BASIC COMMUNICATION SYSTEM

SITI HASMAH BINTI JAMALI

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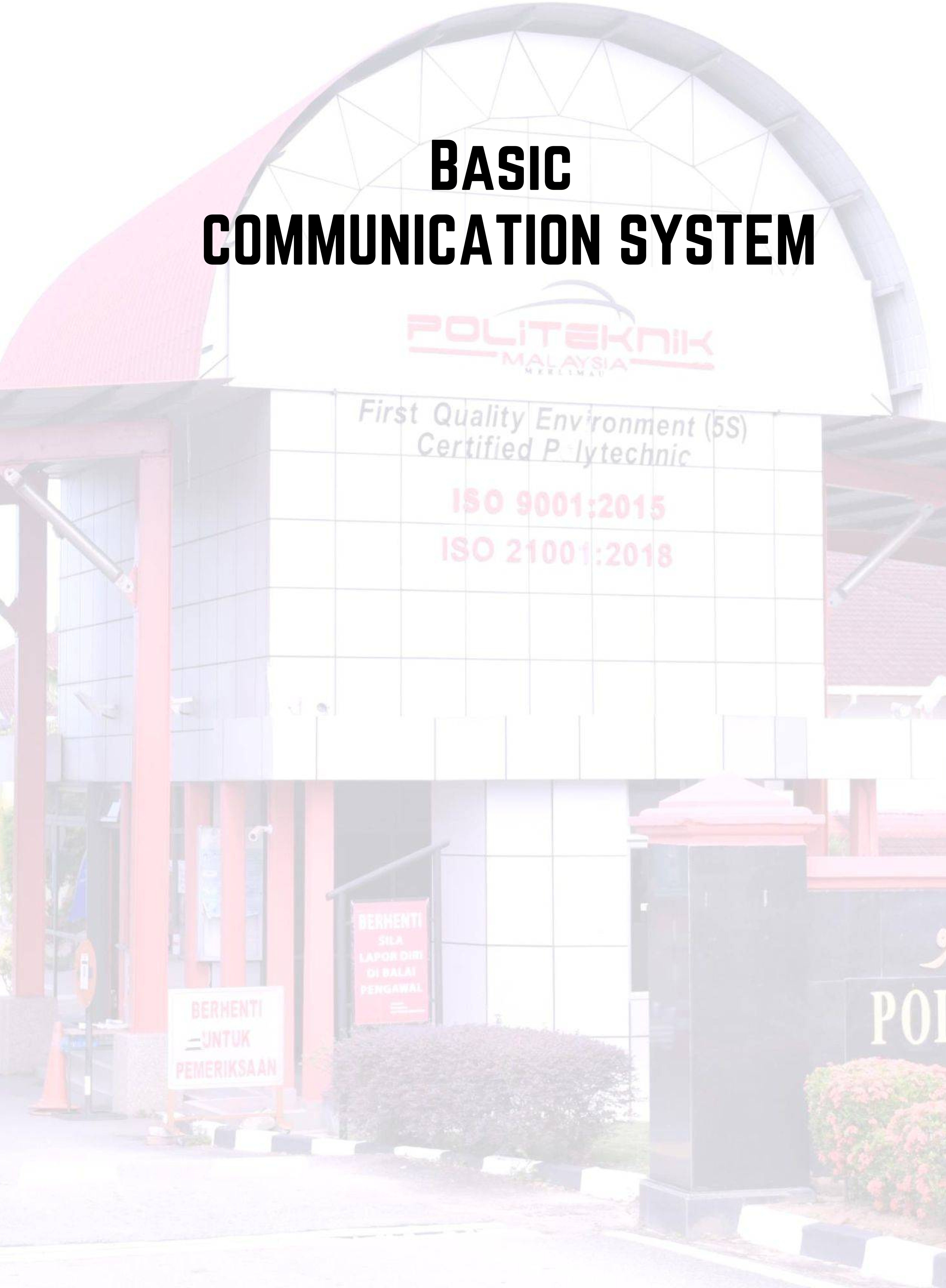

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In the Name of Allah, the Most Merciful, the Most Compassionate. Alhamdulillah all praises belong to Almighty Allah, the Lord of the worlds, and prayers and peace be upon Muhammad His servant and messenger.

First and foremost I would like to thank the Almighty God for giving me the blessings to complete this book. This Basic Communication System eBook is a success due to the assistance and motivation of many people, especially in the Electrical Engineering Department.

Special thanks to my family and colleagues who have directly or indirectly supported me in completing this eBook. Last but not least, I would like to thank the publisher Penerbit PMM, and the e-Learning teams of Politeknik Merlimau (PMM) for their support.

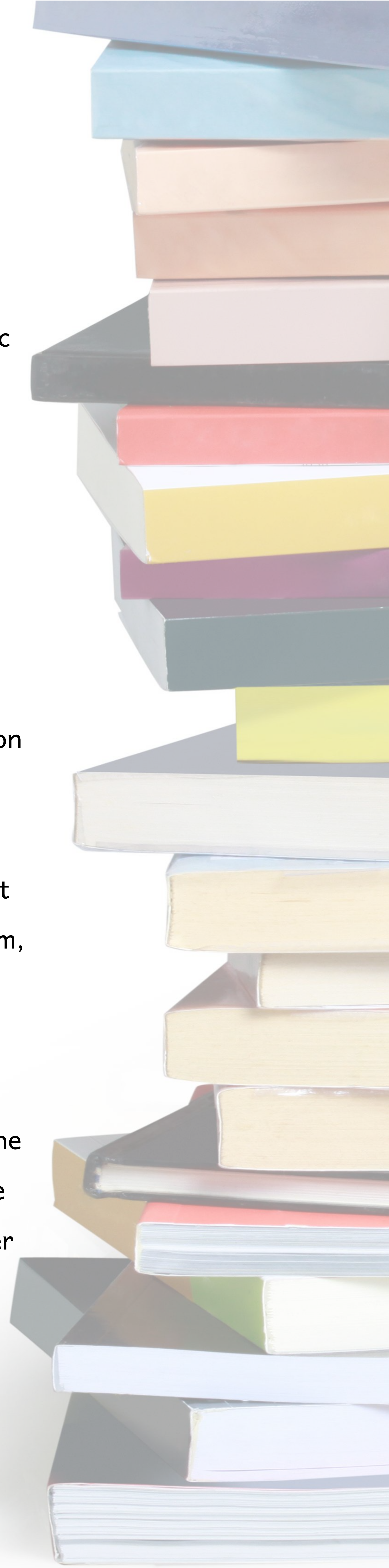
Preface

This book is primarily designed for Electronic (Communication) Engineering students and those who need an understanding of Basic Communication System.

This eBook is written to introduce the basic concepts of a Communication System components which are information source, input transducer, transmitter, communication channel, receiver, output transducer, and destination. It also includes the topic of impairment in communication that will affect the quality of the signal, frequency spectrum, transmission mode, and types of communication system.

Hopefully, this eBook will be beneficial for the students and general readers as well , while at the same time contribute towards a better understanding of Communication Systems.

