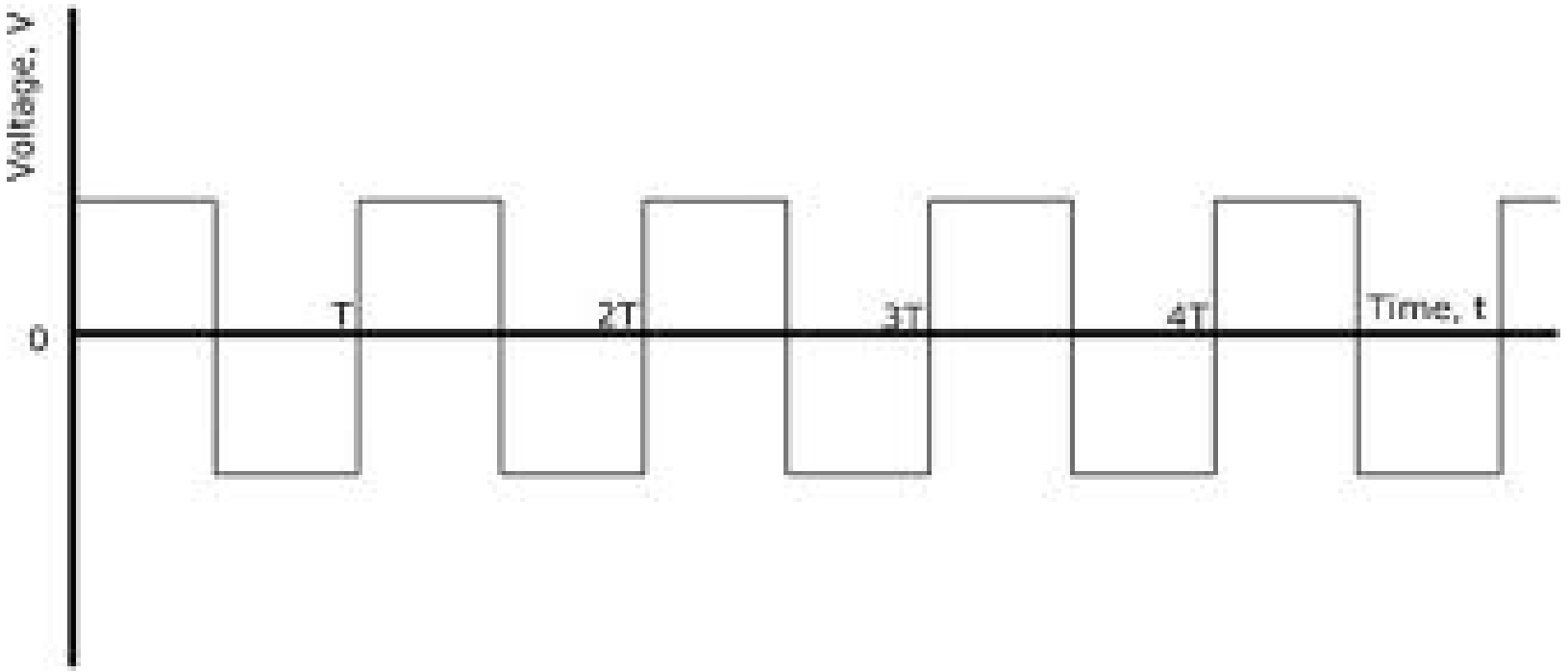


(d) A = 1, f = 1, ϕ = π/4

Square Wave

- A **square wave** is a kind of non-sinusoidal waveform, most typically encountered in electronics and signal processing.

Square Wave



Energy and power signals

- A signal is an energy signal if, and only if, it has nonzero but finite energy for all time:

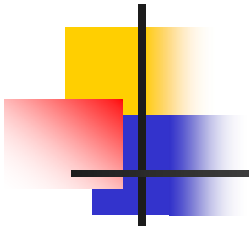
$$E_x = \lim_{T\to\infty} \int_{T/2}^{T/2} |x(t)|^2 dt = \int_{-\infty}^{\infty} |x(t)|^2 dt$$

$$(0 < E_x < \infty)$$

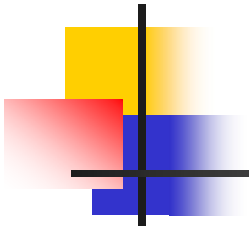
- A signal is a power signal if, and only if, it has finite but nonzero power for all time:

$$P_x = \lim_{T\to\infty} \frac{1}{T} \int_{T/2}^{T/2} |x(t)|^2 dt$$

$$(0 < P_x < \infty)$$



- General rule: Periodic and random signals are power signals. Signals that are both deterministic and non-periodic are energy signals.



