Course objectives

1 Study the basic of Analog and Digital Communication Systems.

2Describe the concept of Noise and Fourier Transform for analyzing communication systems.

3Acquire the knowledge of different modulation techniques such as AM, FM and study the block diagram of transmitter and receiver.

4Study the Sampling theorem and Pulse Analog and digital modulation techniques

5Learn the concept of multiplexing and digital band pass modulation techniques

6 Gain the core idea of electromagnetic radiation and propagation of waves.

Course outcomes

1 Describe analog and digital communication systems
2Differentiate types of noise, analyses the Fourier transform of time and

frequency domain.

3Design transmitter and receiver of AM, DSB, SSB and FM. 4

Describe Sampling theorem and pulse modulation systems.

5 Explain multiplexing and digital band pass modulation

techniques. 6 Describe electromagnetic radiation and propagation

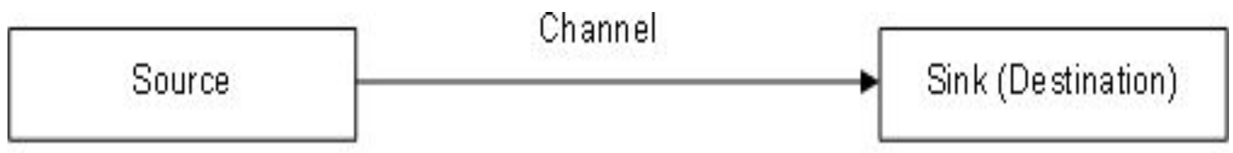
of waves

Topics

1. Basics of analog communication systems
2. Sources of information,
3. Types of communication channels,
4. Frequency / Spectrum allocations,
5. Baseband and bandpass signals,
6. Need for modulation and demodulation

Basics of analog communication systems

Basic Communication Model



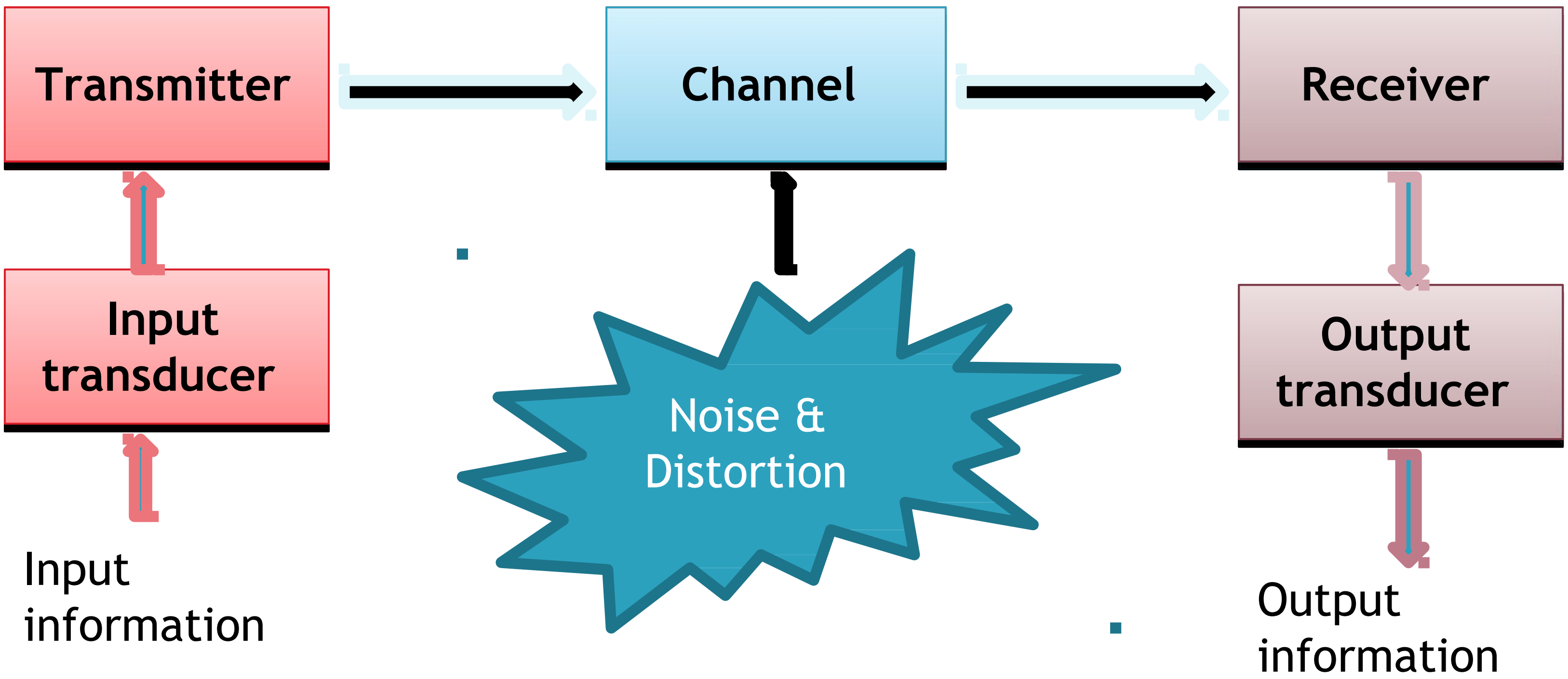
Basic communication model

Source – sender of the information

Sink – receiver that receives the information

Channel – transmission path/medium of the information between the source and sink

