# Lecture Notes
# for
# Analog and Digital Communication Systems

(Electronics : PHYS4008)


Dr. Pawan Kumar
Assistant Professor
Department of Physics
Mahatma Gandhi central university
Motihari-845401,Bihar

# OUTLINE

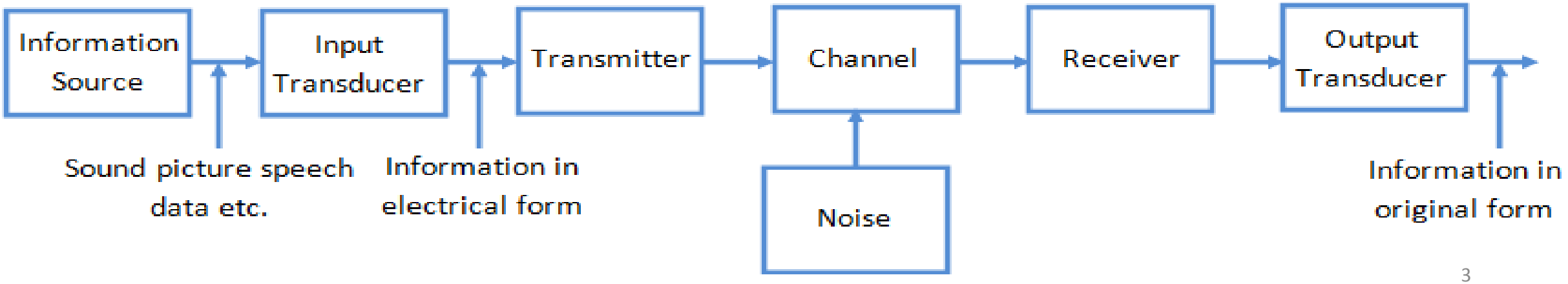
- Introduction
- Model of Communication System
- Modulation Technique
- Analog Modulation
- Digital Modulation
- Signal System
- Bandwidth of PCM,DPCM,DM And ADM
- Detection and Production of AM
- Noise

# INTRODUCTION

- The transmission of information is called communication.
- It is required that sender and receiver should understand the same language.
- we have been improving the quality of communication on behalf of growing demand for speed and complexity of information.

- The aim of this slides is to introduce the concepts of communication and the techniques of modulation sub sequent signal analysis and so on

# MODEL OF COMMUNICATION SYSTEM



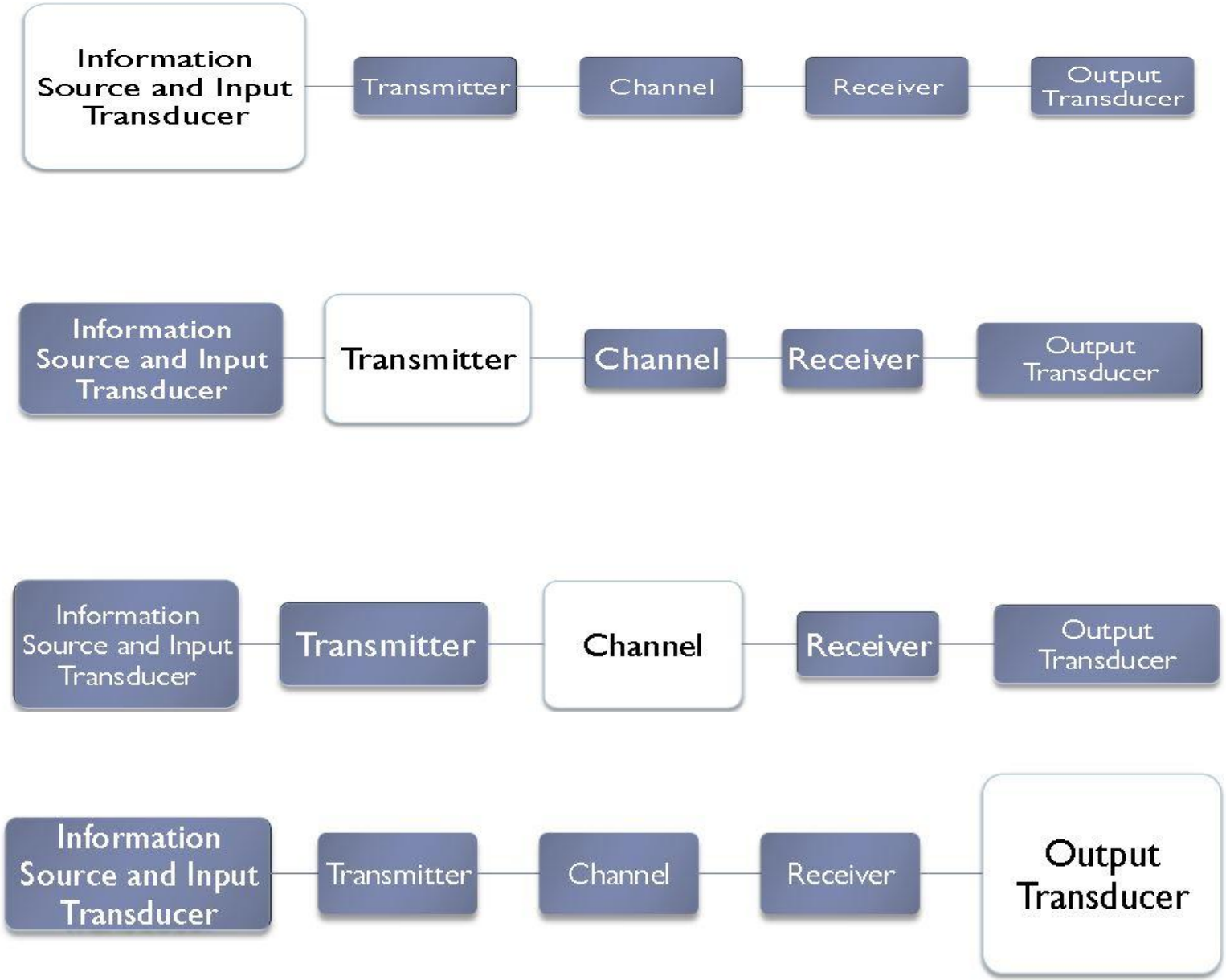
- Every communication has three essential elements : transmitter, channel and receiver Here the transmitter is placed at one place and receiver is placed another place and the channel is the physical medium that connect them.

- The purpose of transmitter is to convert into suitable form of signal that can transmitted through the channel.

- If the o/p of the information source is a non electric signal then a transducer convert it into electric form before it pass through the channel. Moreover, noise is introduced in channel so receiver reconstruct it and send the information to user for.

- There are two basic type of communication namely point to point and broadcast. The former take place over a link between a single transmitter and receiver, while later one have large number of receiver corresponding to a single transmitter.

