UNIT - 1

Electronic Communication

1. Introduction

Communication is the process of exchanging information. People communicate to convey their thoughts, ideas, and feelings to others. The process of communication is inherent to all human life and includes verbal, nonverbal (body language), print, and electronic processes. Two of the main barriers to human communication are language and distance. Language barriers arise between persons of different cultures or nationalities. Communicating over long distances is another problem. Communication between early human beings was limited to face-to-face encounters. Long-distance communication was first accomplished by sending simple signals such as drumbeats, hornblasts, and smoke signals and later by waving signal l ags (semaphores). When messages were relayed from one location to another, even greater distances could be covered. The distance over which communication could be sent was extended by the written word. For many years, long-distance communication was limited to the sending of verbal or written messages by human runner, horseback, ship, and later trains. Human communication took a dramatic leap forward in the late nineteenth century, when electricity was discovered and its many applications were explored. The telegraph was invented in 1844 and the telephone in 1876. Radio was discovered in 1887 and demonstrated in 1895.Years past, and new ways of electronic media emerged, such as the telephone, radio, television, and the Internet, enhancing our capacity to exchange knowledge. How well we connect has a direct impact on how we do things and how effective our work and personal lives are.

The Elements of an Electronic Communication System:

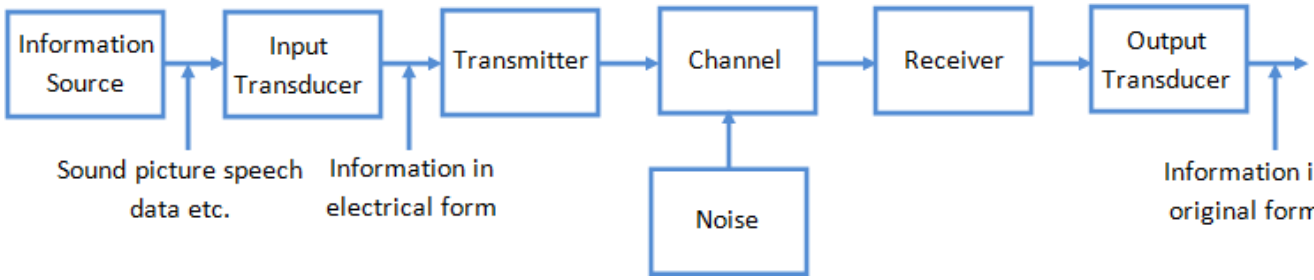


Figure 1: Block diagram of Electronics Communication System.

Primarily communication system consists of three main parts: i) **a transmitter ii) a communication channel and iii) a receiver**. In real Human or Source generate a signal, that contains the information and that signal is sent to the transmitter which transmits the information over a communication channel, and then the message is picked by

the receiver and receiver gives that information to the desired destination say human. In this process, a noise is always added to the information through the communication channel. A noise may be due to environmental effects, temperature, or not proper working of an instrument.

Transmitter:

The first step in sending a message is to convert it into electronic form suitable for transmission. For voice messages, a microphone is used to translate the sound into an electronic *audio* signal. For TV, a camera converts the light information in the scene to a video signal. In computer systems, the message is typed on a keyboard and converted to binary codes that can be stored in memory or transmitted serially. Transducers convert physical characteristics (temperature, pressure, light intensity, and so on) into electrical signals.

The *transmitter* itself is a collection of electronic components and circuits designed to convert the electrical signal to a signal suitable for transmission over a given communication medium. Transmitters are made up of oscillators, amplifiers, tuned circuits and filters, modulators, frequency mixers, and other circuits.

- **Communication Channel:**
- The communication channel is the medium by which the electronic signal is sent from one place to another. Many different types of media are used in communication systems, including wire conductors, fiber-optic cable, and free space.
- Communication channels are divided into two types.
- Guided communication channel: This is generally used in point to point or in-line communication. Parallel wires, coaxial cables are used for this type of communication.
- Non-guided communication channel: This channel is used for space and satellite communication. Free space is an example of a non-guided communication channel.