Basics of analog communication systems



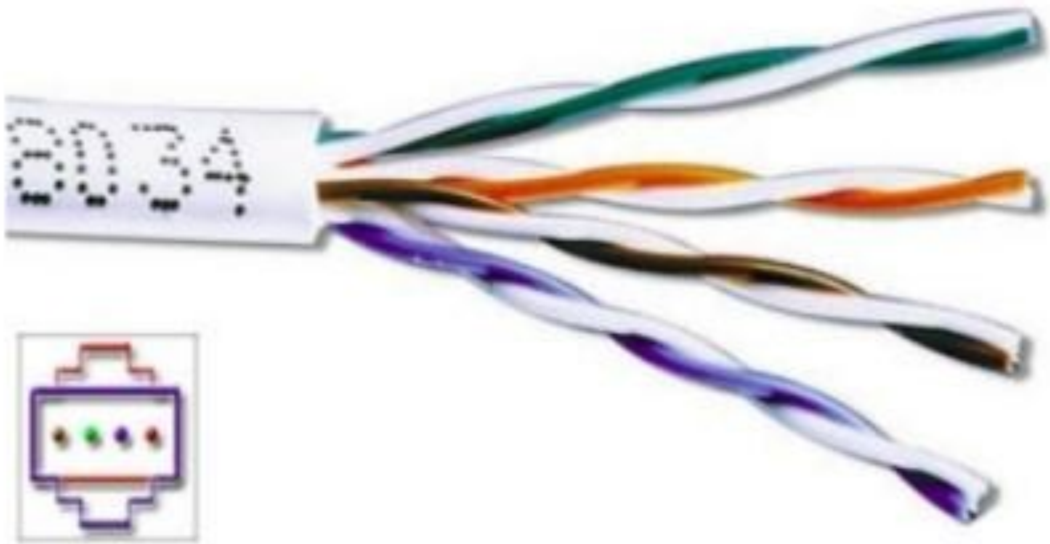
1.2 TYPES OF COMMUNICATION CHANNELS

Communication channel is the medium used for transmission of signals from one place to another. The channels could be either wired or wireless. Some of the channels are described below.

A) Open Wire Lines – The original telephone and telegraph transmission lines which are still in use today. They are used for long distance communication.

Shielded twisted pair (STP)

Unshielded twisted pair (UTP)