- Radio and TV comes under broadcast


Information Source and Input Transducer
Transmitter
Channel
Receiver
Output Transducer
Information Source and Input Transducer
Transmitter
Channel
Receiver
Output Transducer
Information Source and Input Transducer
Transmitter
Channel
Receiver
Output Transducer
Information Source and Input Transducer
Transmitter
Channel
Receiver
Output Transducer

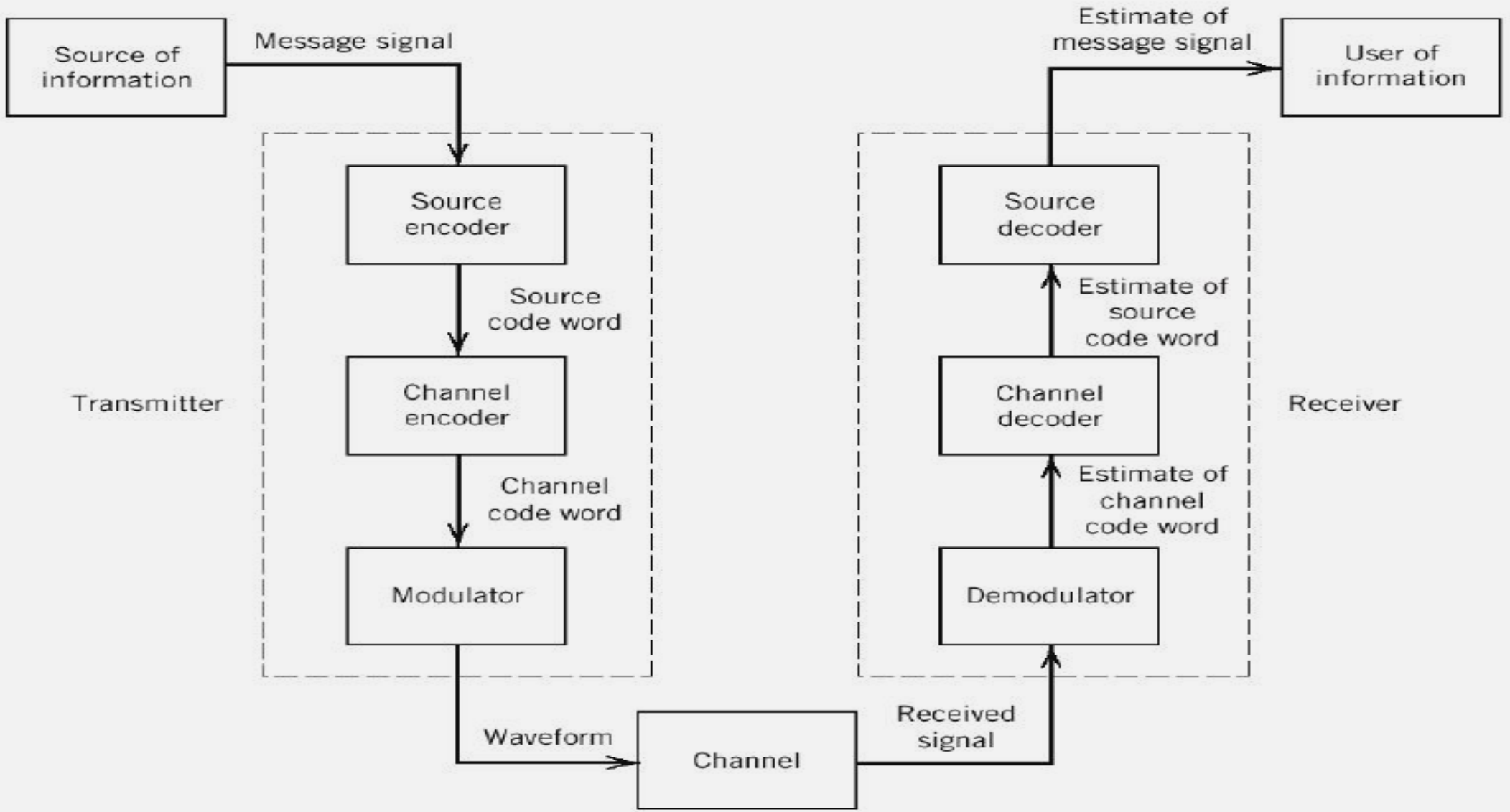
# Communication Channel

- The channel is central to operation of a communication System.
- The information-carrying capacity of a communication system is proportional to the channel bandwidth.
- Pursuit for wider bandwidth

  - Copper wire: 1 MHz
  - Coaxial cable: 100 MHz
  - Microwave: GHz
  - Optical fibre: THz

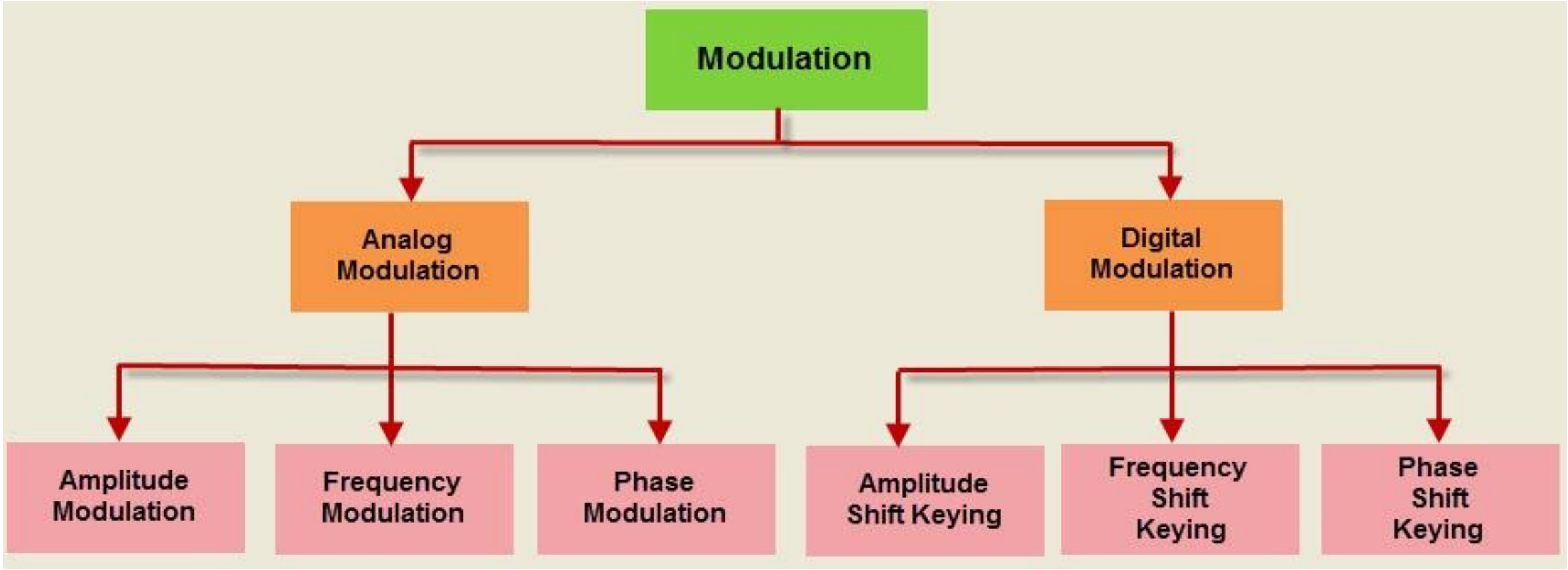
- Uses light as the signal carrier.
- Highest capacity among all practical signals.

# Model of Digital Communication



# MODULATION TECHNIQUES

**Modulation technique is used for its faithful passage through the channel ; it is of following types:**



# ANALOG MODULATION

The analog signal is used as a carrier signal, that modulate the message signal, mainly they are in the form of sinusoidal waveform. So, we can alter their frequency, amplitude and phase.

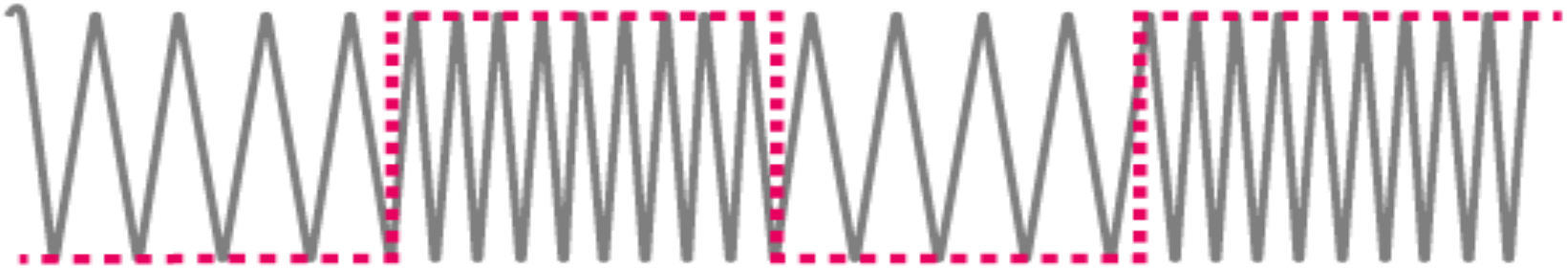
- **Amplitude Modulation**: The amplitude of carrier signal varies accordingly as the message signal, while other factor such as frequency, phase likes remain constant. Computer modem comes under it.