Noise:

- Noise refers to the unwanted signals that tend to disturb the transmission and processing of message signals in a communication system.
- The source generating the noise may be located inside or outside the system. Lightning, turning on or off electrical appliances may cause noise.

Receiver:

A receiver is a collection of electronic components and circuits that accepts the transmitted message from the channel and converts it back to a form understandable by humans. Receivers contain amplifiers, oscillators, mixers, tuned circuits and filters, and a demodulator or detector that recovers the original intelligence signal from the modulated carrier. The output is the original signal, which is then read out or displayed. It may be a voice signal sent to a speaker, a video signal that is fed to an LCD screen for display, or binary data that is received by a computer and then printed out or displayed on a video monitor.

2. The Terminology of Communication System:

2.1 Transducer:

Any device that converts one form of energy into another can be termed as a transducer. An electrical transducer may be defined as a device that converts some physical variable (pressure, displacement, force, temperature, etc.) into corresponding variations in the electrical signal at its output.

2.2 Signal:

- Information converted into electrical form and suitable for transmission is called a signal. Signals can be either analog or digital. A message is defined as a physical manifestation of information as produced by the source. The terms signal and message are used interchangeably.
- In an electronic communication system, a signal means time-varying electrical signal obtained from the original signal using transducer. These signals have their own nature, frequency and amplitude. There are two types of electrical signals

2.2.3 Analog Signals: Analog signals are continuous variations of voltage or current. They are essentially single-valued functions of time. The sine wave is a fundamental analog signal. All other analog signals can be fully understood in terms of their sine wave components. Sound and picture signals in TV are analog in nature.

2.2.4 Digital Signals: Digital signals are those which can take only discrete stepwise values. Binary system that is extensively used in digital electronics employs just two levels of a signal. „0“ corresponds to a low level and „1“ corresponds to a high level of voltage/ current. Generally, such signals are in the form of pulses. There are several coding schemes used for digital communication. The output of a computer, transmission of documents through the internet is done using digital signals. The digits 0 and 1 are called bits. A group

of bits is called byte or binary word. There are several coding schemes used for digital communication. They employ suitable combinations of number systems such as the binary coded decimal (BCD). American Standard Code for Information Interchange (ASCII) is a universally popular digital code to represent numbers, letters and certain characters.

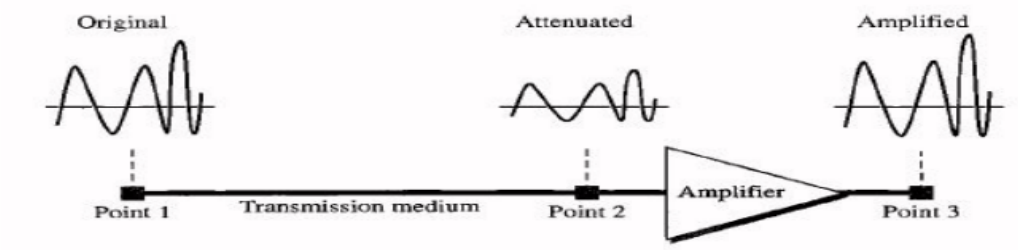
2.3 Attenuation:

- The loss of strength of a signal while propagating through the communication channel is known as attenuation.

  - The strength of a signal falls off with distance over any transmission medium.
  - Attenuation leads to loss of energy in decibel.

$$dB = 10 \log_{10}(P_2/P_1)$$

  - It decides how far a signal can be sent without amplification.



  - An amplifier can be used to compensate the attenuation of the medium.

2. 4 Amplification:

- It is the process of increasing the amplitude (and consequently the strength) of a signal using an electronic circuit called the amplifier
- Amplification is necessary to compensate for the attenuation of the signal in communication systems. The energy needed for additional signal strength is obtained from a DC power source. Amplification is done at a place between the source and the destination wherever signal strength becomes weaker than the required strength.