Siti Hasmah Jamali

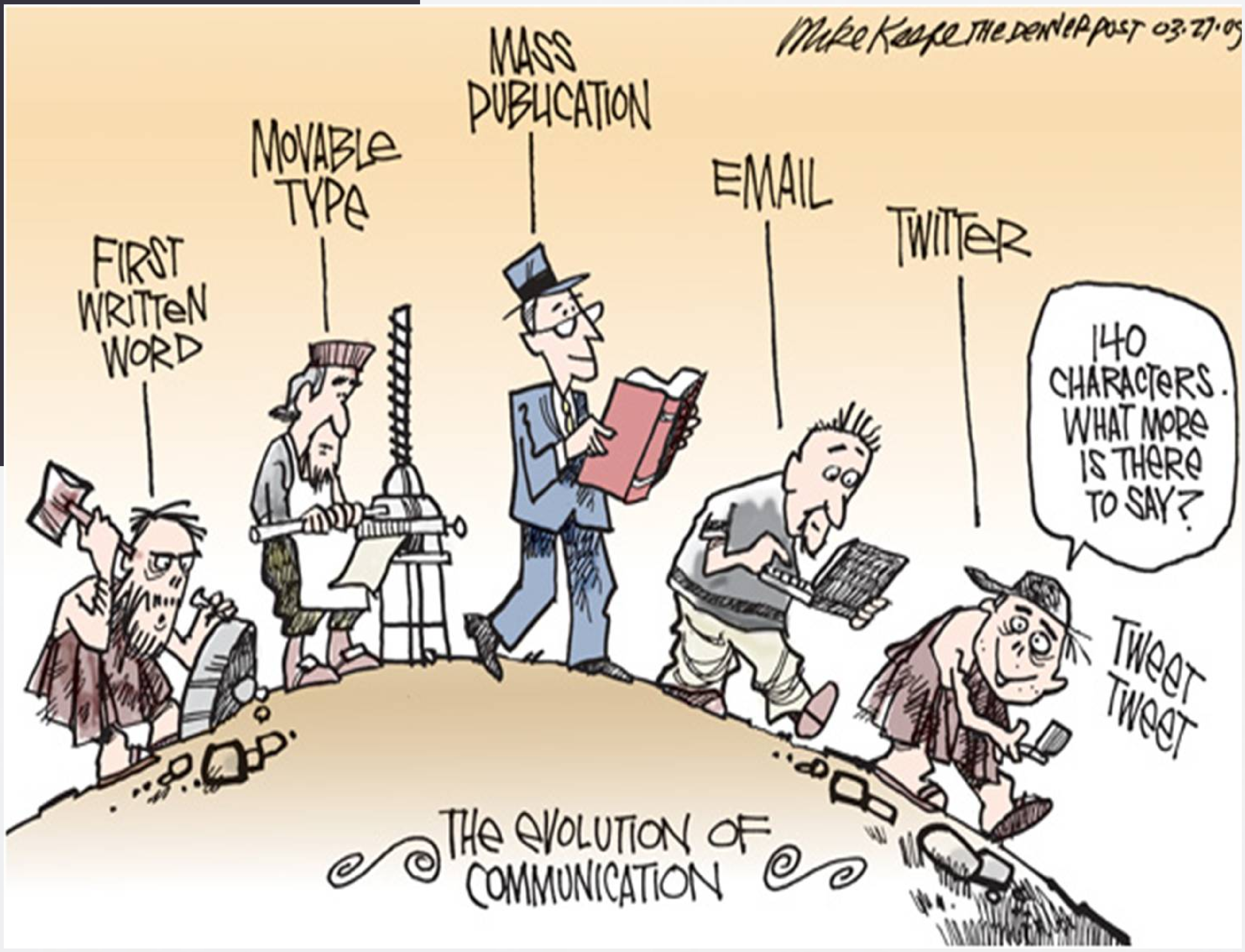


"How do you want to send iformation to someone that is far from you?"

"If the information that you want to send is your voice, how to make sure that what you are saying is understood by your friend?"

"What is the source and technology available around you that can assist you ?"

Table of Content



Topic 1

Introduction to Communication System

The Significance of Human Communication

A communication system conveys information from its source to a destination.

"People communicate to convey their thoughts, ideas and the main barriers to human communication are languages as well as distance."

An Overview of Communication Systems

Figure 1.1 : An Overview of Communication Systems

1.1 WHAT IS A COMMUNICATION SYSTEM?

A communication system is a process of transferring and receiving information through a transmission medium between two or more points. In contrast, telecommunication is the process of sending information over long distances between two or more poi

Historically, communication methods included using audio or visual cues, like smoke or flag signals. Rhythmic drumming and lung-blown horns Figure 1.2 illustrates visual telegraphy, also known as semaphore in 1792.

Figure. 1.2 : Semaphore

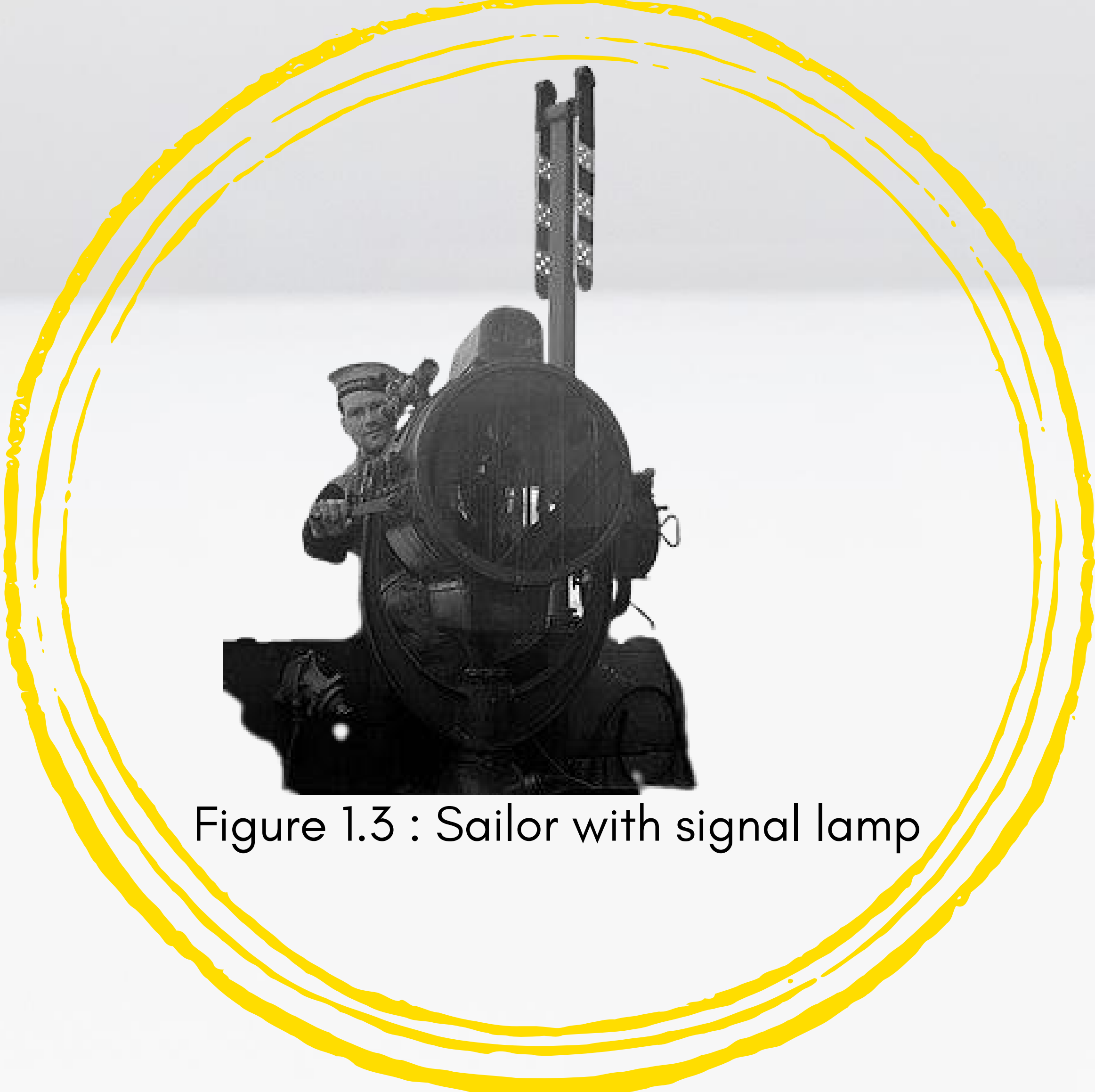


Figure 1.3 : Sailor with signal lamp

As seen in Figure 1.3, a signal lamp is a semaphore system that uses a visual signalling device and frequently uses Morse code.

The Royal Navy started utilising signal lamps in the 1800s. A tower, building, or other kind of structure intended to emit light is used as a semaphore in the modern lighthouse.

In the current electronic and electrical era, various methods have been used for communication, as shown in Figures 1.4 and 1.5. These methods include the use of telegraph (1839), telephone (1876), teletype, radio, television, microwave communication, satellite, radar, cellular, data communication, fibre optic communication, and others.

Figure 1.4 : Telegraph

Figure 1.5 : Microwave Communication

1.2 ELEMENTS IN A COMMUNICATION SYSTEM

Every electronic communication system consists of a transmitter, a medium and a receiver. A basic communication system is made up of FIVE (5) elements, as shown by Shannon's basic communication block diagram. Figure 1.6 depicts these elements.