- **Frequency Modulation**:The frequency of the carrier signal varies as message signal remaining other variable constant.Rador,Radio comes under it.

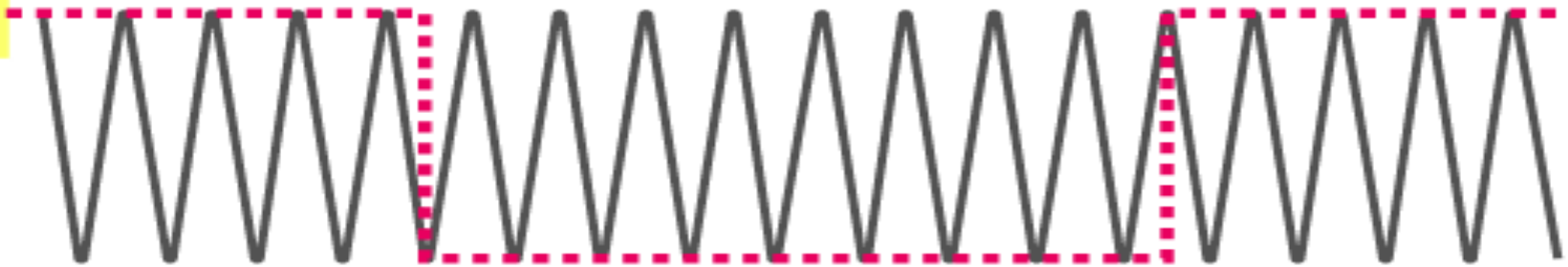
- **Phase Modulation**: The phase of the carrier wave adjust as like the message wave but here the frequency changes ,for which it comes under frequency modulation

Amplitude modulation

Frequency modulation



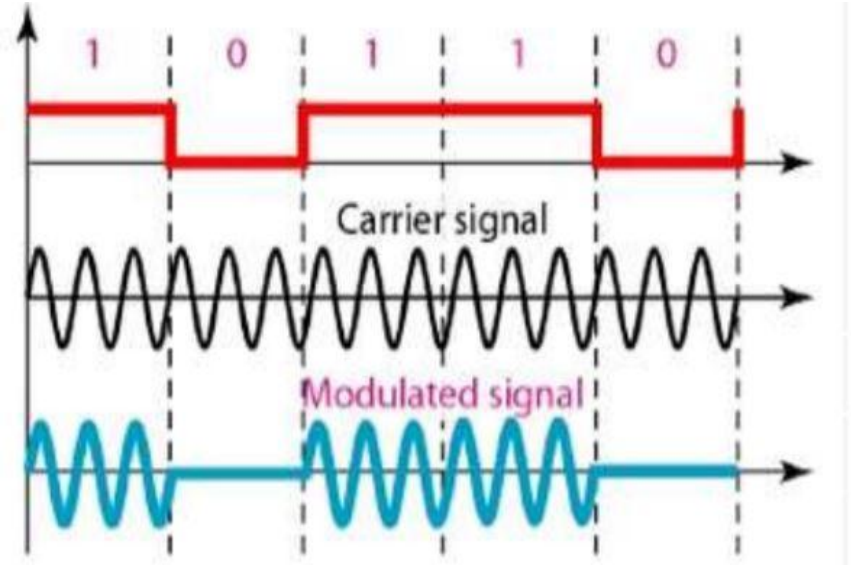
Phase modulation



# DIGITAL MODULATION

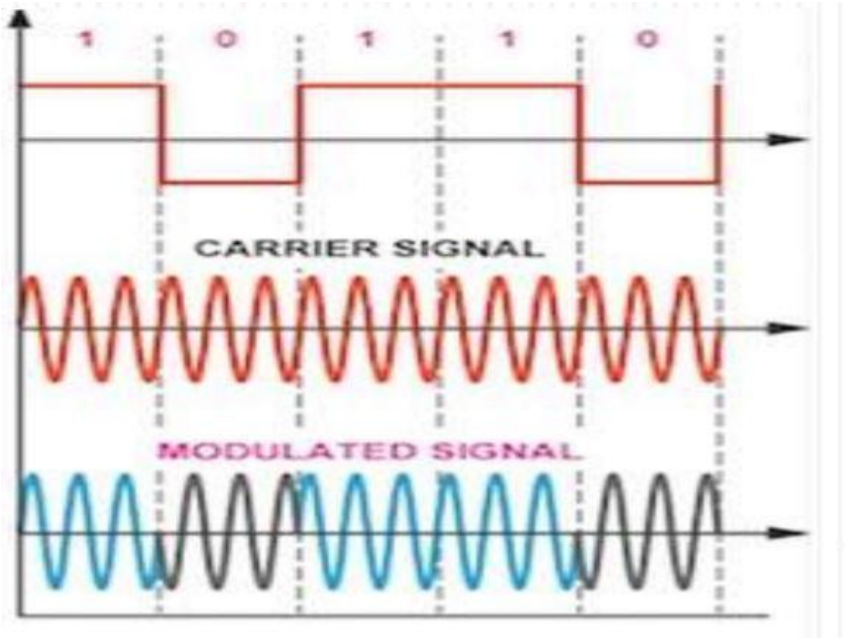
It provides more information capacity, high data security, quicker system availability with great quality communication. It is of following types:

- Amplitude Shift Keying: The amplitude of the carrier is changed in response to the information and all else are kept constant. One off Keying is special form of ASK, where one of the amplitude is zero
- Frequency Shift Keying: Here, the frequency is changed in response to the information. A synchronous method is used for detection of FSK.
- Phase Shift Keying: In PSK ,we change the sinusoidal carrier to indicate information. These are mainly two types Binary Phase Shift Keying and Quadrature Phase Shift Keying




**(ASK MODULATION)**

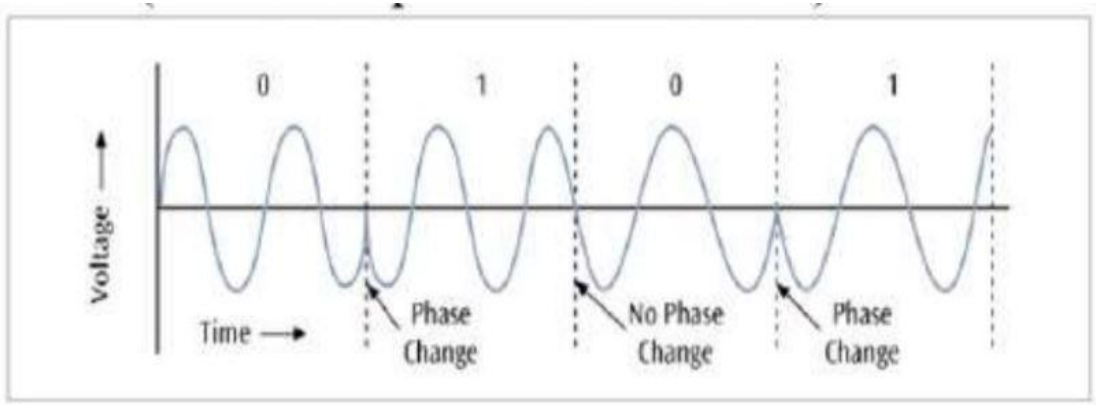
- In ASK Bit 1 is transmitted by a signal of one particular amplitude, to transmit 0, we change the amplitude keeping the frequency constant




**(FSK MODULATION)**

- One particular frequency for a 1 to be transmitted, while another frequency for 0.