2. 5 Gain

Gain means amplification. If a signal is applied to a circuit such as the amplifier shown in Fig. 1.2 and the output of the circuit has a greater amplitude than the input signal, the circuit has gain. Gain is simply the ratio of the output to the input. For input (Vin) and output (Vout) voltages, voltage gain AV is expressed as follows:

$$A_V = \frac{\text{output}}{\text{input}} = \frac{V_{out}}{V_{in}}$$

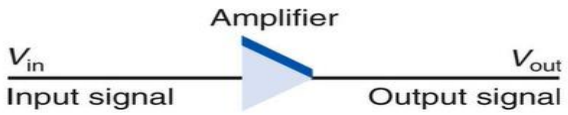


Figure 1.2: An amplifier has gain.

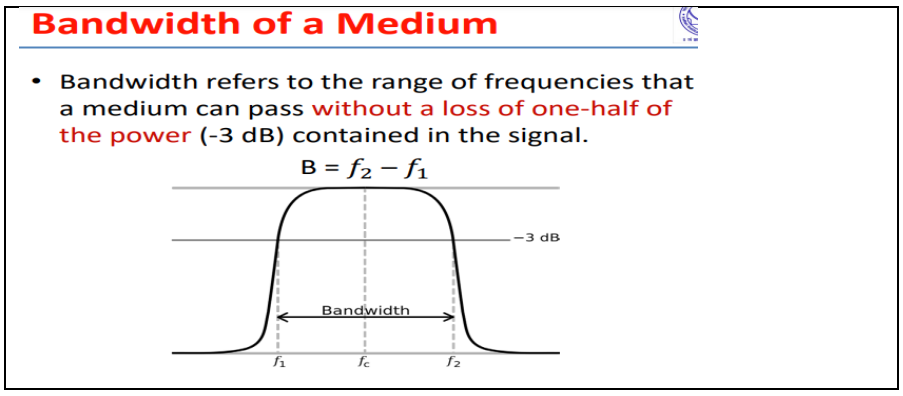
2. 6 Bandwidth

- Bandwidth refers to the frequency range over which an equipment operates or the portion of the spectrum occupied by the signal. Different types of signals have different bandwidth. It is also the frequency range over which a receiver or other electronic circuit operates. More specifically, bandwidth is the difference between the upper and lower frequency limits of the signal or the equipment operation range.

A Bandwidth of a Signal:

- In a communication system, the message signal can be voice, music, and picture or computer data. Each of these signals has different ranges of frequencies. The type of communication system needed for a given signal depends on the band of frequencies which is considered essential for the communication process.

  - Bandwidth of an analog signal is expressed in terms of its frequencies. It is defined as the range of frequencies that the composite analog signal carries. It is calculated by the difference between the maximum frequency and the minimum frequency.



For example, the range of music signal is 20 Hz to 15000 Hz.

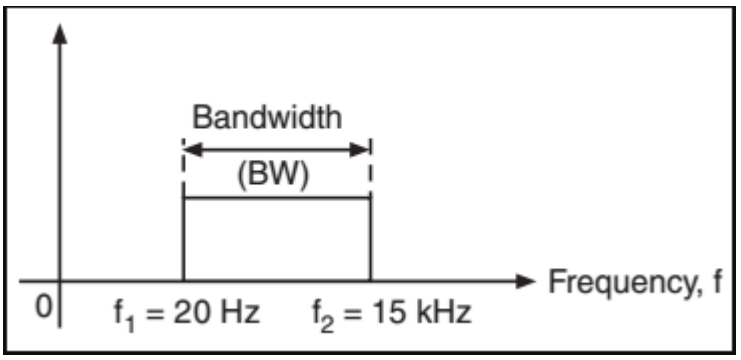


Figure.1 : Bandwidth of music signal

Therefore, as shown in figure 1, the bandwidth is = f2 – f1

Thus, BW = f2 – f1

BW = 15000 – 20 = 14980 Hz

The bandwidths of different signals are listed in table 1 below.