The General Communication Model by Claude Shannon

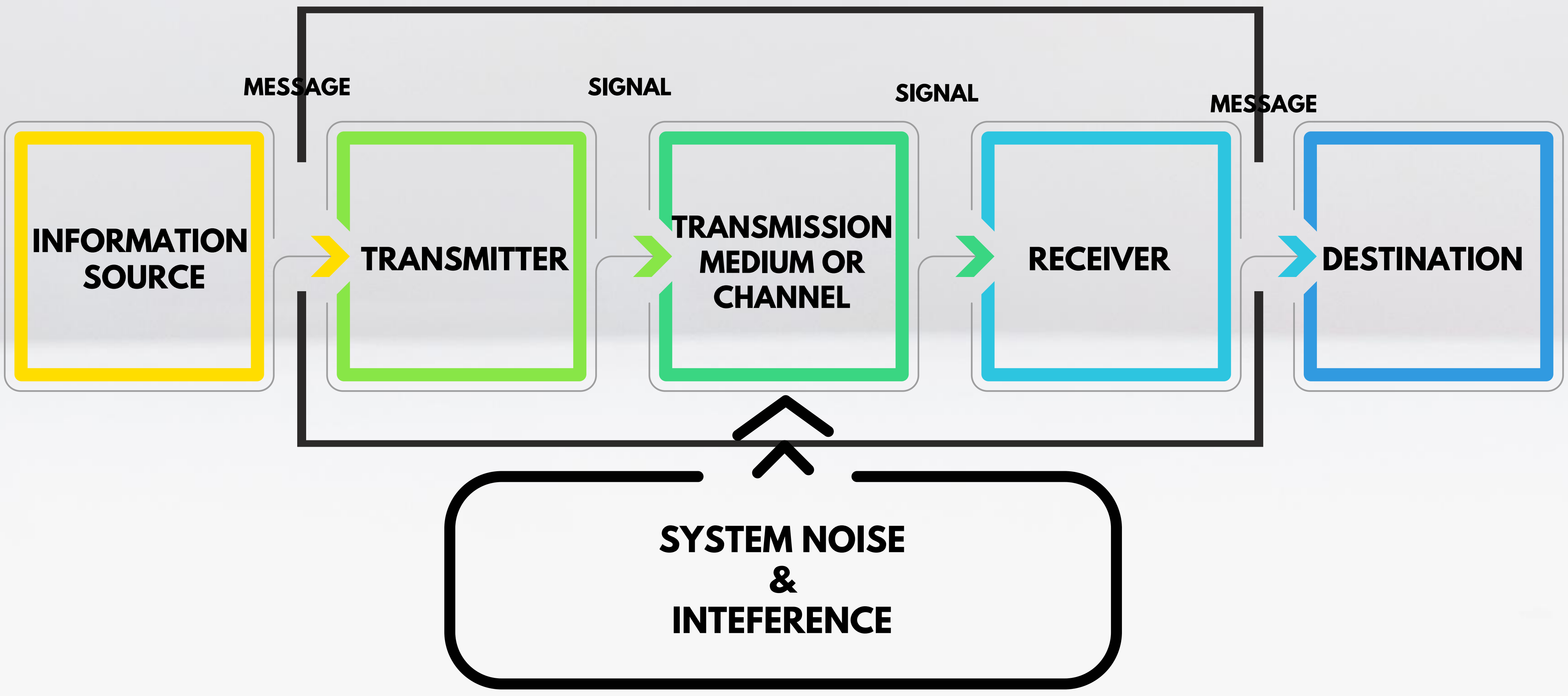


Figure 1.6: Block Diagram for a Basic Electronic Communication System

INFORMATION SOURCE

- Text, audio, image, and video content that needs to be forwarded to the recipient are all produced by the original source.
- The source's information may be produced in digital (alphanumeric codes, binary coded numbers) or analogue (human voice, audio) formats.
- Examples: electronic gadgets, computers, and cell phones.

TRANSMITTER

- An electronic component or device that transforms data from the original source into a format better suited for delivery via a specific transmission channel.
- Consists of the multiplexing, encoding, and modulation processes.
- Examples: Light source, encoder, modulator, multiplexer

TRANSMISSION MEDIUM/CHANNEL

- A channel is a medium, path or link that is capable of transferring the electronic signal from transmitter to receiver.
- Waveguide, Microstrip, Free Space, Coaxial, Fibre Optic, and Twisted Pair cables are a few examples.

(a) Fiber Optic

(b) Coaxial Cable

(c) Twisted pair

(d) Antenna

Figure 1.7 : Transmission Medium/Channel

RECEIVER

- A grouping of one or more electronic components that acts as a transmission medium to receive signals and then transform them back into the original form of information.
- Consists of the decoding, demultiplexing, and demodulation procedures.
- Demultiplexer, photo detector, transducer, demodulator, and decoder are a few examples.

DESTINATION

- Any devices that can receive and store the data that has been transmitted.
- People, computers, cell phones, and electronic gadgets are some examples.

SYSTEM NOISE

- Noise is defined as anything that unintentionally disrupts the information signal.
- Internal, cosmic, man-made, thermal, and atmospheric noises are a few examples.

A Data Communication System is depicted in Figure 1.8 below, while a Telephone Communication System is shown in Figure 1.9. Additionally displayed are the examples for each element in Figures 1.8 and 1.9.

Figure. 1.8 : System of Data Communication

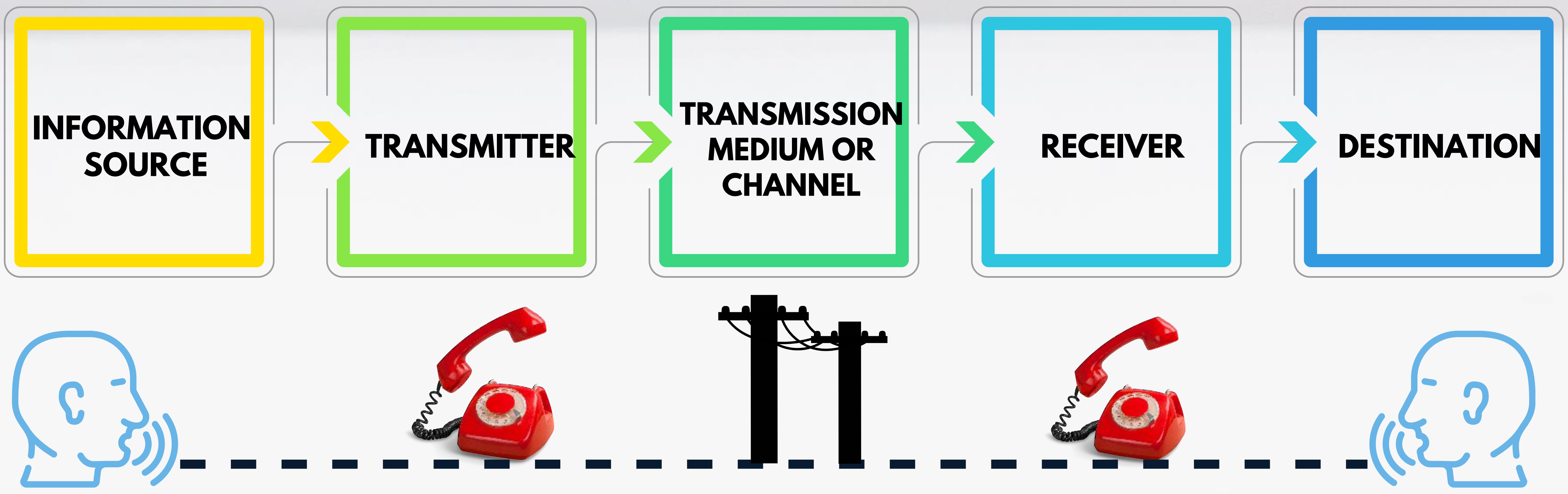


Figure. 1.9 : Telephony Communication system

1.3 INFORMATION, MESSAGE AND SIGNAL

Every electronic communication system consists of a transmitter, a medium and a receiver. Communication starts when a person produces a message, information, or other intelligence that needs to be understood by other people.

Information is a source of original data that is not processed or transformed into a signal by the transmitter. It can be kept on any kind of device, including digital cameras, recorders, computers, and video cameras. Information can be presented as text, images, audio, video, or alphanumeric characters.

A message, which can also be produced by an electronic current or a computer, is a representation of information. The message is called an intelligence signal or information in electronic communication systems. This message is sent to the transmitter as an electronic signal, which uses the communication channel to send it out. The recipient receives the message and transmits it to another person. Both the communication channel and the receiver are subjected to noise along the route. Noise is any phenomenon that deteriorates or interferes with information being transmitted.

Figure 1.10 show the information conversion as it goes along the element in the communication system.