- One phase change encodes to 0 ,while another phase change encodes to 1.
- To transmit 0 we shift the phase of sinusoidal by 180 degree.




**(PSK MODULATION)**

# METRICS FOR DIGITAL MODULATION

**POWER EFFICIENCY**

- Ability of a modulation technique to preserve the fidelity of digital message at low power.
- Designer can increase noise immunity, by increasing signal power.

**BANDWIDTH EFFICIENCY**

- Trade off between data rate and pulse width.
- Easy to implement and cost effective to operate.

# SIGNAL SYSTEM

Signal is a function that conveys about the information. we will discuss three broad categories of signal classification i.e. Periodic, aperiodic and random.

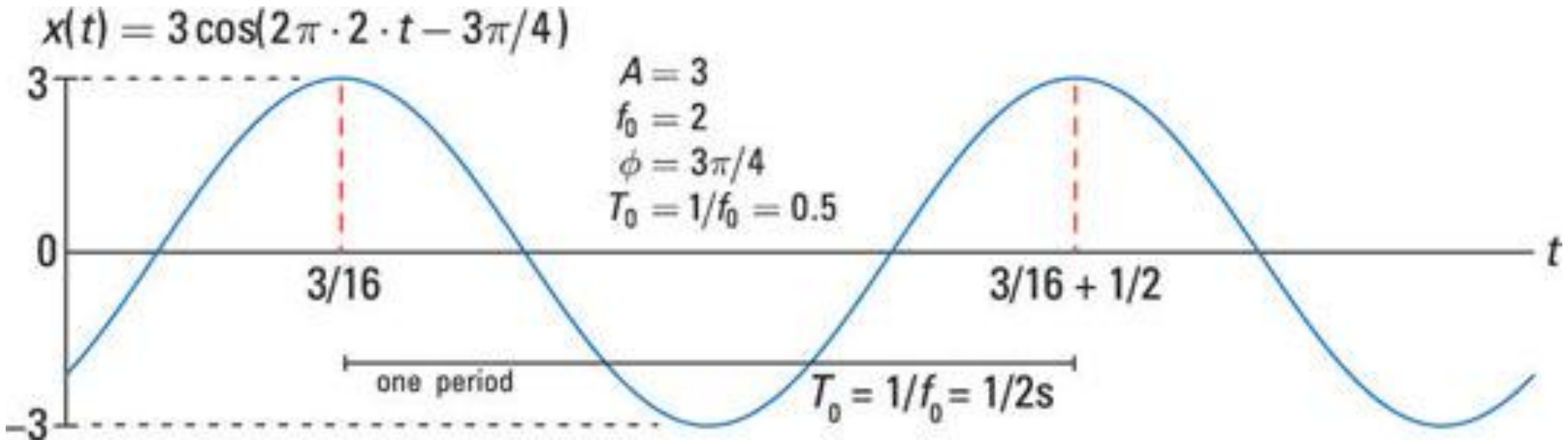
# PERIODIC SIGNAL

Signals that repeat over and over define this type of signal.

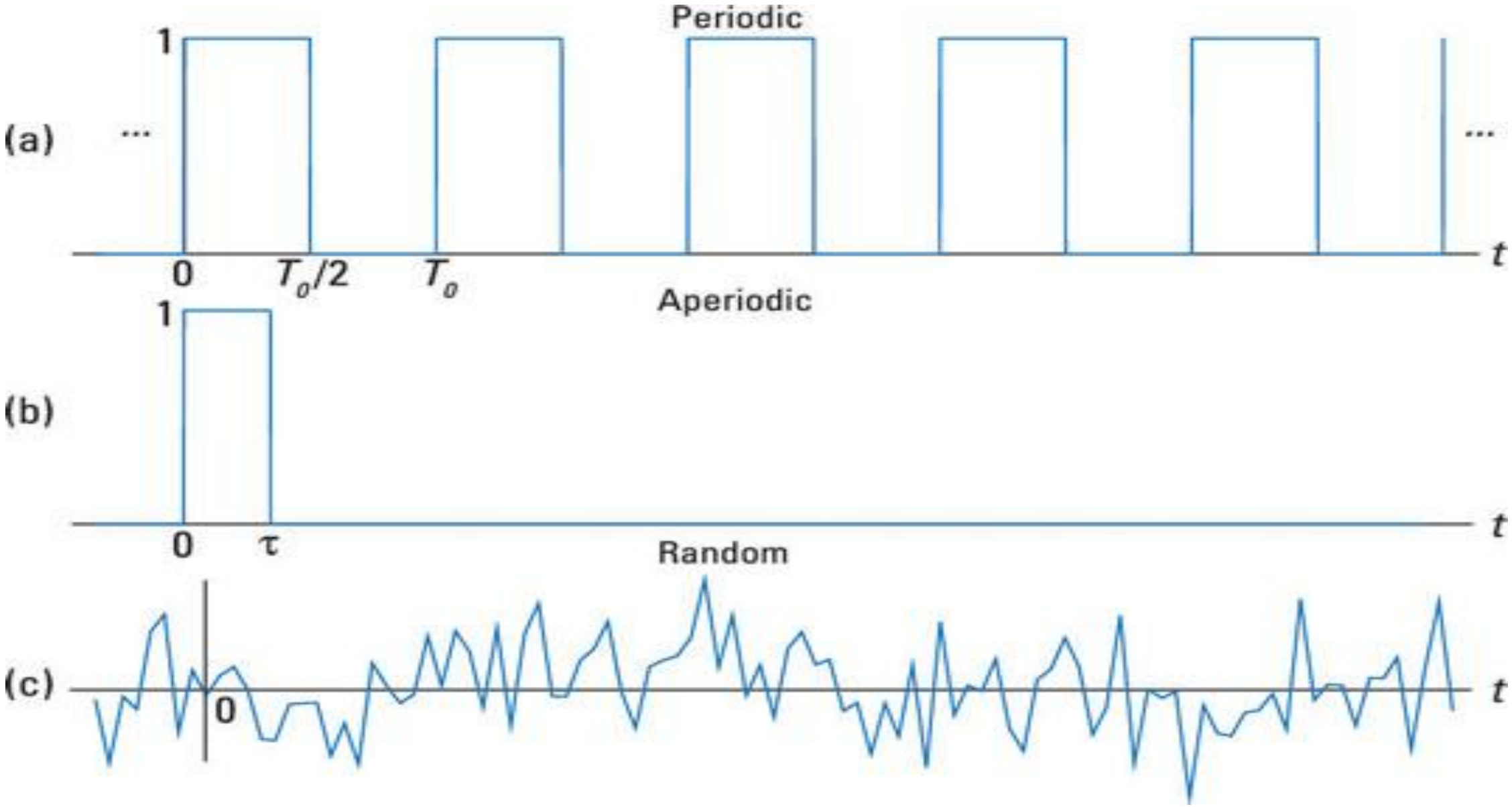
A signal is periodic if,

$x(t + T) = x(t)$ (continuous-time)
$x[n + N] = x[n]$ (discrete-time)

The smallest $T$ or $N$ for which the equality holds is the signal period. The sinusoidal signal of the following figure is periodic because of the mod $2\pi$ property of cosine.

- 


The signal has period 0.5 seconds (s), which turns out to be the reciprocal of the frequency $f_0 = 2$ Hz. The *square wave* signal that follows in part (a) is another example of a periodic signal is given in the next page along with aperiodic and random one.


Periodic
(a)
1
...
...
0
$T_0/2$
$T_0$
t
Aperiodic
(b)
1
0
τ
t
Random
(c)
0
t

# APERIODIC SIGNAL

- Signals that are deterministic (completely determined functions of time) but not periodic are known as aperiodic. Point of view matters.

- If a signal occurs infrequently, you may view it as aperiodic.