Signals	Frequency Range	Bandwidth of signal
Speech	300 Hz to 3100 Hz	2800 Hz
Music	20 Hz to 15000 Hz	14980 Hz
Video	1500 MHz to 1506 MHz	6 MHz
Computer data	2000 MHz to 2600 MHz	600 MHz

Bandwidth of Transmission Medium (Channel Bandwidth):

- Similar to message signals, different types of transmission media offer different bandwidths. The commonly used transmission media are wire, free space, and fibre optic cable.
- Coaxial cable is a widely used wire medium, which offers a bandwidth of approximately 750 MHz. Such cables are normally operated below 18 GHz. Communication through free space using radio waves takes place over a very wide range of frequencies: from a few hundreds of kHz to a few GHz. This range of frequencies is further subdivided and allocated for various services.
- Optical communication using fibers is performed in the frequency range of 1 THz to 1000 THz (microwaves to ultraviolet). An optical fiber can offer a transmission bandwidth in

excess of 100 GHz.

- Spectrum allocations are arrived at by an international agreement. The International Telecommunication Union (ITU) administers the present system of frequency allocations.
- Frequency allocation to different services is given below.

Nature of Broadcast	Frequency Band
Amplitude modulated (AM)	540 kHz to 1600 kHz
Frequency modulated (FM)	88 MHz to 108 MHz
Very high frequency (VHF) T.V.	54-72 MHz to 174-216 MHz
Ultra high frequency (UHF) T.V.	420 MHz to 890 MHz
Mobile telephony Mobile to base station	896 MHz to 901 MHz
Mobile telephony Base station to Mobile	840 MHz to 935 MHz
Satellite Communication Uplink	5.925 GHz to 6.425 GHz
Satellite Communication Downlink	3.7 GHz to 4.2 GHz

3. Types of Electronic Communication:

Electronic communications are classified according to whether they are (1) one-way (simplex) or two-way (full duplex or half duplex) transmissions, (2) analog or digital signals and (3) Baseband and Modulated Signal.

(1) One-way (Simplex) and Two-Way Communication (Duplex):

(2) Analog and Digital Communication:

(3) Baseband and Broadband (Modulated) Signal:

3. 1. One-way (Simplex) and Two-Way Communication (Duplex)

1. One-Way Communication (Simplex System):

One-way communication or simplex communication is the simplest form of communication. In Simplex communication, information travels only in one direction. A common Example of One-

way or Simplex Communication is TV Broadcasting, RADIO, and Music. In these all types of Electronic communication, information travels from source to destination through one-way only.

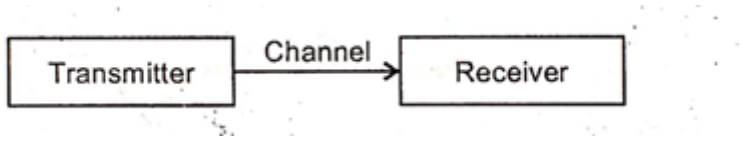


Figure 2: Simplex Communication System

2. Two-Way Communication (Duplex System):

Two-Way Communication is further classified into two different ways.

A. Half Duplex B. Full Duplex

A. Half Duplex: In a Half Duplex Mode, the data/information can be sent in both the directions, but one at a time and not simultaneously. For example, a *walkie-talkie* is a device that can be used to send message in both the directions, but both the persons cannot exchange the message simultaneously. One can only speak and the other can only listen.