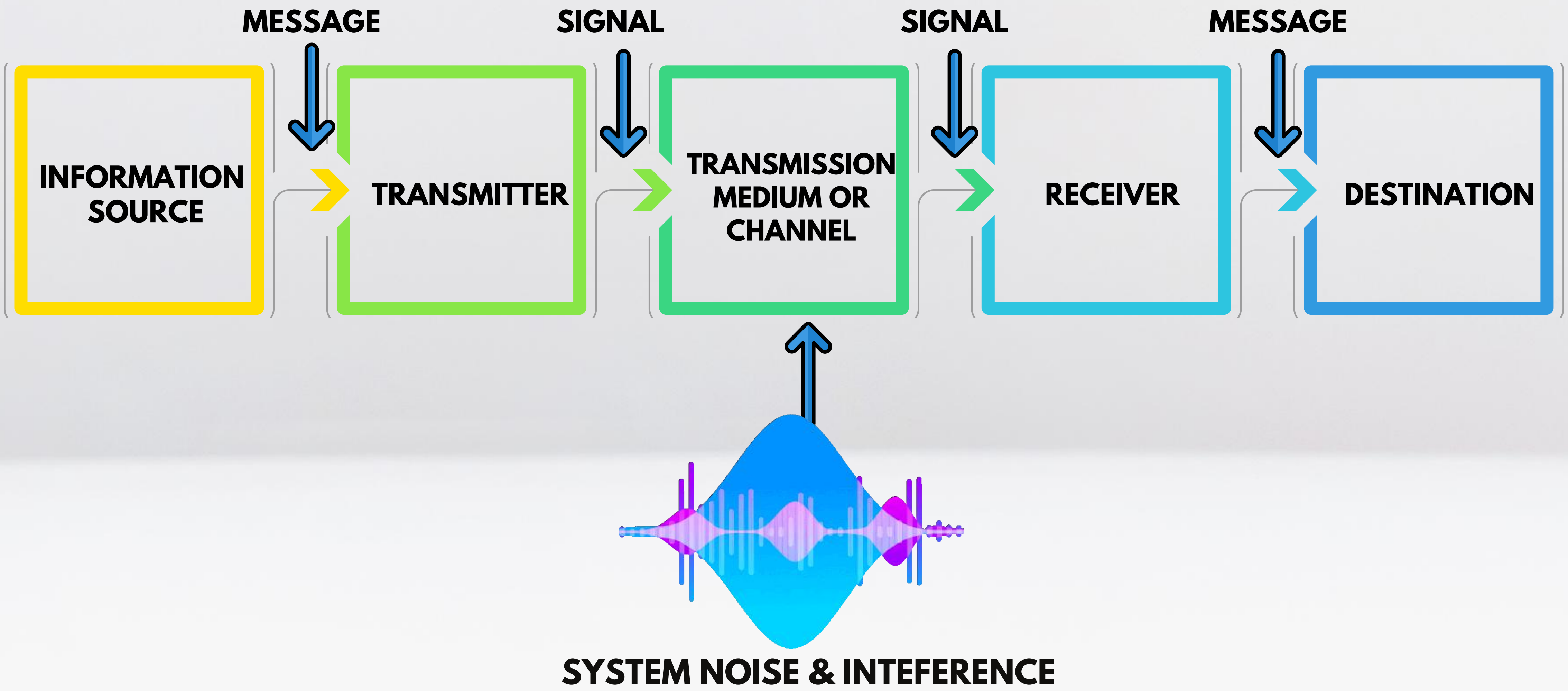


Figure 1.10 : Different between Information, Messge and Signal

What is Signal?

An electrical or electromagnetic current used to send data between networks or systems is referred to as a signal. An information-carrying function for a phenomenon is called a signal.

The signal is information that has been transformed into a quantity that can vary in space or time and be measured. Any time-varying voltage that is an electromagnetic wave that transmits data is referred to as it in electronics and telecommunications. When data needs to be transferred from one location to another, a signal can be an electromagnetic wave, electric current, or light. An observable change in quality, like quantity, can also be referred to as a signal. Signals can be divided into two categories: digital signals (which have discrete times) and analogue signals (which have continuous times).

What is an Analog Signal?

A continuous signal with one time-varying quantity representing another time-based variable is called an analog signal.

It can have amplitudes that are limitless (uncountable), such as those of audio and human speech. The analog waveform obtained using an oscilloscope is displayed in Figure 1.11.

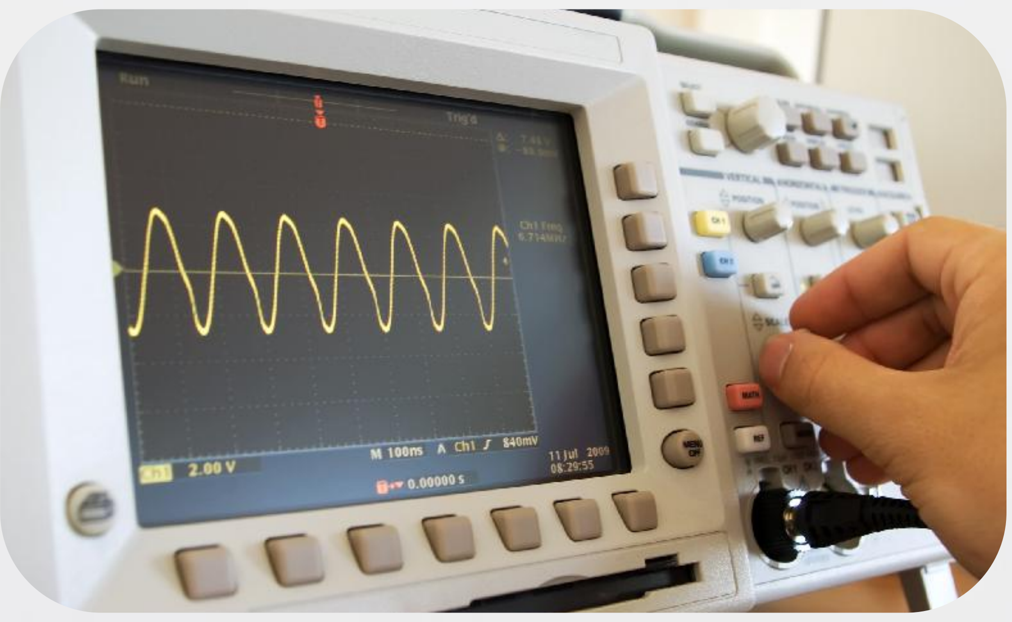


Fig. 1.11 : Analog waveform

What is a Digital Signal?

A discrete or limited signal that produces and interprets data as ones and zeros (1s and 0s).

Figure 1.12 illustrates its finite (countable) set of amplitudes. Examples include digitally encoded analog signals, computer-generated data, alphanumeric codes, binary-encoded numbers, etc.

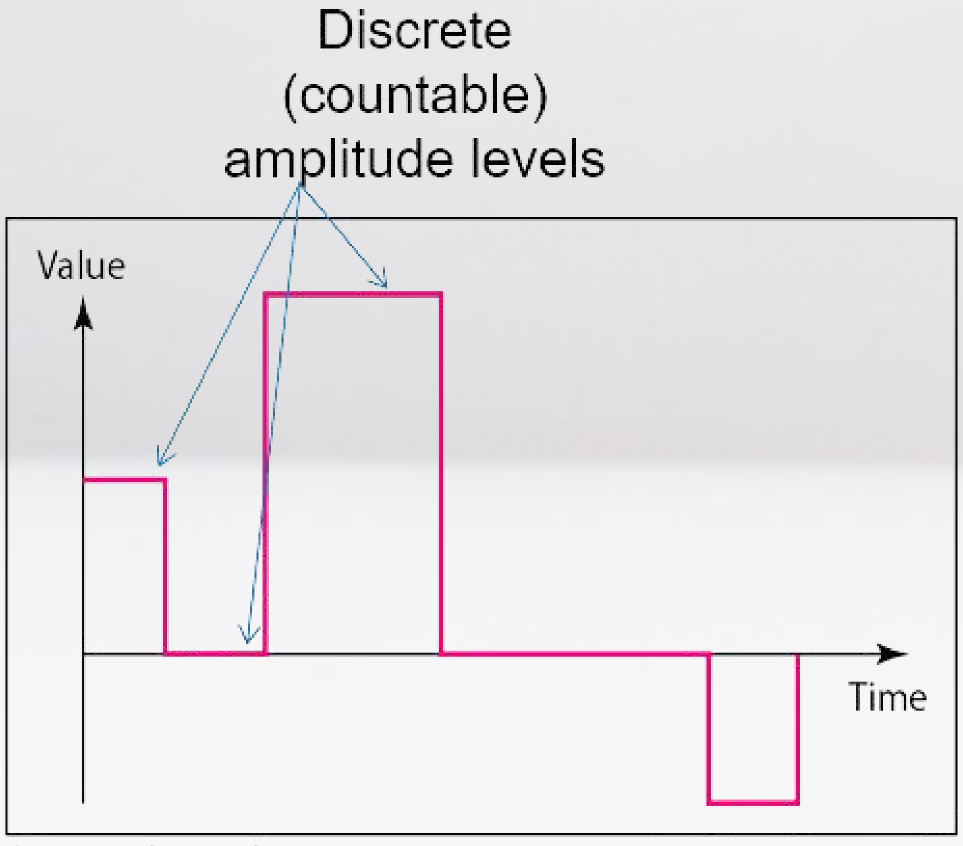


Fig. 1.12 : Digital Waveform

REVIEW TOPIC 1

Question 1:
State the function of the transmitter.

A. Generate information
B. Convert the information to its original form
C. Convert the original source to a form more suitable for transmission
D. Transfer electronic signal to receiver

Question 2:
The basic elements of a communication system are

A. Information source, transmission medium, transmitter
B. Transmitter, transmission medium, receiver
C. Information source, transmission medium, receiver
D. Receiver, transmission medium, destination

Question 3:
The equipment used to capture the transmitted signal from the transmission medium and convert it back to the original information signal.

A. Receiver
B. Channel
C. Modulator
D. Transmitter

Question 4:
List **THREE (3)** examples of circuits in a transmitter.

....