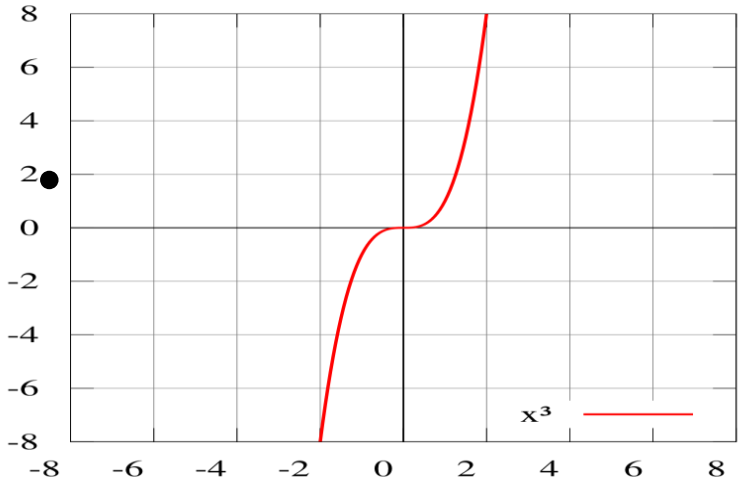
# RANDOM SIGNAL

- A signal is random if one or more signal attributes takes on unpredictable values in a probability sense

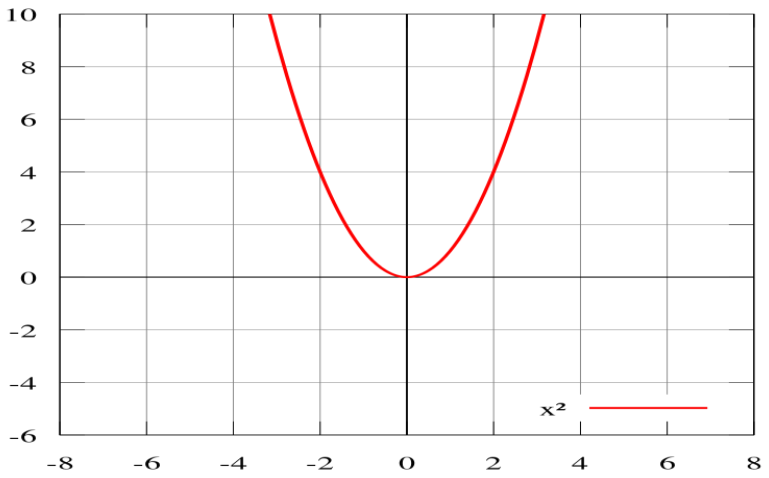
- The noise you hear when you're between stations on an FM radio. See a waveform representation of this noise in part (c).

- Speech: If you try to capture audio samples on a computer of someone speaking the word hello over and over, you'll find that each capture looks a little different.

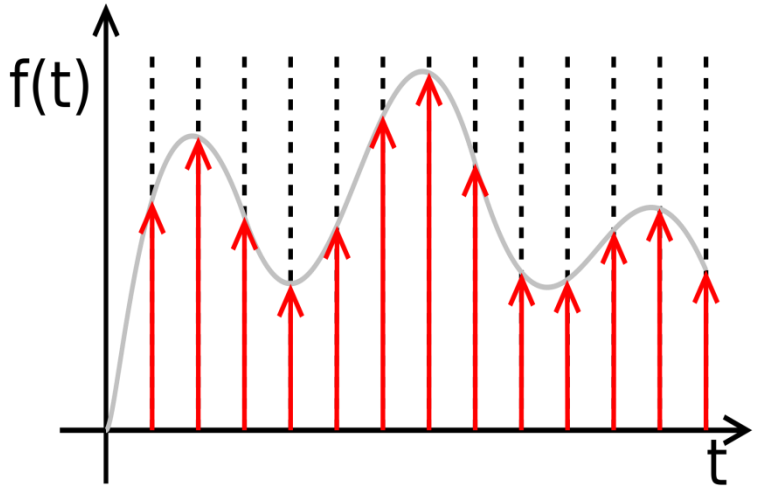
Let us see some picture of signals



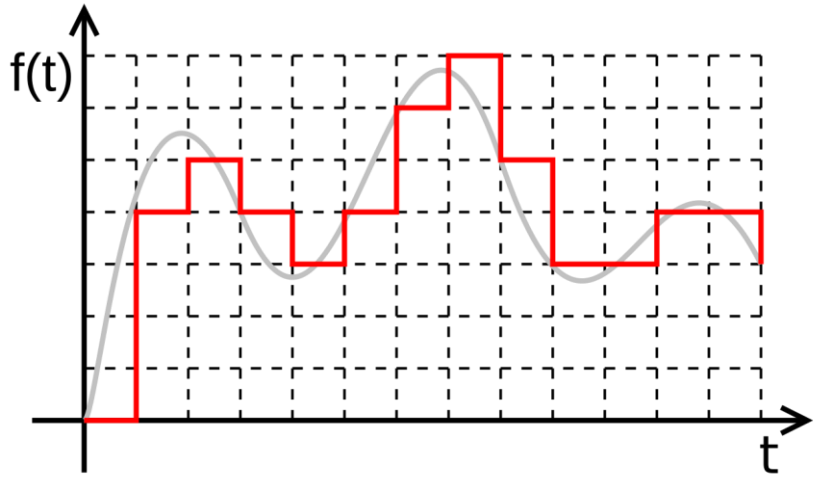

(Odd signal)




(Even signal)




(Time varying analog signal)




(Time varying digital signal)