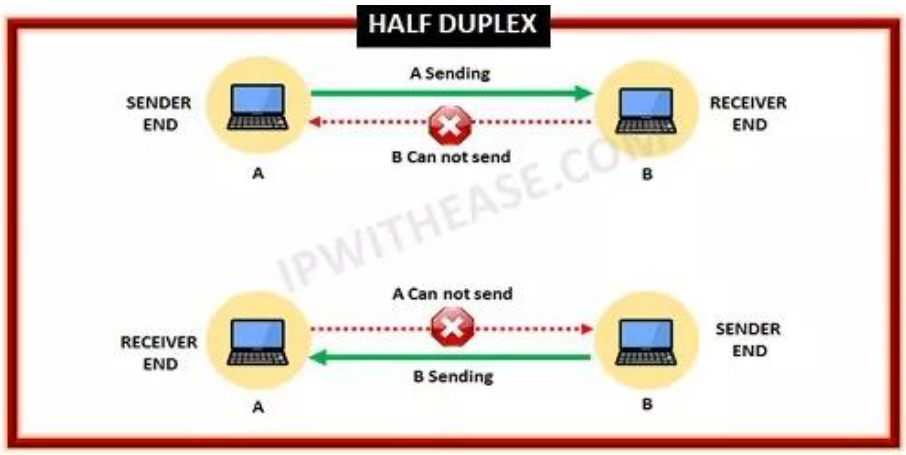


Figure 3: Half Duplex Communication

B. Full Duplex: In a Full Duplex Mode, the transmission of the information between the sender and the receiver can occur simultaneously. It is used when communication in both directions is required all the time. For example, a telephone is a two way communication in which both the persons can talk and listen to each other at the same time.

e.g: Telephone, Two-way radio, Radar, and Sonar etc…

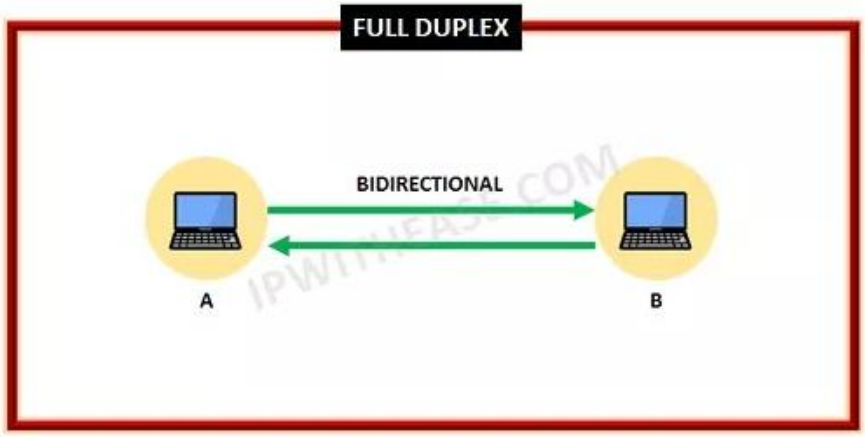


Figure 4: Full Duplex Communication

3.2. Analog and Digital Communication:

Another way to classify electronic communication is by the type of information transmitted over the channel. Signals are basically of two types-

1. Analog

2. Digital

Accordingly one can have analog communication or digital communication.

a. **Analog Communication:** An analog signal is a physical quantity that varies continuously with time. All naturally occurring signals are analog in nature. *Example*: voice signal, video signal of television etc. Traditional electronic communication systems that use conventional analog modulation, such as Amplitude Modulation (AM), Frequency Modulation (FM), and Phase Modulation (PM) are analog communication systems.

b. **Digital Communication:** A digital signal on the other hand, is discrete in value and time. Digital communication is a rather ambiguous term that could have entirely different meaning to different people. Digital communication systems transport information in digital form. If the information is analog, it is converted to digital for transmission. At the receiver, it is reconverted to analog. Following figure shows voice transmission over digital channel.

3. 3. Baseband and Broadband Communication

Baseband means the signal is transmitted at its base frequencies, and no modulation to another frequency range has occurred.