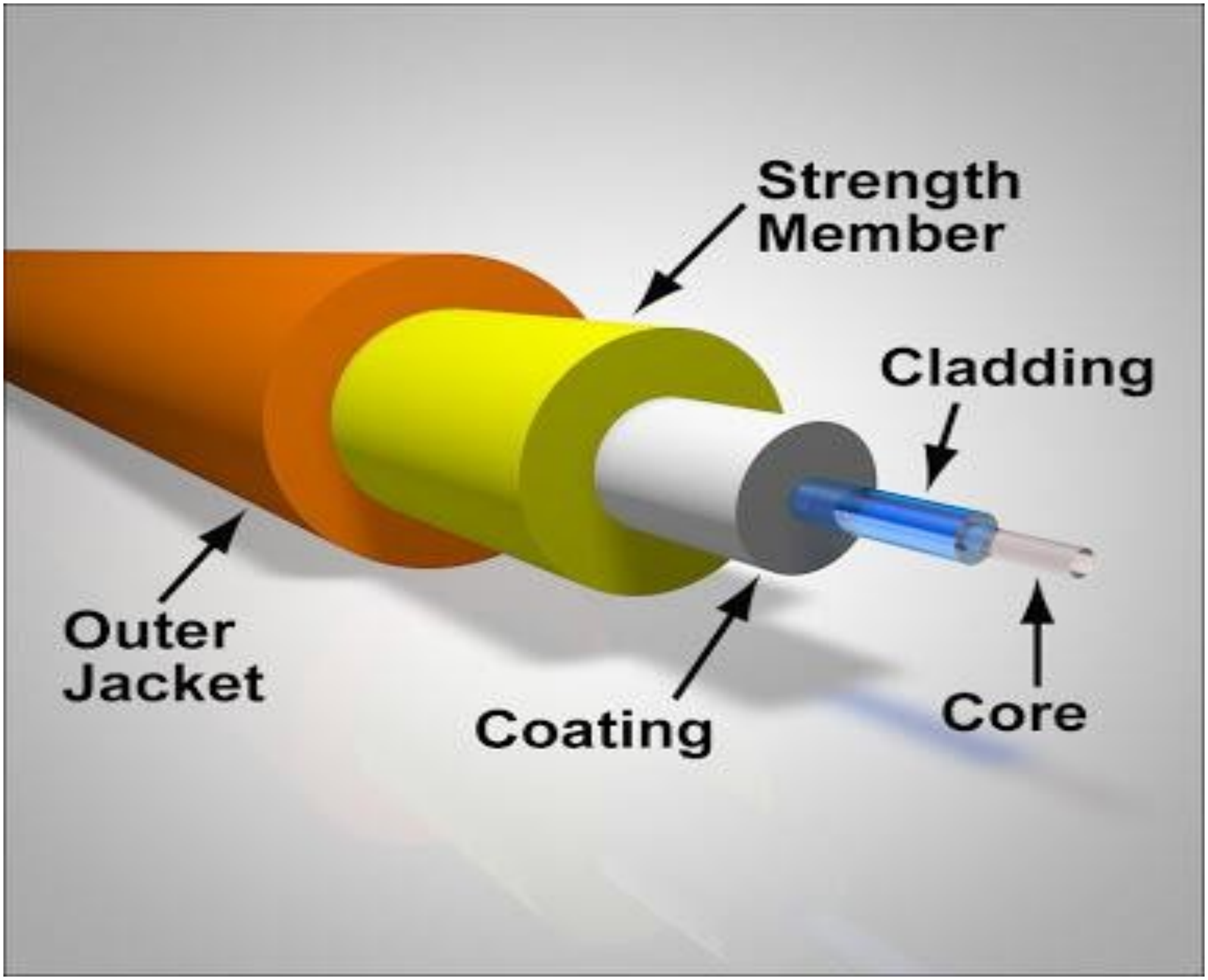


B) Coaxial Cables – It consists of a single wire conductor at the centre of a cylindrical cable and an outer cable, typically a wire mesh separated by dielectric. It is used for television connection, LAN for computers etc.

COAXIAL CABLE

C) Waveguides – This is a hollow conductor which sends or receives signals from transmitter or receiverantenna in radio propagation.

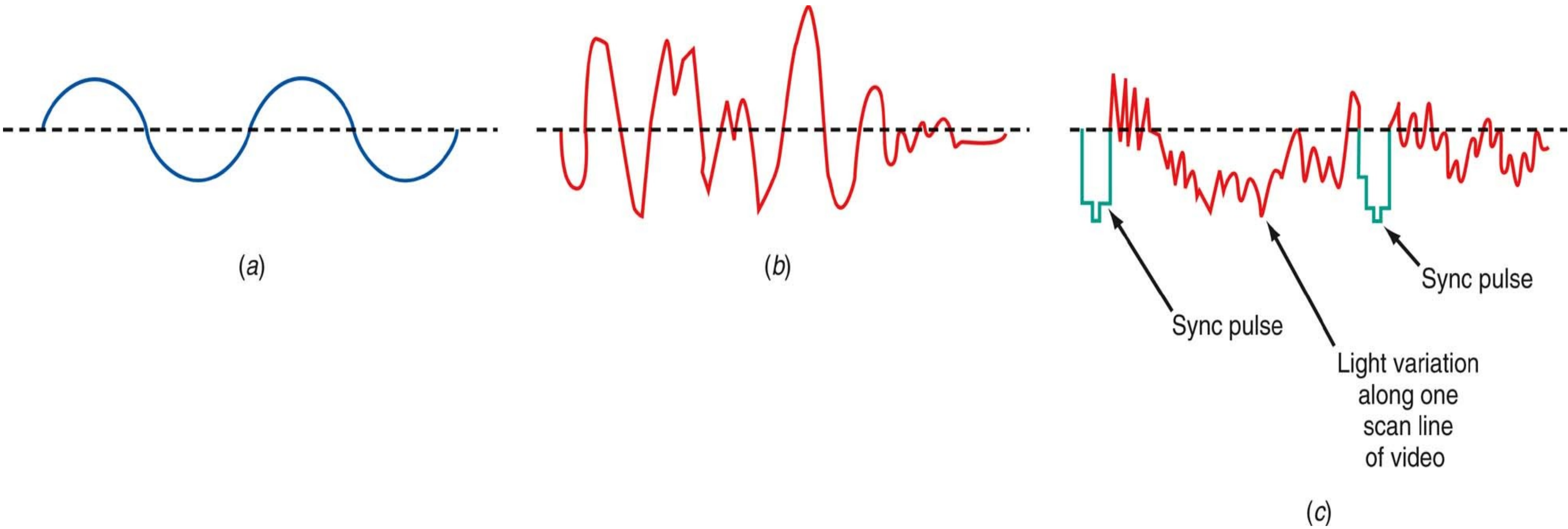
D) Optical Fibre – It consists of a core that allows light wave to propagate through it. An outer layer called cladding ensures total internal reflection. It is increasingly used in the field of communication.