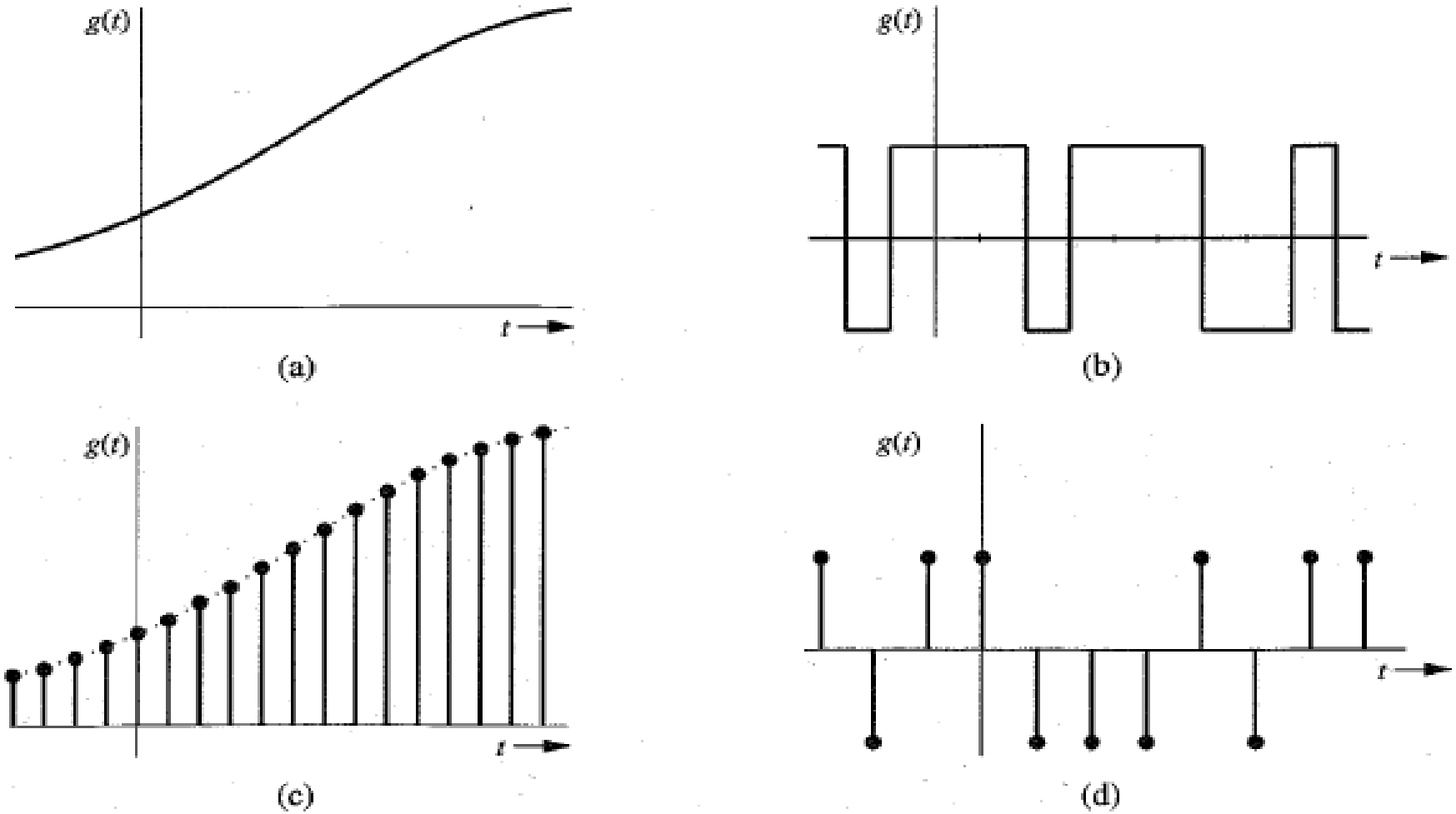



**Figure 2.5** Examples of signals. (a) Analog, continuous time. (b) Digital, continuous time. (c) Analog, discrete time. (d) Digital, discrete time.

# BANDWIDTH

- It is the difference between the upper and lower frequencies in a continuous band of frequencies.
- It is typically measured in hertz, and depending on context, may specifically refer to passband bandwidth or baseband bandwidth.
- Pass band bandwidth is the difference between the upper and lower cutoff frequencies of, for example, a band-pass filter or a signal spectrum.
- Baseband bandwidth applies to a low-pass filter or baseband signal; the bandwidth is equal to its upper cutoff frequency.

# PCM (PULSE CODE MODULATION) AND ITS BANDWIDTH

- Pulse-code modulation (PCM) is used to digitally represent sampled analog signals.
- It is the standard form of digital audio in computers, CDs, digital telephony and other digital audio applications.
- The amplitude of the analog signal is sampled at uniform intervals and each sample is quantized to its nearest value within a predetermined range of digital levels

- In binary PCM, we have a group of n bits corresponding to L levels with n bits. Thus,

$$L = 2n$$

Signal m(t) is band-limited to B Hz, which requires 2B samples per second.

For 2nB elements of information, we must transfer 2nB bits/second. Thus, the minimum bandwidth BT needed to transmit 2nB bits/second is

$$BT = nB \text{ Hz}$$

## DPCM (DIFFERENTIAL PULSE CODE MODULATION) AND ITS BANDWIDTH

- It is a technique of analog to digital signal conversion.
- This technique samples the analog signal and then quantizes the difference between the sampled value and its predicted value, then encodes the signal to form a digital value.

**Usually it required less bandwidth as compared to DPCM**

# DM (DELTA MODULATION) AND ITS BANDWIDTH

➢**It** (DM or Δ-modulation) is an analog-to-digital and digital-to-analog signal conversion technique used for transmission of voice information where quality is not of primary importance.

➢ DM is the simplest form of differential pulse-code modulation (DPCM) where the difference between successive samples are encoded into n-bit data streams.

➢In delta modulation, the transmitted data are reduced to a 1-bit data stream.

➢The bandwidth in bits/second needed to transmit a delta-modulated signal is simply equal to the sampling frequency.

the bandwidth to transmit the modulated signal
= ffs samples/second X 1 bit/sample
= **ffs bits/second**

Where fs is chosen as sampling frequency

# ADM (ADAPTIVE DELTA MODULATION)

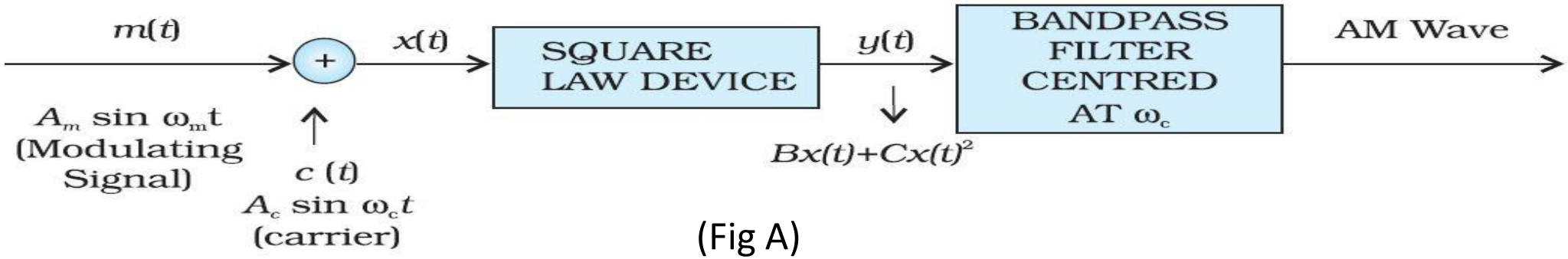
- This Modulation is the refined form of delta modulation.
- It was introduced to solve the granular noise and slope overload error caused during Delta modulation.
- Adaptive delta modulation decreases slope error present in delta modulation.
- During demodulation, it uses a low pass filter which removes the quantized noise.
- The slope overload error and granular error present in delta modulation are solved using this modulation.
- In the presence of bit errors, this modulation provides robust performance. This reduces the need for error detection and correction circuits in radio design.
- The dynamic range of Adaptive delta modulation is large as the variable step size covers large range of values.

# COMPARISION OF DIFFERENT MODULATION

| S.NO | Parameter of Comparison | Pulse Code Modulation (PCM) | Delta Modulation (DM) | Adaptive Delta Modulation (ADM) | Differential Pulse Code Modulation (DPCM) |
|---|---|---|---|---|---|
| 1. | Number of bits | It can use 4, 8, or 16 bits per sample. | It uses only one bit for one sample | It uses only one bit for one sample | Bits can be more than one but are less than PCM. |
| 2. | Levels and step size | The number of levels depends on number of bits. Level size is fixed. | Step size is kept fixed and cannot be varied. | According to the signal variation, step size varies. | Number of levels is fixed. |
| 3. | Quantization error and distortion | Quantization error depends on number of levels used. | Slope overload distortion and granular noise are present. | Quantization noise is present but other errors are absent. | Slope overload distortion and quantization noise is present. |
| 4. | Transmission bandwidth | Highest bandwidth is required since numbers of bits are high. | Lowest bandwidth is required. | Lowest bandwidth is required. | Bandwidth required is less than PCM. |
| 5. | Feedback | There is no feedback in transmitter or receiver. | Feedback exists in transmitter. | Feedback exists. | Feedback exists. |
| 6. | Complexity of Implementation | System is complex. | Simple | Simple | Simple |

# PRODUCTION OF AMPLITUDE MODULATED SIGNAL

Amplitude modulation can be produced by a variety of methods. A conceptually simple method is shown in the block diagram




(Fig A)

- Here the modulating signal *Am* sin w*mt* is added to the carrier signal *Ac*sin(w*ct)* to produce the signal *x* (*t*).
- This signal *x* (*t*) = *Am*sin(w*mt)*+ *Ac*sin(w*ct)* is passed through a square law device which is a non-linear device which produces an output.

$y(t) = Bx(t) + Cx2(t)$

where $B$ and $C$ are constants. Thus

- Obtained final equation form of signal is passed through a band pass filter, which rejects dc and sinusoidal frequencies and retains the remaining.

- The o/p of the the band pass filter therefore is of the same form as obtained from above equation and therefore an AM signal.