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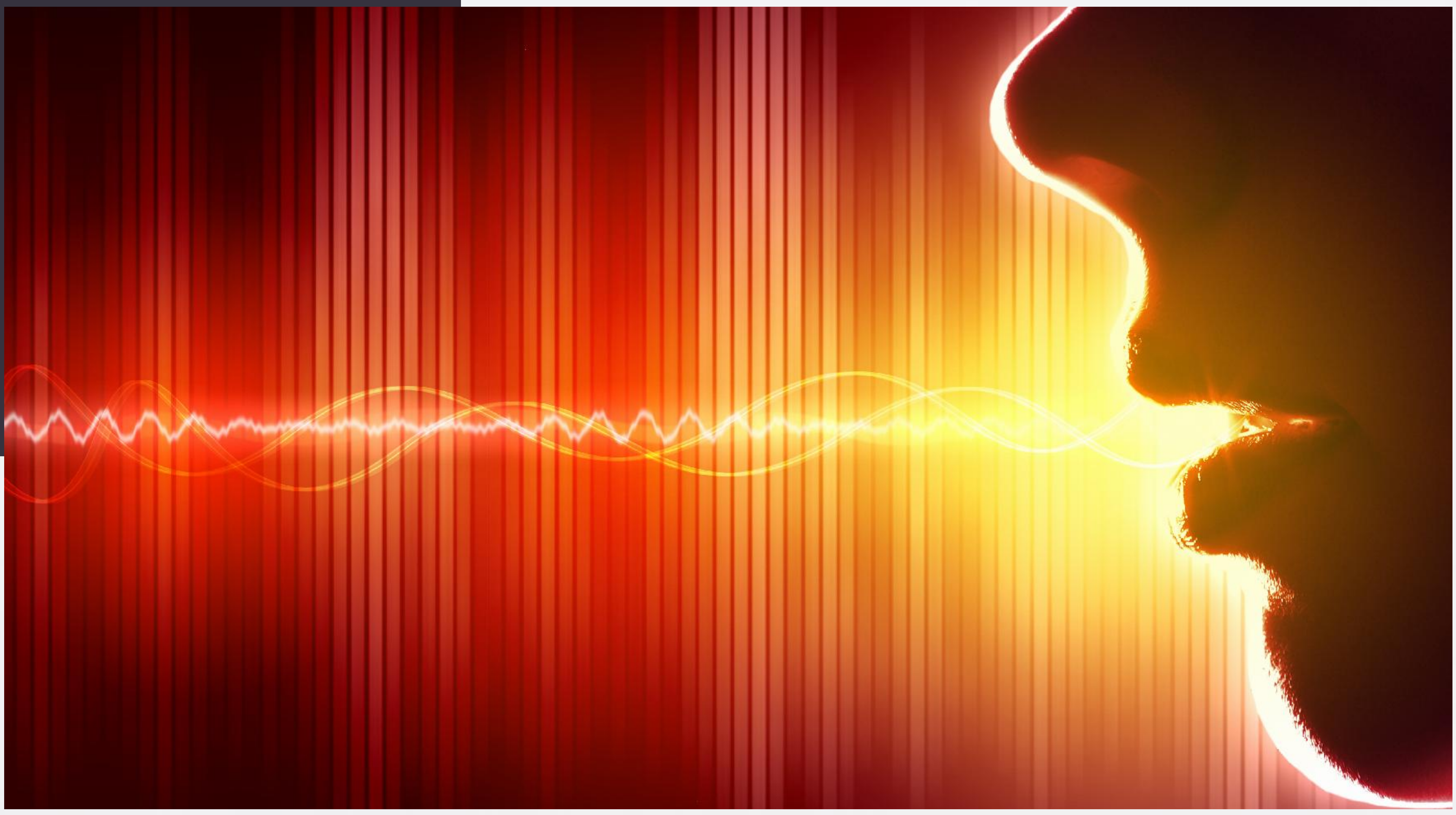
Question 5:
The basic elements of an electronic communication system are shown in the answer above, **EXCEPT............**

A. Receiver
B. Channel
C. Noise
D. Transmitter



Topic 2

Noise, Interference and Distortion

2.1 Noise, Interference and Distortion
2.2 Signal-to-Noise Power Ratio, Noise Factor and Noise Figure

2.1 What is Noise, Interference and Distortion?

Noise, interference and distortion are the undesirable phenomena that can affect signals in various systems, including electronics, communication, audio, and more. They both degrade the quality of signals and can make it difficult to accurately interpret or reproduce the original information. The transmission media that analog signals go through in communication systems tends to degrade the signal's quality. In other words, the signal at the start of the medium and the signal at the end are different. Signal impairment results from the flaw.

Noise and interference are ubiquitous in electronic systems and are encountered in a wide range of settings, from consumer electronics to industrial machinery. Understanding the causes and effects of these issues is key in ensuring optimal performance and reliability in real-world applications.

What is Noise?

Unwanted or random signals that interfere with the original signal and don't carry any information are called noise. When it comes to electrical terminology, noise is any unwanted energy that tends to obstruct the proper reception and reproduction of signals that are being transmitted. Any unwanted electrical signals, for instance, that are within the audio frequency range of 0 Hz to 15 kHz during audio recording will disrupt the music and be classified as **NOISE**. Noise can be divided into **TWO (2)** Internal Noise and External Noise. Figure 2.1 shows that the signal transmitted with noise affects the received signal while Figure 2.2 shows noise in analog and digital signals.

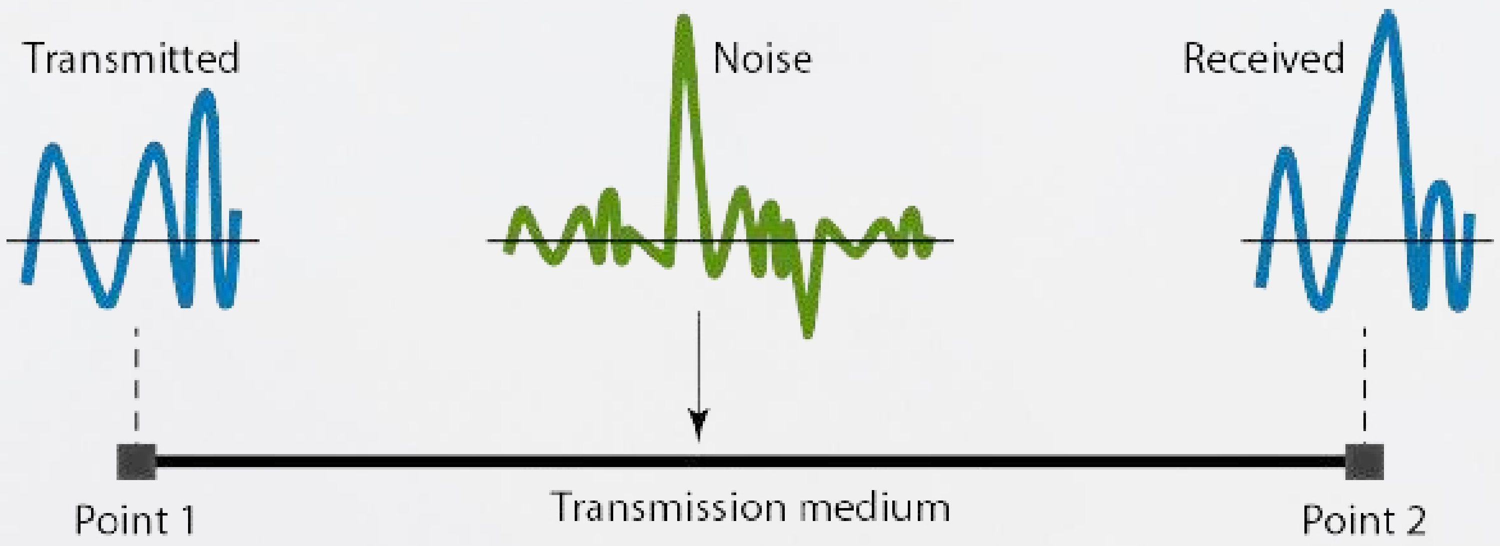


Fig. 2.1 : Noise in Communication System

Signal noise can affect both digital and analog signals, but a much higher level of noise is needed to affect a digital signal. This is due to the fact that digital signals transmit digital "bits" through a series of distinct electrical pulses. Figure 1.2 illustrates how many noises would need to be mixed together for those electrical pulses to be confused with one another.

On the other hand, analog signals use a predefined range, like 4–20 mA or 0–10 V, to represent an infinite range of possible values. In this instance, any undesired spikes in voltage or current will result in a variation in the signal that is being sent. Small differences along analogue signals, such as millivolts or microamps, usually don't cause a big difference. On the other hand, high electrical noise levels can result in significant variations and significant discrepancies, which make it impossible to manage communication between process control devices.