Strength
Member
Cladding
Outer
Jacket
Coating
Core

E) Radio – Radio is a wireless propagation where atmosphere or free space is used as transmission

Analog Communication

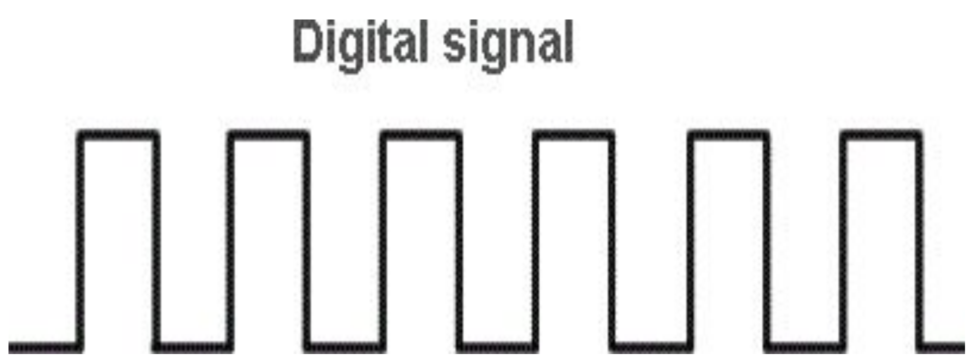
- Continuously varies with time.
- Is less costly.
- Required bandwidth is less.
- Examples – Speech, video



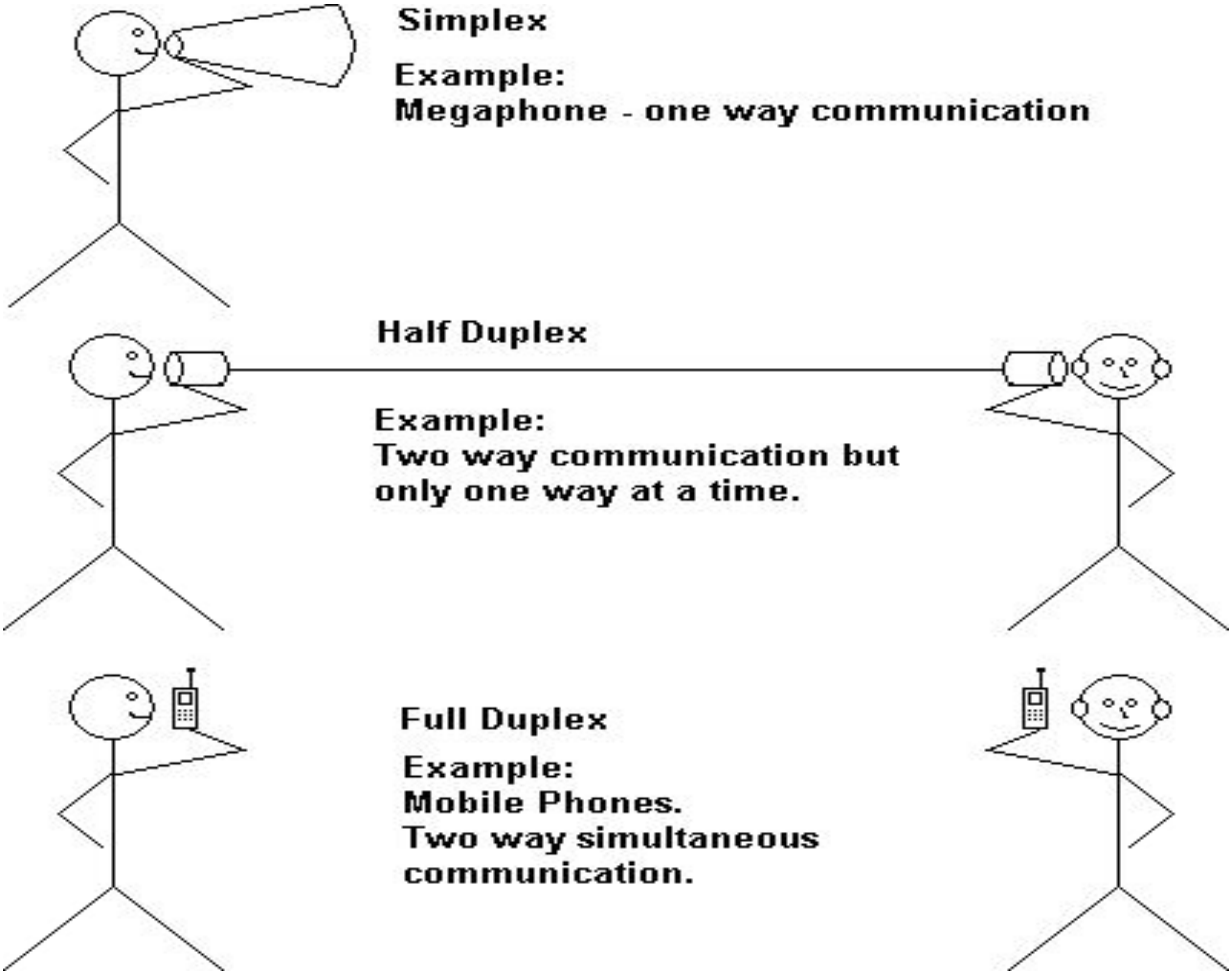
(a)Sine wave (b)Speech signal (c)Video (TV) signal