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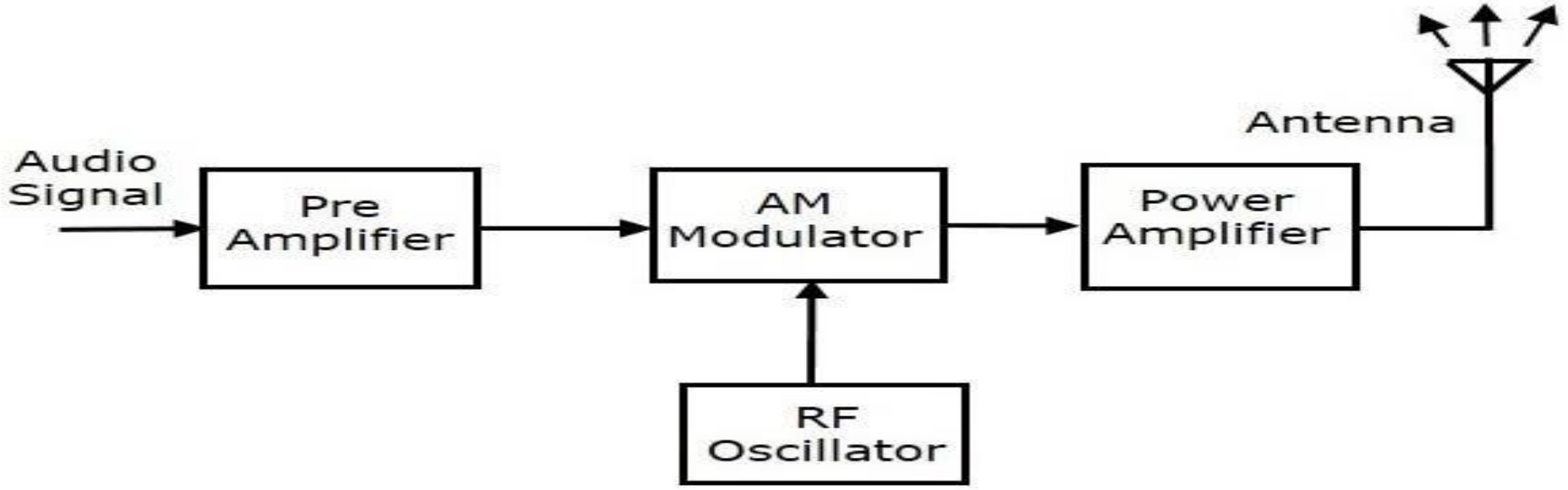
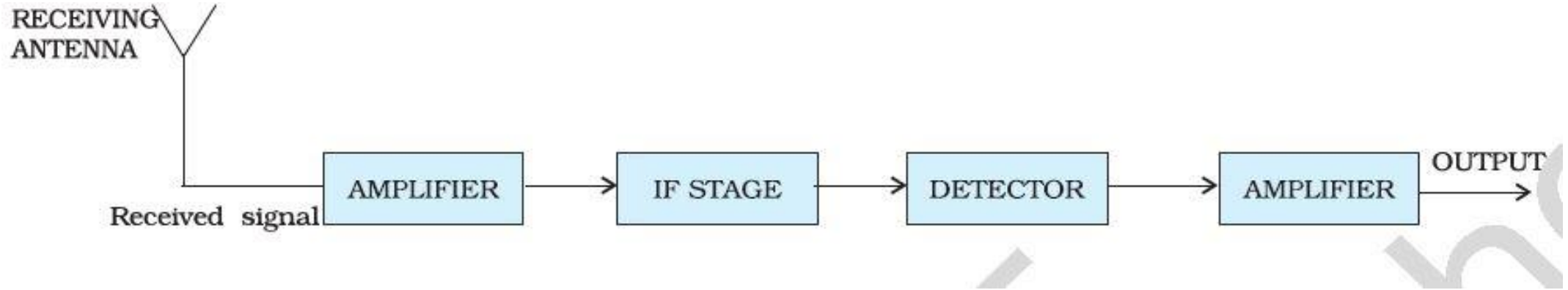



(Fig B)

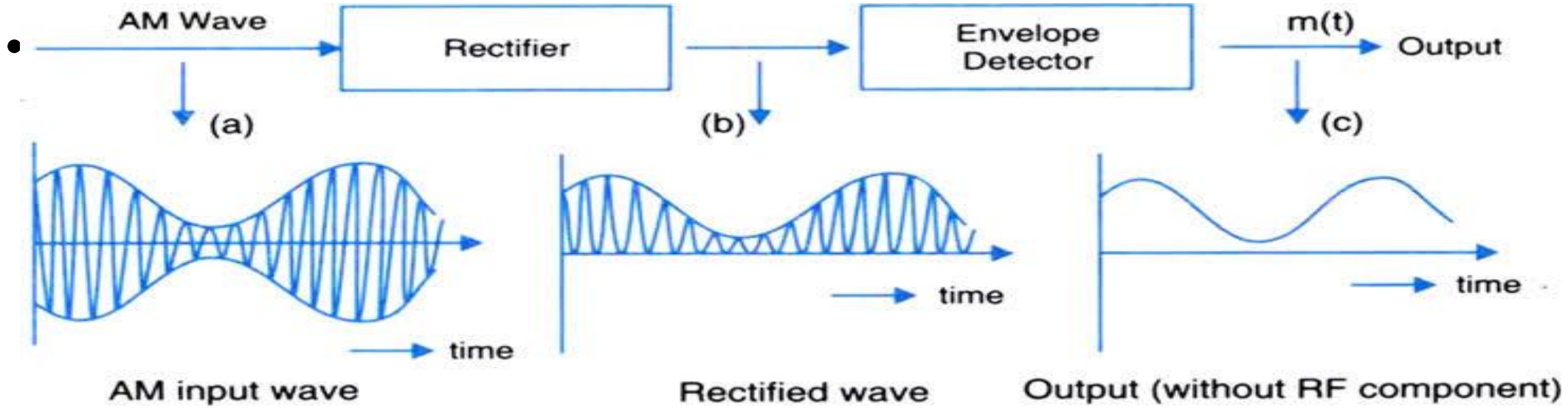
It is to be mentioned that the modulated signal cannot be transmitted as such. The modulator is to be followed by a power amplifier which provides the necessary power and then the modulated signal is fed to an antenna of appropriate size for radiation as shown fig B.

# DETECTION OF AMPLITUDE MODULATED SIGNAL

- The transmitted message gets attenuated in propagating through the channel.
- The receiving antenna is therefore to be followed by an amplifier and a detector. the carrier frequency is usually changed to a lower frequency by what is called an intermediate frequency (IF) stage preceding the detection.
- The detected signal may not be strong enough to be made use of and hence is required to be amplified.



➢ Detection is the process of recovering the modulating signal from the modulated carrier wave.




➢The modulated signal of the form given in (a) of above is passed through a rectifier to produce the output shown in (b). This envelope of signal (b) is the message signal. In order to retrieve *m*(*t* ), the signal is passed through an envelope detector (which may consist of a simple RC circuit)

# NOISE

➢Noise may be defined as a unwanted form of energy which tends to interfere with proper reception and reproduction of unwanted signal.