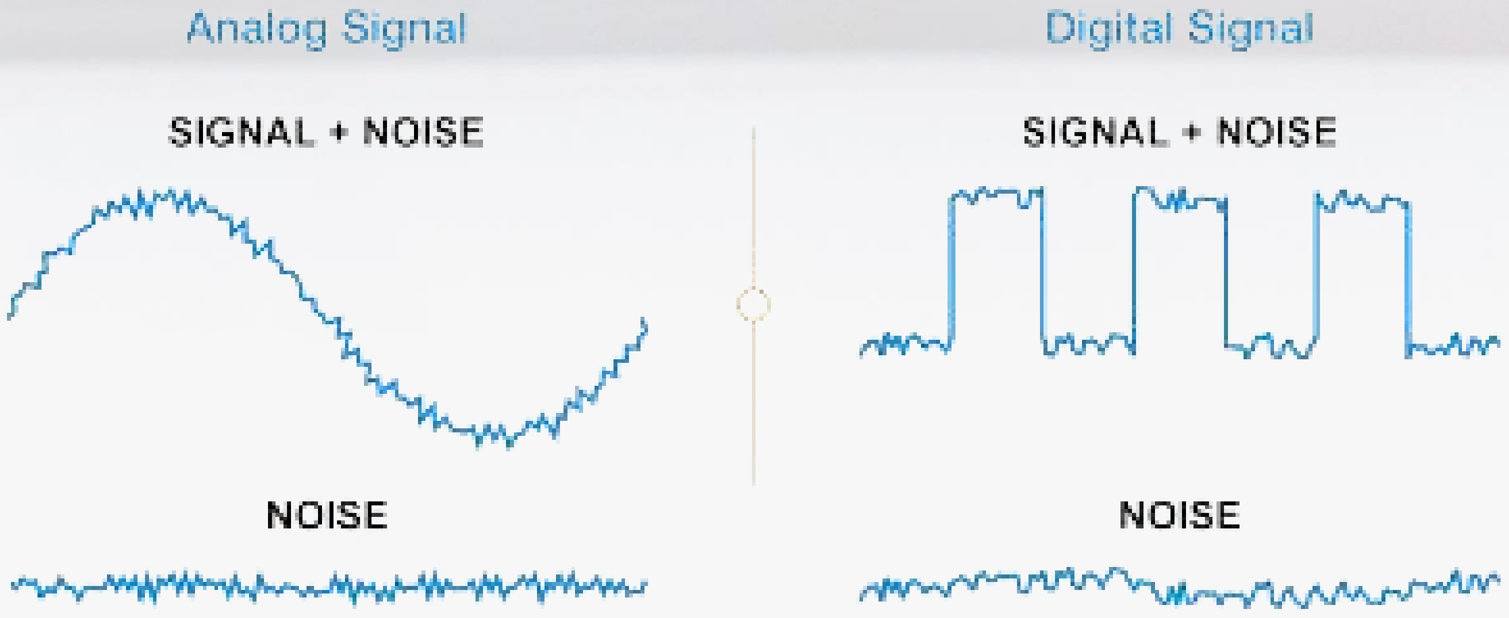


Fig. 2.2 : Noise in analog and digital signal

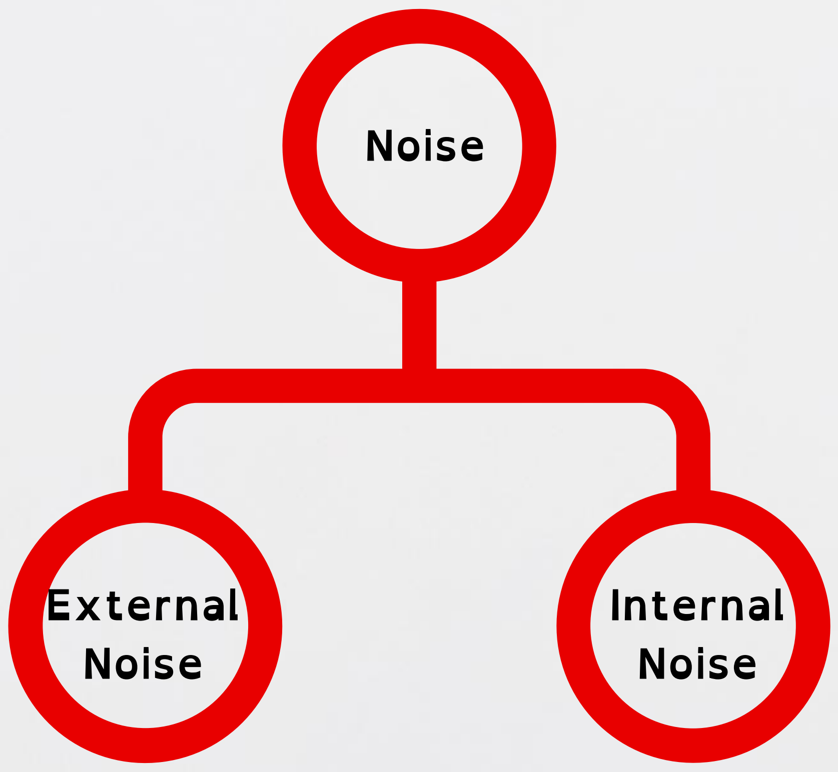
Problem asscociated with signal noise ?

APPARENT SIGNAL LOSS

An apparent loss of signal can result from extreme signal noise. Noise filtering is a feature that is integrated into most modern electronics. This filter, however, will not be sufficient in very noisy environments, which may result in the equipment not receiving a signal at all and no communication.

Classification of Noise in communication system

Although there are many ways to categorise noise in communication systems, it can be broadly divided into two groups, which are as follows:



External Noise

Any noise in a communication system that originates from the outside can be referred to as **external noise,** meaning that they come from sources outside of the communication system. An analysis based on numbers is not possible with external noise. Moreover, it is impossible to control outside noise at a specific geographic point.

As a result, moving the communication system to a different area with relatively less outside noise is the only method to lessen its impact.
Because of this, the satellite earth stations are typically situated in valleys with little noise. The following categories apply to external noise:

1. Atmospheric Noise

2. Extra-Terrestrial/ Space Noise

3. Industrial Noise

1. ATMOSHPHERIC NOISE

- Lightning strikes during thunderstorms and other naturally occurring electrical disturbances in the environment result in atmospheric noise, commonly known as static.

- The nature of these electric impulses is random. As a result, the entire frequency spectrum that is used for radio communication is covered by this energy.

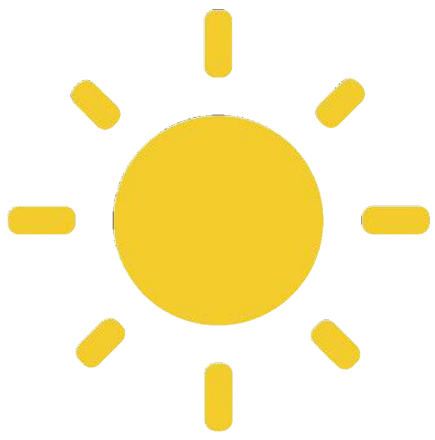
- Spurious radio signals that are disrupted across a broad frequency range are found in atmospheric noise.

- It has been noted that atmospheric noise field strength approximates a frequency variation that is inverse. Thus, very little atmospheric noise is produced in the VHF and UHF bands, while a large amount is produced in the low and medium frequency bands.

- Frequencies above 30 MHz cause less severe atmospheric noise.

2. EXTRATERRESTRIAL NOISE

There are several types of extraterrestrial noise or space noise depending upon their sources. The two sub-groups of extraterrestrial noise listed below are as follows:



Solar Noise

- Solar noise is the electrical noise that originates from the sun. The sun regularly emits noise when the environment is stable.

- Because of its extremely high temperature, the sun emits noise across a very wide frequency spectrum, including the spectrum used for radio communication.

Cosmic Noise

- Suns can also be thought of as distant stars. Due to their high temperatures, these far-off stars emit noise in a similar way to how the Sun does.

- Thermal noise is what we receive from these far-off stars, and it covers nearly the whole sky.

- Although this kind of noise is fairly intense, the Earth only occupies a small portion of the angle because it originates from very far away. As a result, the Earth receives noise with less intensity.

3. INDUSTRIAL NOISE

- The term "industrial noise," often known as "man-made noise," refers to noise that comes from heavy electrical equipment, electrical motors, switch gears, high voltage transmission lines, and ignition from cars and airplanes, among other sources.

- The arc discharge that occurs while all of these devices or pieces of equipment are operating is what causes this kind of noise.

- There is a lot of industrial noise in both densely populated metropolitan areas and industrial locations. Because industrial or man-made noise is highly variable, its analysis is restricted to statistical techniques.

- It is an electrical noise made by vehicles, including aircraft ignition, electric motors, and higher voltage light leaking from switch gears.

- Urban regions with high population densities and industrial sectors have a lot of fluorescent lighting and artificial noise from electrical machinery. Examples of electrical motors and switchgear are shown in Figure 2.3.

Fig. 2.3 : Industrial Noise

Internal Noise

The term "internal noise" refers to noise produced by the communication system or receiver itself. In addition to being quantitatively addressed, internal noise can also be eliminated or reduced by appropriate system design.

Internal noise is present in a given bandwidth at any frequency in the frequency spectrum because it is randomly distributed throughout the whole frequency spectrum. The following categories apply to internal noise:

5

1. **Shot Noise**
2. **Partition Noise**
3. **Low frequency or Flicker Noise**
4. **High frequency or Transit time Noise**
5. **Thermal Noise**

1. Shot Noise:

- Shot noise in semiconductor devices is caused by purely random electron-hole pair generation and recombination, or by the random diffusion of minority carriers. The random emission of electrons from cathodes in electron tubes is known as shot noise.

- In actuality, every time a charge carrier travels from one location to another, the current in electron devices actually flows as discrete pulses. Consequently, the current is still a discrete phenomenon even though it looks to be continuous.

2. Partition Noise:

- When a current has to split between two or more paths in a circuit, partition noise is produced.

- This indicates that the division's random fluctuations are the cause of the partition noise. Thus, under all other circumstances, a diode will be quieter than a transistor. This is the reason diode mixers receive the inputs from microwave receivers directly.