Digital Communication

- Has finite number of discrete levels.
- Less affected by noise.
- Long distance communication can use regenerative repeaters – devices placedat intermediate places which removes noise, regenerates original binary information and retransmits them.
- Coding techniques can be used to improve quality.



Types of communication channels



bandwidth required in digital communication is larger than that of analog communication.

1.4 THE ELECTROMAGNETIC SPECTRUM

Wireless transmission takes place using electromagnetic waves. Hence the information signal must be converted to an electromagnetic signal. The electromagnetic waves consist of electric and magnetic fields. They can travel a long distance through space. The EM signal ranges from very low to very high frequencies. This entire range of frequencies is called the electromagnetic spectrum (EM spectrum).

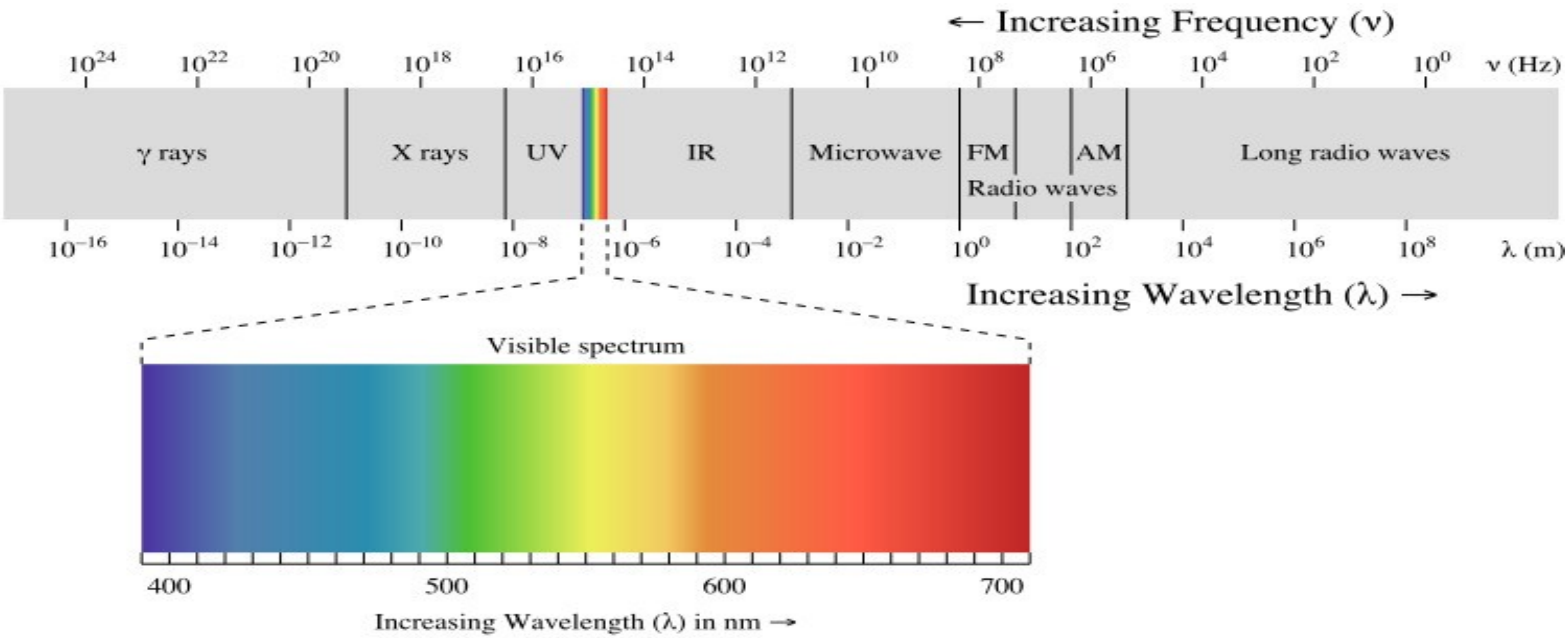


Fig 1.2: The EM Spectrum

From Fig 1.2, quite a few important observations can be made.