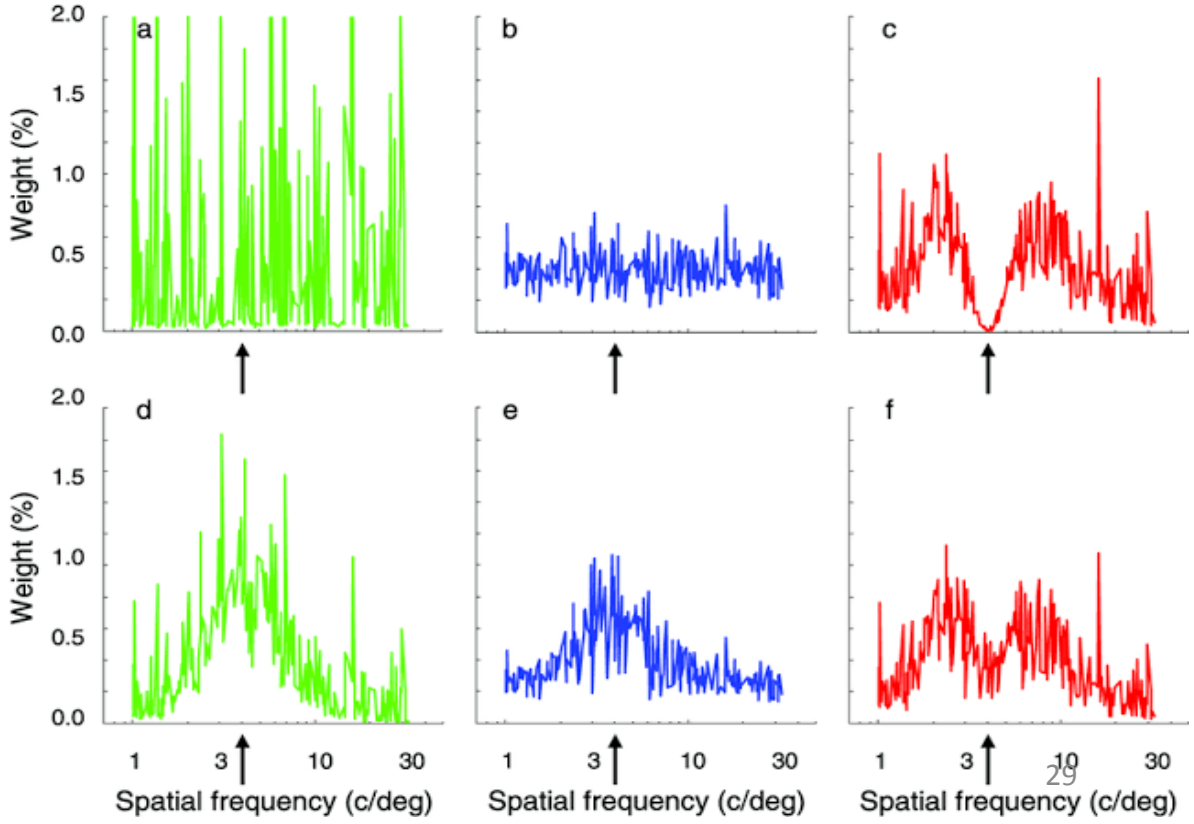
➢ A widely used metric is the signal-to-noise (power) ratio

$$SNR = \frac{\text{signal power}}{\text{noise power}}$$

# EXTERNAL NOISE

Noise whose source are external, can affect as shown in the side figure

- Extraterrestrial Noise
- Atmospheric Noise
- Industrial Noise/Man made Noise

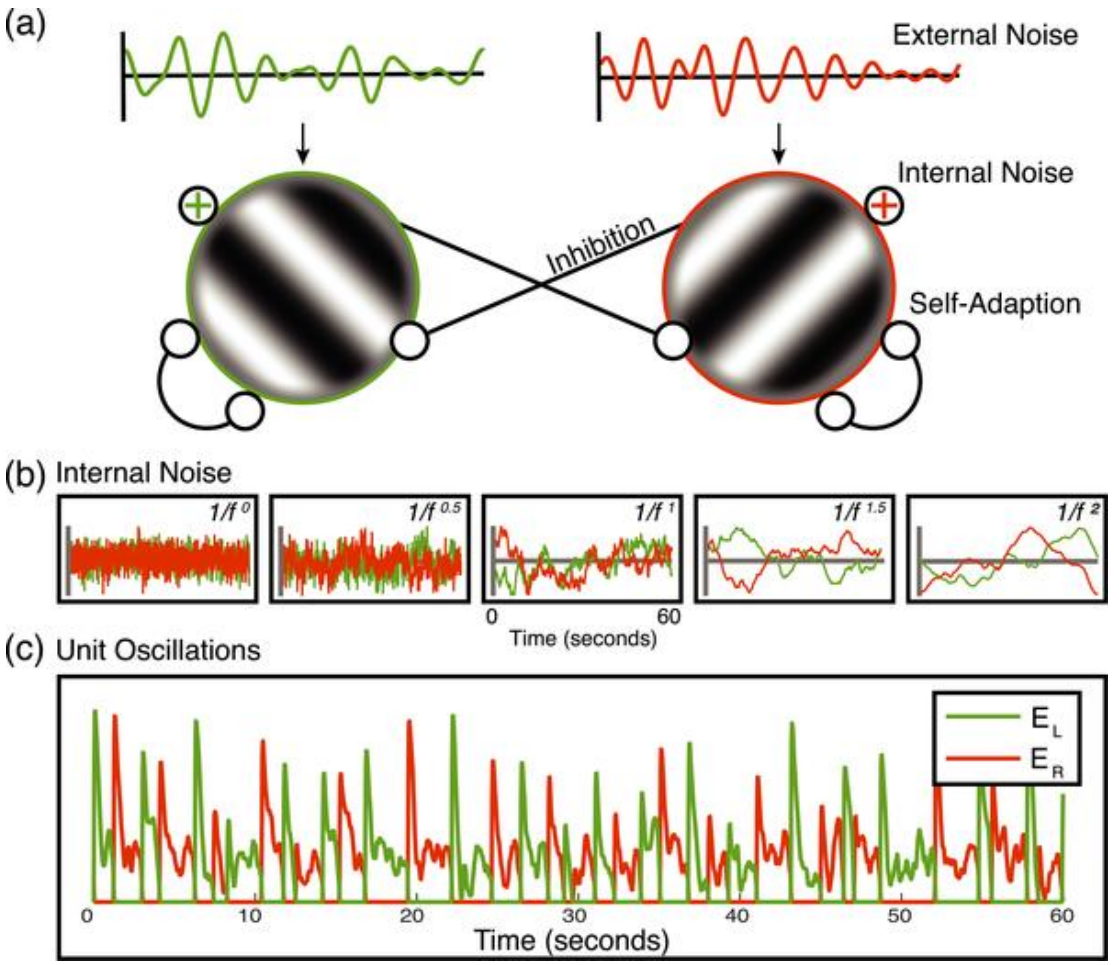


# INTERNAL NOISE

➢Noise which get generated within the communication system, and alter the required message and a type of distortion is shown in the figure

➢It can classified into following types:

- Thermal Noise
- Shot Noise
- Transit time Noise
- Miscellaneous Internal Noise



# TABLE OF FREQUENCY

**ELF** : 0 – 3 kHz. Submarine communications.

**VLF** : 3 – 30 kHz. Submarine communications, TimeSignals, Navigation

**LF** : 30 – 300 kHz. Navigation, Time Signals.

**MF**: 300 kHz – 3 MHz Maritime Voice/Data, AM Broadcasting, Aeronautical Communications.

**HF**: 3 – 30 MHz “Shortwave” Broadcasting. Amateur,Point to Point data. Maritime Voice/Data, Aeronautical Communications.

**VHF** : 30 – 300 MHz Police, Fire, Public Service mobile. Amateur. Satellite. Analog TV. FM Broadcast

**UHF** : 300 – 3,000 mHz (3 GHz) Police, Fire, Public Service communications. Satellite. Analog and HD TV. Telemetry(flight test). Radar. Microwave links (telephone/data)Wife.

**SHF** : 3 – 30 GHz Radar. Satellite. Telemetry. Microwave links

**EHF** : 30 – 300 GHz Radar. Satellite. Microwave links

# References


1. Communication System, NCERT Book ,Class XII
2. Modern Digital And Analog Communication Systems by B.P Lathi
3. Noise System, DAE notes.
4. Introduction to Communication System by James Flynn
5. Communication System by Dr. Cong Ling


**THANK YOU**