Baseband Communication: All original signals- whether analog or digital are referred to as baseband signals. In baseband transmission, the original signal is directly sent over the communication channel.

Example: In many telephone and intercom systems, the voice signal is sent over wires over some distance to the receiver; digital signals are transmitted over coaxial cables in some computer networks.

Broadband Communication: There are certain limitations regarding baseband signals. They may be incompatible with the media or cannot be transmitted over longer distance because of signal attenuation.

4. Electromagnetic Communication Spectrum

When you tune your radio, watch TV, send a text message, or pop popcorn in a microwave oven, you are using electromagnetic energy. You depend on this energy every hour of every day. Without it, the world you know could not exist.

Electromagnetic energy travels in waves and spans a broad spectrum from very long radio waves to very short gamma rays. The human eye can only detect only a small portion of this spectrum called visible light. A radio detects a different portion of the spectrum, and an x-ray machine uses yet another portion. NASA's scientific instruments use the full range of the electromagnetic spectrum to study the Earth, the solar system, and the universe beyond.

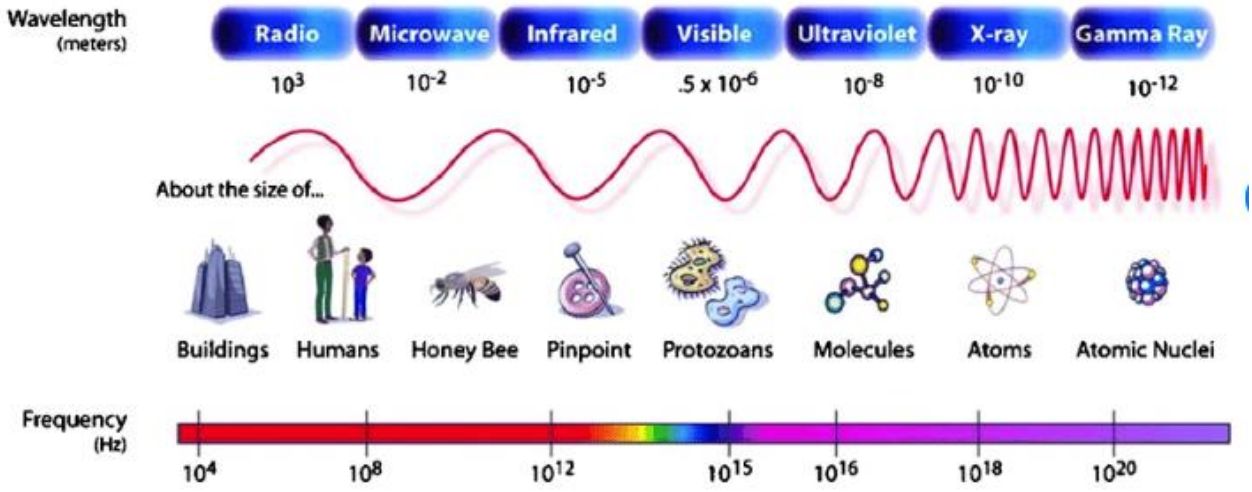


Figure 5: Electromagnetic spectrum

Radio waves:

Radio waves are the electromagnetic waves with the longest wavelengths and lowest frequencies. They include broadcast waves (for radio and television) and microwaves.

Radio waves with longer wavelengths are used in broadcasting. They carry signals for both

radio and television programs. A broadcast station sends out radio waves at certain frequencies. Your radio or TV antenna picks up the waves and converts the radio signal into an electrical signal. Inside your radio, the electrical signal is converted to sound. Inside your TV, the signal is converted to sound and pictures.

Microwaves: Frequencies between the 3GHz and 30GHZ range arc called Microwave. Microwave ovens usually operate at 2.45 GHz. Super high frequencies (SHFs) are in the 3- to 30-GHz range. Microwaves The radio waves with the shortest wavelengths and the highest frequencies are microwaves. When you think of microwaves, you probably think of microwave ovens that cook and heat your food. But microwaves have many uses, including cellular phone communication, satellite communication and radar.