- ✔ The frequency and wavelength are inversely proportional to each other.
- ✔ The radio waves have the shortest frequency and the longest wavelength.
- ✔ The gamma rays have the highest frequency in the EM spectrum.
- ✔ In the visible light spectrum, the color violet has the highest frequency while the color red has the lowest frequency.

The radio frequencies which are used for two way communication encompasses a range of the EM spectrum which can be listed below.

Frequency band	Name	Application
30 – 300 Hz	Extremely Low Frequency (ELF)	Power Transmission
300 – 3000 Hz	Voice Frequency (VF)	Audio applications
3 – 30 kHz	Very Low Frequency (VLF)	Navy, Military communication
30 – 300 kHz	Low Frequency (LF)	Aeronautic & marine communication
300 – 3000 kHz	Medium Frequency (MF)	AM radio broadcasting
3 – 30 MHz	High Frequency (HF)	Amateur & CB communication
30 – 300 MHz	Very High Frequency (VHF)	FM, TV Broadcasting
300 – 3000 MHz	Ultra High Frequency (UHF) Microwave (above 1000 MHz)	Cellular phone, UHF TV channels
3 – 30 GHz	Super High Frequency (SHF)	Satellite & radar communication
30 – 300 GHz	Extremely High Frequency (EHF)	Satellites & specialized radar

Beyond the radio spectrum lies the optical spectrum which consists of infrared, visible light and ultra violet rays. The UV rays are generally not used in communication.

1.5FREQUENCY & WAVELENGTH

Frequency is the number of cycles of a repetitive wave that occur in a given period of time. A cycle consists of two voltage polarity reversals or current reversals. Frequency is measured in cycles per second (cps). The unit of frequency is the hertz (Hz).

1 kHz = 1000 Hz; 1 MHz = 1000 kHz = 1×10^6 Hz and 1 GHz = 1000 MHz = 1×10^9 Hz

Wavelength is the distance occupied by one cycle of a wave and is usually expressed in meters. The wavelength of a signal is represented by the Greek letter lambda (λ).