- The spectrum is flat for partition noise. Additionally, the active three-terminal components with lower current draws from the control terminal also have lower noise levels. Recently, nearly zero gate bias current-drawing Metal-Oxide Semiconductor Field Effect Transistors have been created. These devices find use in low noise microwave amplification because of their low partition noise.

3. Low frequency or Flicker Noise:

- A specific kind of noise can be heard at low frequencies (below a few kHz). As the frequency drops, this noise's power spectral density rises. We refer to this noise as (1/f) noise or flicker noise.

- The slow alterations in the oxide structure of cathodes coated with oxide and the migration of impurity ions are the primary sources of flicker noise in vacuum tubes. Flicker noise is produced by variations in the carrier density in semiconductor devices, and at low frequencies, it causes more issues for semiconductor amplifying devices than vacuum tubes.

- In actuality, variations in the carrier density cause variations in the material's conductivity. When a direct current flows through this, a fluctuating voltage drop results. The flicker-noise voltage is the name given to this varying voltage drop. The flicker noise's power density spectrum shows an inverse relationship with frequency. For this reason, at very low frequencies—generally below a few kHz—the flicker noise becomes significant.

4. Transit Time Noise or High Frequency Noise

- It is commonly observed in semiconductor devices that when the transit time of charge carriers across a junction is similar to the signal's period, some charge carriers diffuse back to the emitters or source.

- Any alteration to a carrier signal stream that results in an irregular, random variation as it travels from the input to the output of a device (like from a transistor's emitter to collector) is referred to as transit-time noise. Transistor construction, bias voltage, and carrier mobility all affect transit-time noise.

5. Thermal Noise

- Often referred to as Johnson noise or white noise, thermal noise is random. The random noise produced by the fast and erratic motion of molecules, atoms, and electrons in a resistor or the resistive element of a complex impedance is known as thermal noise, white noise, or Johnson noise.

- A particle's temperature indicates its internal kinetic energy, according to the kinetic theory of thermodynamics. Accordingly, a body's temperature expresses the root mean square of the particle motion velocity within it. According to this kinetic theory, these particles' kinetic energy approaches zero at absolute zero, or zero velocity.

What is Distortion?

Any modifications to the original signal that corrupt its shape or form are referred to as distortions. It is the alteration of the initial information signal's shape or other properties. Unwanted frequencies known as harmonics are produced, interfering with the original signal and lowering performance. This type of noise is known as related noise, in which distortion occurs when there is a signal.

After the original signal is passed through a variety of distorting functions, Figure 2.4 displays the various types of distortion. The initial signal had a square wave form, but it was distorted and took on the shape of a sine wave.

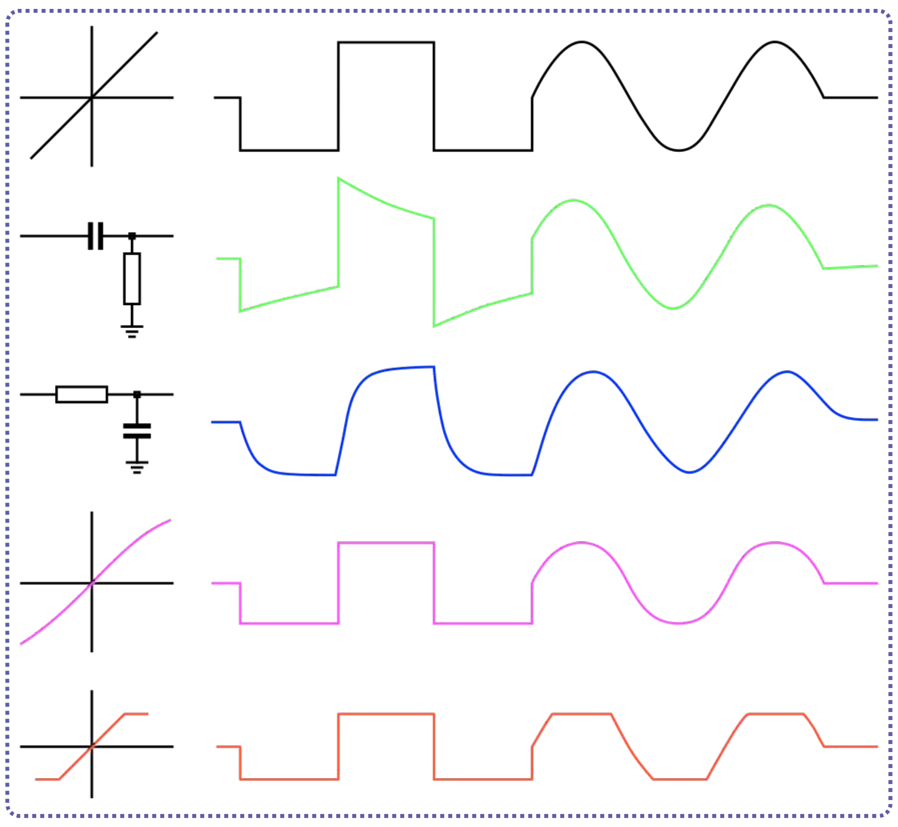
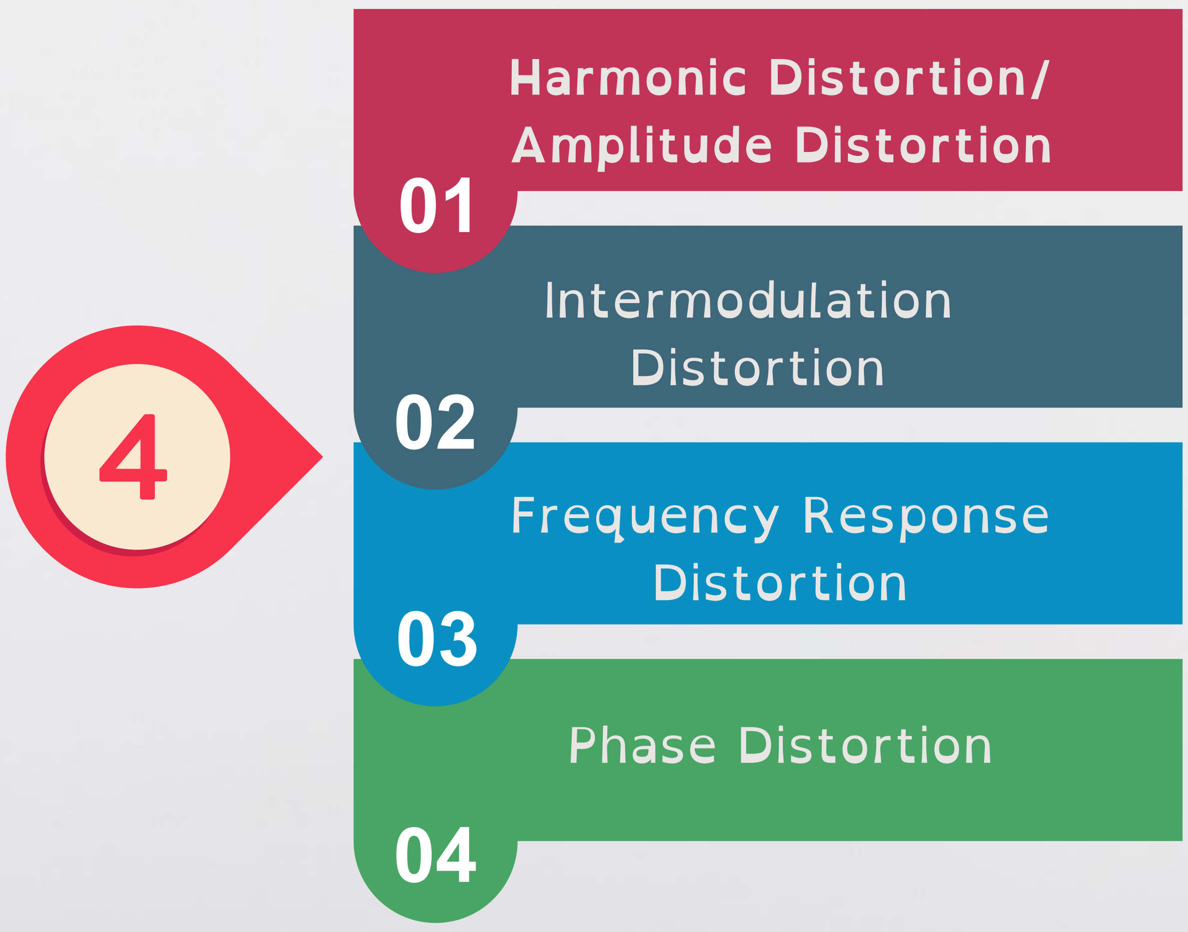


Figure 2.4 : Waveform graph along with various types of distorted

From Figure 2.4 :

1. The first trace (in black) shows the input. It also shows the output from a non-distorting transfer function (straight line).
2. A high-pass filter (green trace) distorts the shape of a square wave by reducing its low frequency components. This is the cause of the "droop" seen on the top of the pulses. This "pulse distortion" can be very significant when a train of pulses must pass through an AC-coupled (high-pass filtered) amplifier. As the sine wave contains only one frequency, its shape is unaltered.
3. A low-pass filter (blue trace) rounds the pulses by removing the high frequency components. All systems are low pass to some extent. Note that the phase of the sine wave is different for the lowpass and the highpass cases, due to the phase distortion of the filters.
4. A slightly non-linear transfer function (purple), this one gently compresses the peaks of the sine wave, as may be typical of a tube audio amplifier. This generates small amounts of low order harmonics.
5. A hard-clipping transfer function (red) generates high order harmonics. Parts of the transfer function are flat, which indicates that all information about the input signal has been lost in this region.