Infrared :

The infrared part of the electromagnetic spectrum covers the range from roughly 300 GHz to 400 THz (1 mm - 750 nm).

Infrared radiation is generally associated with heat. Infrared is produced by light bulbs. our bodies and many physical equipment that generates heats. Infrared signal can also be generated by special types of light-emitting diodes (LEDs) and laser infrared is also used in new TV remote-control and to guide the missiles to targets.

Visible radiation (light)

Light is a special type of electromagnetic radiation that has wavelength between 380 nm and 760 nm (400–790 terahertz). Red is low-frequency or long-wavelength light, whereas violet is high-frequency or short-wavelength light.

Light is used for various kinds of communication. Light waves can be modulated and transmitted through glass fibers, just as electric signals can be transmitted over wires.

Ultraviolet: Ultraviolet light (UV) covers the range from about 4 to 400 nm. Ultraviolet is not used for communication; its primary use is medical.

Beyond the visible region are the X-rays, gamma rays and cosmic rays. These are all forms of electromagnetic radiation, but they do not figure into communication systems and are not covered here.

X-Ray: **X-rays** are electromagnetic waves with wavelengths just shorter than those of ultraviolet rays. Their frequencies are just a little higher than ultraviolet rays. Because of their high frequencies, X-rays carry more energy than ultraviolet rays and can penetrate most matter. But dense matter, such as bone or lead, absorbs X-rays and does not allow them to pass through. Therefore, X-rays are used to make images of bones inside the body or of

teeth. X-rays pass through skin and soft tissues, causing the photographic film in the X-ray machine to darken when it is developed.

Gamma Rays

Gamma rays are the electromagnetic waves with the shortest wavelengths and highest frequencies. Because they have the greatest amount of energy, gamma rays are the most penetrating of all the electromagnetic waves. Some radioactive substances and certain nuclear reactions produce gamma rays. Because of their great penetrating ability, gamma rays have some medical uses. For example, gamma rays can be used to kill cancer cells inside the body

5. Noise

Definition of noise

"In common use, the word noise means any unwanted sound". Noise is unwanted signal presented in the given wanted signal due the random fluctuation in an electrical signal and circuit characteristics.

5.1 Types of Noise:

There are several sources of noise. The noise introduced in the transmitting medium is termed as *external noise*. The noise introduced by the electronic circuit is termed as *internal noise*.

External noise occurs due to following:

a. ***Human-made noise:*** Produced by spark-producing mechanisms such as engine ignition system, fluorescent lights, electric motors. Human-made noise occurs randomly at frequencies up to around 500 MHz.

b. ***Atmospheric noise;*** It is caused by naturally occurring disturbances in the earth's atmosphere because of lightning discharges, thunderstorm etc. The frequency content is spread over the entire radio spectrum.

c. ***Space noise:*** Noise arises due to sun is called solar noise which is cyclical and reaches peaks about every 11 years. All other stars also contribute to space noise called as cosmic noise. Frequency spectrum is 8 MHz up to 1.5 GHz.

Internal noises generated by electronic circuits are of two basic types

a. ***Johnson noise / Thermal noise:*** At temperature greater than absolute zero, thermal energy causes microscopic particles to exhibit random motion. The random motion of charged particles such as electrons generates random currents or voltages called as thermal noise. It's frequency content is spread equally throughout the usable spectrum. So it is also called as white noise. It appears in every communication system.

b. ***Shot noise:*** Introduced by transistor.

Other than this at low frequency (<1 KHz) flicker noise and at high frequencies transit –time noise occurs. These two also contribute to internal noise.