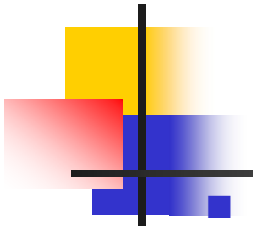
- **Energy Signals: an energy signal is a signal with finite energy and zero average power**

$$(0 \le E < \infty, \quad P = 0)$$

- **Power Signals: a power signal is a signal with infinite energy but finite average power**

$$(0 < P < \infty, \quad E \to \infty)$$

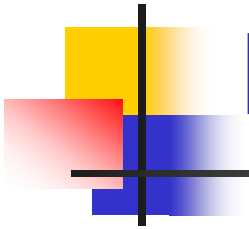
Properties of signals



- Peak Amplitude (A)
  - maximum strength of signal
  - volts
- Frequency (f)
  - Rate of change of signal
  - Hertz (Hz) or cycles per second
  - Period = time for one repetition (T)
  - T = 1/f
- Time Period
  - Time Taken by wave to complete one cycle.
- Phase (ϕ)
  - Relative position in time
  - Distance travelled by wave in one time period

Wave Length

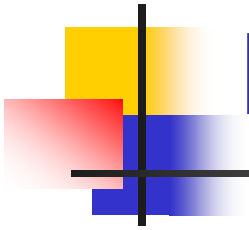
- Distance occupied by one cycle
  - Distance between two points of corresponding phase in two consecutive cycles
  - λ
- Assuming signal velocity v
  - $\lambda = vT$
  - $\lambda f = v$
  - $c = 3X10^{8}\ ms^{-1}$ (speed of light in free space)



Bandwidth

- Speed, rate of information, capacity of channel, signal to noise ratio all depend upon the bandwidth.
- Range of frequency that is used for transmission.
- For sinusoidal, the frequency range between the lowest and highest signal component is said to be bandwidth.
- If bandwidth will be higher then reconstruction of original signal at receiver become easy

Effect of limited bandwidth



- limiting the bandwidth, increases distortion, and hence the error rate
- Greater bandwidth leads to greater costs
- The transmission medium limits the bandwidth
- If bandwidth will be high then signal to noise ratio will be high, therefore communication less affected by noise.

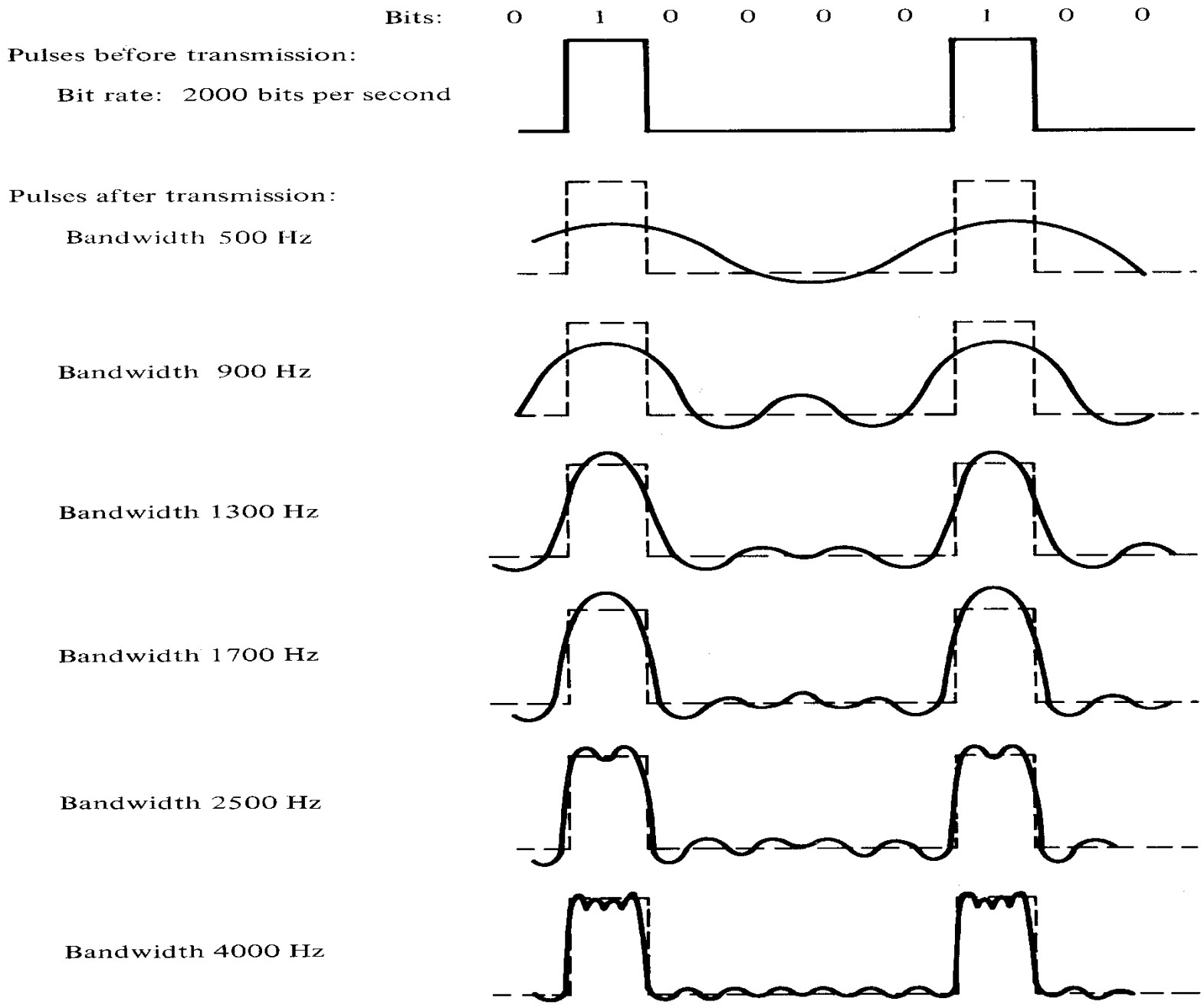


FIGURE 2.9. Effect of bandwidth on a digital signal.