The wavelength and frequency are related by the formula $\boxed{f = c/\lambda}$

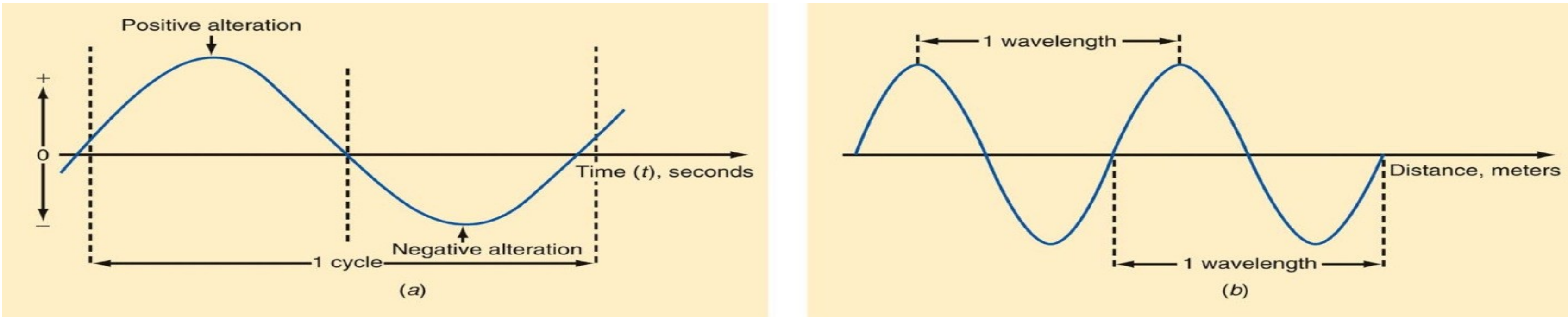
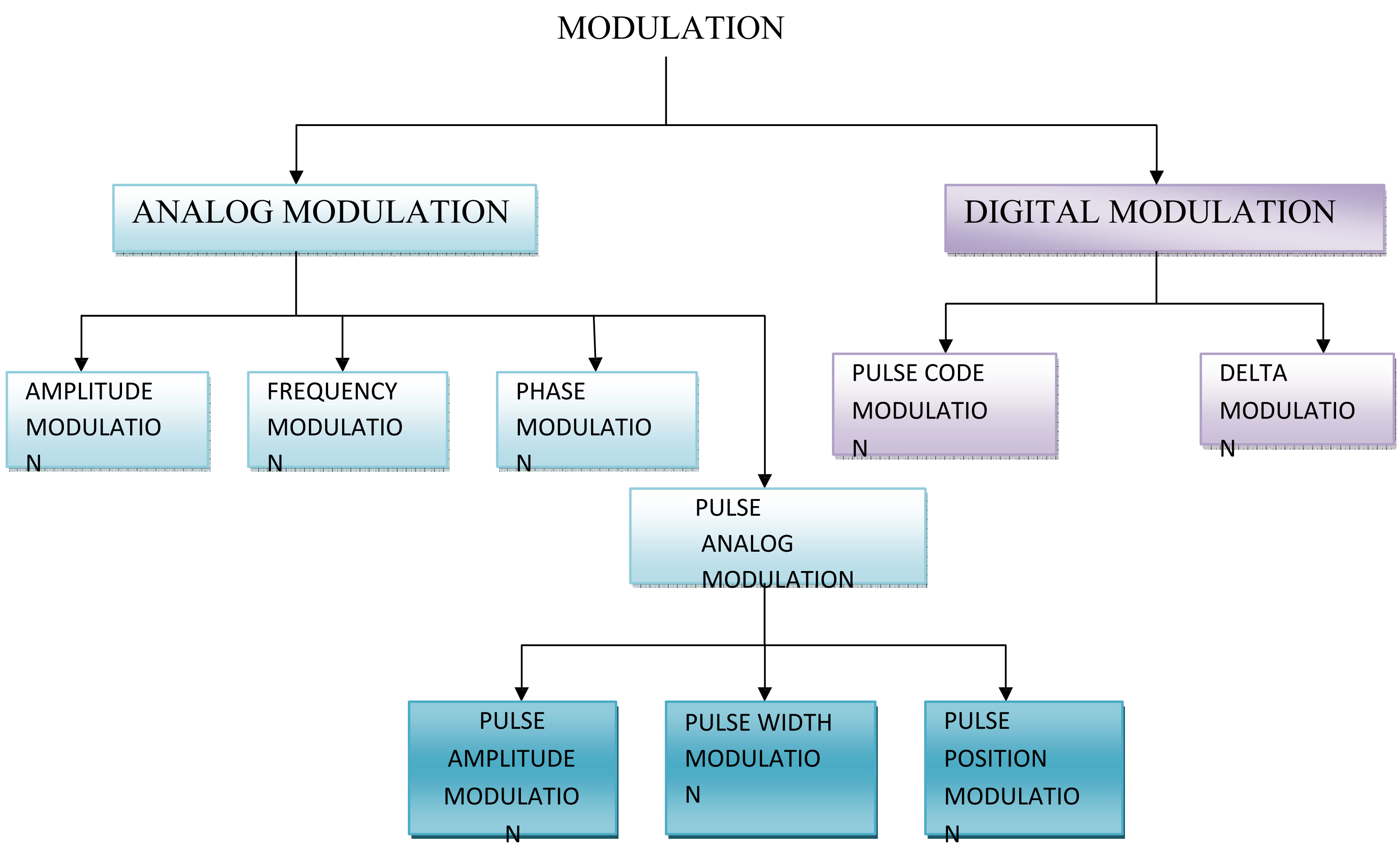


Fig 1.3: Frequency and wavelength

1.6 MODULATION

The electrical equivalent of the original information signal is called as the baseband signal. For the process of modulation, a high frequency signal called the carrier signal is needed along with the baseband signal. Modulation is the process of varying one attribute of the carrier signal by the message signal. A typical carrier signal can be represented as $v=A*\sin(2*\pi*f*t+\Phi)$. The three attributes that can be varied are the amplitude (A), frequency (f) and phase (Φ) of the signal. Accordingly they are called amplitude modulation, frequency modulation and phase modulation. The different kinds of modulation are shown below.



7. NEED FOR MODULATION

- Reduction in height of antenna – For efficient transmission and reception, the antennas should have height comparable to quarter wavelength of the frequency used.

As an example, to transmit a signal at f=10 kHz:

Minimum antenna height = $\lambda/4 = c/4f = 7500$ m. An antenna of this height is practically impossible to install.

For a modulated signal at f = 1 MHz:

Minimum antenna height = $\lambda/4 = c/4f = 75$ m. This can be installed practically.