5.2 Signal-to-noise (S/N) Ratio:

The signal-to-noise (S/N) ratio, also designated SNR, indicates the relative strengths of the signal and the noise in a communication system. The stronger the signal and the weaker the noise, the higher the S/ N ratio. If the signal is weak and the noise is strong, the SIN ratio will be low and reception will be unreliable. Communication equipment is designed to produce the highest feasible S/ N ratio. Signals can be expressed in terms of voltage or power. The S/N ratio is computed by using either voltage or power values:

$$\frac{S}{N} = \frac{V_S}{V_n} \quad \text{or} \quad \frac{S}{N} = \frac{P_S}{P_n}$$

where Vs = signal voltage

Vn = noise voltage

Ps = signal power

Pn = noise power

Assume, e.g., that the signal voltage is 1.2 μV and the noise is 0.3 μV. The S/N ratio is 1.2/0.3 = 4. Most S/ N ratios are expressed in terms of power rather than voltage.

For example, if the signal power is 5 μW and the noise power is 125 nW, the S/ N ratio is $5 \times 10^{-6} / 125 \times 10^{-9} = 40$.

Usually S/N is expressed in decibels as follows:

For voltage: dB = 20 log S/ N = 20 log 4 = 20(0.602) = 12 dB

For power: dB = 10 log S/N = 10 log 40 = 10(1.602) = 16 dB

For example: A receiver has an input signal power is 1.2 mW and the noise power is 0.3 mW. The S/N ratio is

S/ N=10 log(1.2/0.4)= 10 log 3

=4.77dB

To improve value of S/N, either signal power should be increased or noise power should be reduced. Some modulation techniques provide more options for betterment of S/N.

Multiple choice Questions

1. An analog signal is a continuously varying …..
   A) Voltage or current B) Only voltage
   C) Only current D) none of these
2. Original information signal is known as …..
   A) Only Voice B) base band signal
   C) Only video D) none of these
3. For successful communications, amplification of signal is required.....
   A) at transmitter only B) at receiver only
   C) both at transmitter & at receiver D)None of these
4. Communication technique using modulation is referred to as …….
   A) Only Voice B) base band signal
   C) Only video D) broad band

5 .Example of simplex communication is ……

A) radio B) walky-talky
C) ATM machin D) none of these

6. Example of duplex communication is ……
   A) radio B) television
   C) telephone D) printer
7. Communication through walky-talky is a….
   A) Simplex B) Half Duplex
   C) Full Duplex D) None of these.
8. Any unwanted signal that is associated with desired signal is known as ……..
   A) Digit B) Noise
   C) Echo D) temperature
9. The communication medium cause the signal to be ……
   A) amplified B) detected
   C) attenuated D) modulated

10. In any communication system, the S/N ratio should be …….

A) As low as possible B) As high as possible

C) Infinite D) none of these

11. A television (TV) transmission is an example of …… type of transmission

A) Simplex B) Half Duplex

C) Full Duplex D) All of these

12. The portion of the electromagnetic spectrum occupied by a signal is called as …….

A) bandwidth B) wavelength

C) frequency D) All of these

13. Noise always affects the signal in communications systems at the……..

A) transmitter B) channel

C) information source D) destination

Long Answer Questions

1) Draw the basic block diagram of electronic communication system. State the function of transmitter.
2) What are modes of communication system? Explain each mode in brief.
3) Explain electromagnetic spectrum in brief.
4) Explain the concept of noise and also explain its types.

Short Answer Questions

1) Define the term signal to noise ratio.
2) Compare simplex and duplex mode of communication.
3) Write short notes on:
   1. Analog and digital Communication
   2. Base band and Broadband communication
4) Explain the classification of noise as an external noise and internal noise.
5) If a receiver has an input signal power of 1.5μW and the noise power is 0.2 μW, than calculate its signal to noise ratio.
6. Explain the following terms
   1. Bandwidth
   2.Attenuation
   3.Broadband communication
   4.Signal to noise ratio