Need for Modulation

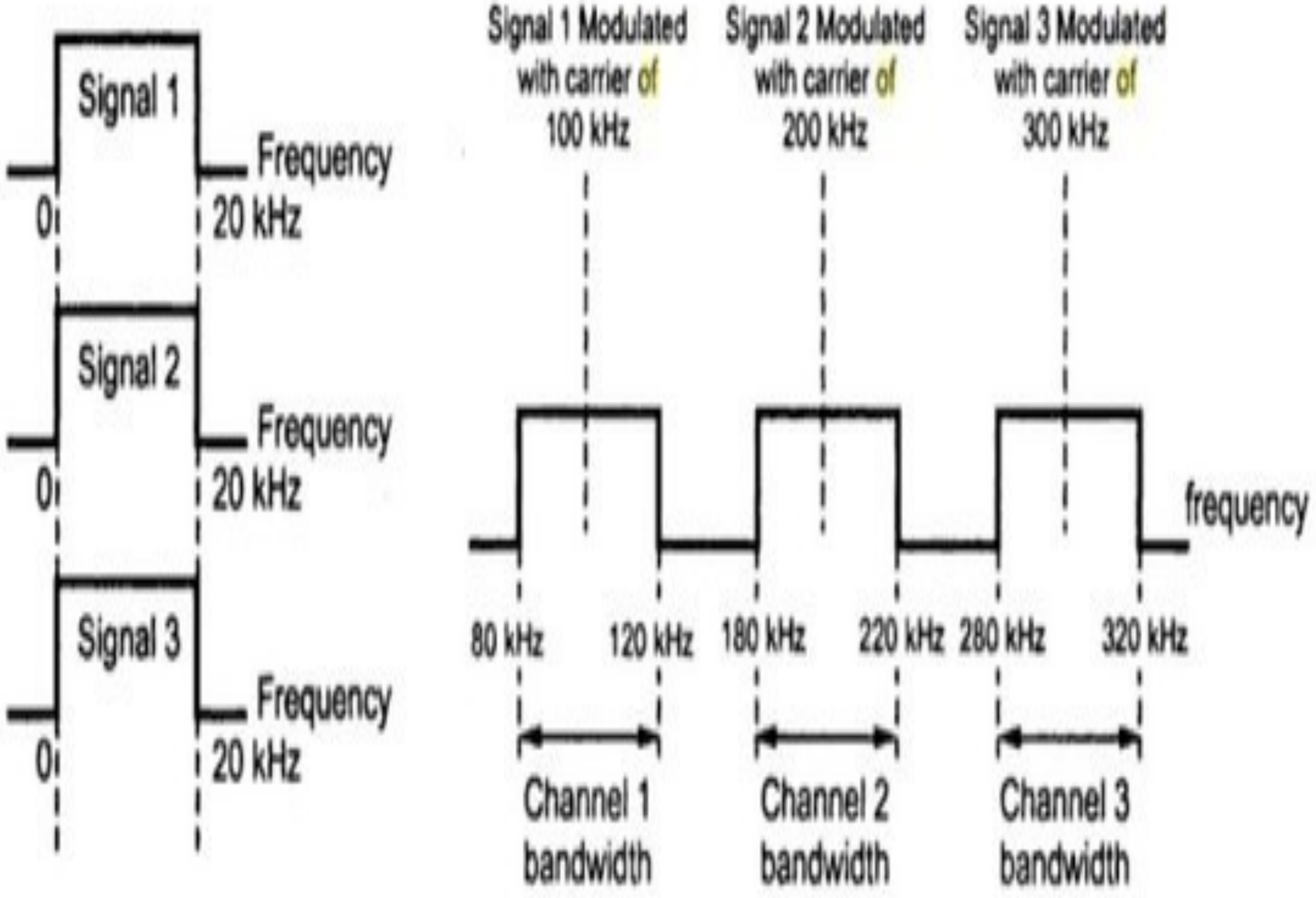
- Reduction in height of antenna
- Avoids mixing of signals
- Allows for multiplexing
- Increases range of communication
- Improves quality of reception

Reduction in height of antenna

- For efficient transmission & reception, the antenna height should be at least one-fourth the signal wavelength (λ/4).
- To transmit a signal of f = 10kHz
  - Minimum antenna height = λ/4 = c/(4f) = 7500 m
  - This is practically impossible !!
- Consider a modulated signal at f = 1 MHz
  - Minimum antenna height = λ/4 = c/(4f) = 75 m
  - This can be installed practically.

Avoids mixing of signals

- All soundis concentrated withinthe range from 20 Hz to 20 kHz.
- If no modulation is used, all the signals would get mixed up. The receiver would not be able to separate them from each other.
- If each baseband signal is used to modulate a different carrier, then they will occupy different slots in the frequency domain.



Signal 1
Frequency
0
20 kHz
Signal 2
Frequency
0
20 kHz
Signal 3
Frequency
0
20 kHz
Signal 1 Modulated with carrier of 100 kHz
Signal 2 Modulated with carrier of 200 kHz
Signal 3 Modulated with carrier of 300 kHz
frequency
80 kHz
120 kHz
180 kHz
220 kHz
280 kHz
320 kHz
Channel 1 bandwidth
Channel 2 bandwidth
Channel 3 bandwidth

Allows for multiplexing

- Multiplexing – Two or more signals can be transmitted over the same channel simultaneously.
- Multiplexing allows the same channel to be used by many signals.
- Therefore, many TV channels can use the same frequency range without getting mixed up with each other.

Increases range of communication

- Low frequency signal – low energy – travels low distances
- High frequency signal – high energy – travels longer distances.

Improves quality of reception

- Digital modulation techniques reduce the effect of noise to a large extent.