Some possible types of nonlinear distortion are shown below. These types of distortion occur in an amplifier when the signal input is large and the active device is driven into a non-linear region of its characteristics.



1. Harmonic Distortion/ Amplitude Distortion:

- The terms "phase distortion" and "amplitude distortion" describe variations in the phase relationships between the harmonic components of a complex wave and the unequal amplification or attenuation of the signal's various frequency components, respectively. It happens when a signal's unwanted harmonics are amplified through non-linear amplification. For example, harmonics are integer multiples of the original signal's frequency, such as 2f1, 3f1, etc.

- The frequency (F1) and amplitude (V1) of the original input signal are used to illustrate the occurrence of harmonic or amplitude distortion in Figure 2.5. In the event of distortion, 2f1, 3f1, 4f1, and so forth are produced.

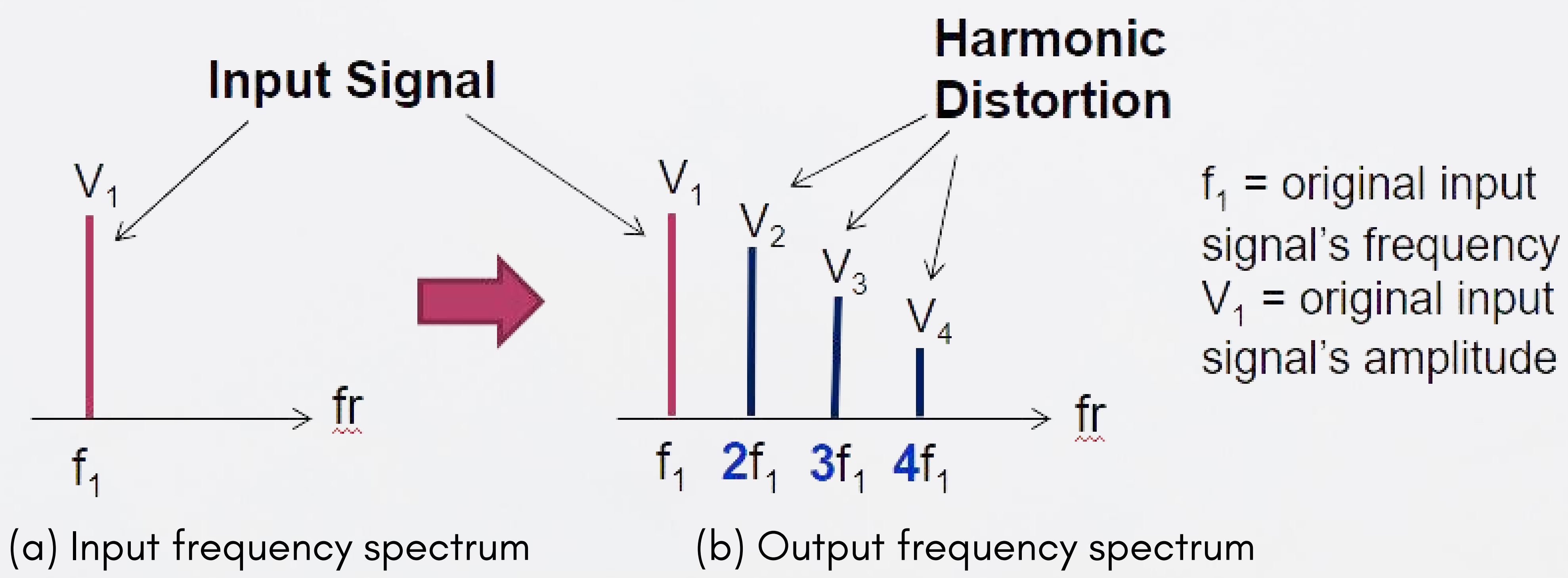


Fig 2.5 Harmonic / Amplitude distortion occured

2. Intermodulation Distortion

In a nonlinear device, when two or more signals are combined, unwanted cross-product frequencies, or the sum (f1+f2) and difference (f1-f2) frequencies, are produced.

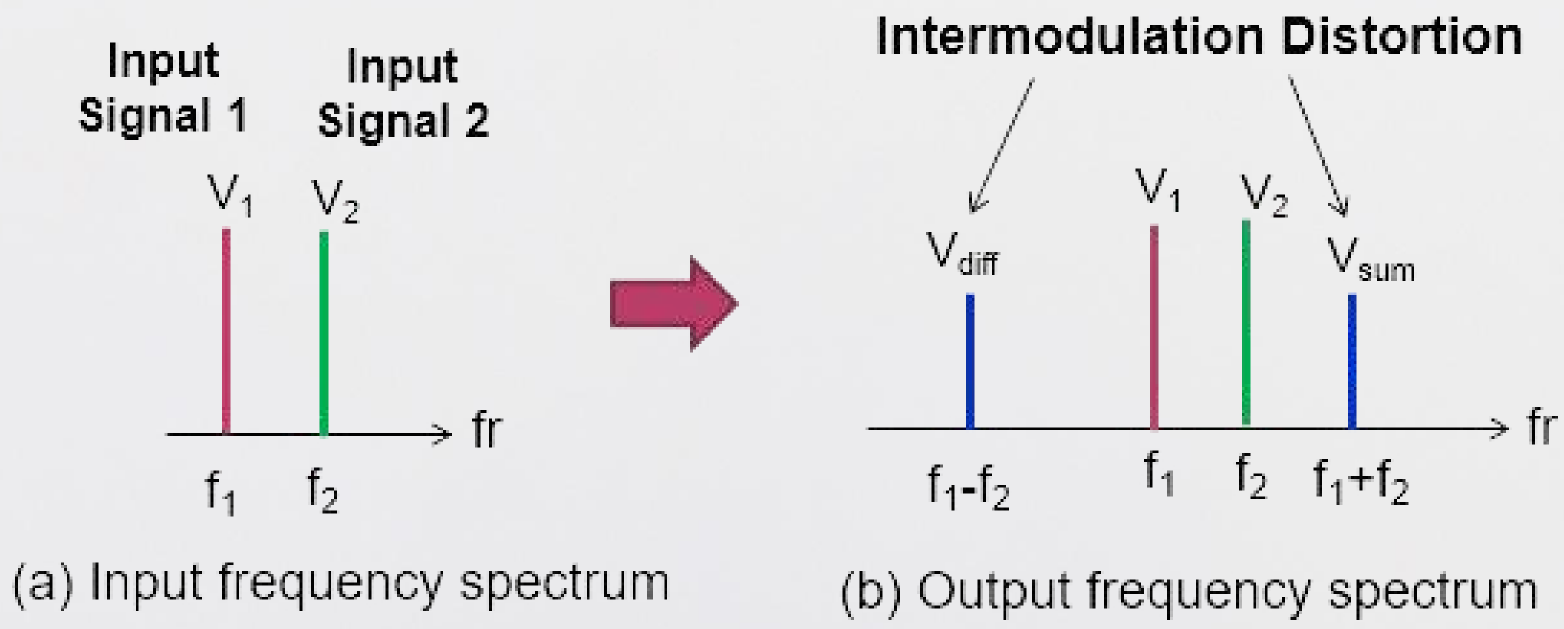


Fig 2.6 Intermodulation Distortion

3. Frequency Response Distortion:

A distortion that results from filters amplifying different frequencies by varying amounts. As an illustration, consider the AC-coupled cascade amplifier's non-uniform frequency response curve. Poor loudspeakers or the acoustics of the room are the main causes of this in the audio case.

When the transmission medium's frequency-dependent properties or those of system components like resonators, capacitors, or inductors cause the signal frequency to alter or shift from its initial value, this is known as frequency distortion.

4. Phase Distortion:

A distortion is generated by the reactive element, like inductive or capacitive reactance. Between the original signal's components, there is a phase shift as a consequence. Phase-dependent features of the transmission medium or circuitry such as phase shifters, mixers, or demodulators can cause phase distortion, which is defined as a shift or modification of the signal phase from its original value.

How to reduce signal distortion?

To reduce signal distortion, it is important to apply techniques and methods that can either prevent or minimize the factors that cause distortion, or correct or compensate for the effects of distortion. Signal conditioning, for instance, modifies or enhances the signal before or after transmission using devices such as filters, amplifiers, attenuators, or equalizers. This is done to improve the signal quality, stability, and compatibility with the system and remove or reduce unwanted components or noise.

Signal modulation is another technique used to vary one or more parameters of the signal, such as amplitude, frequency, or phase. This is done to increase the signal power, efficiency, and resistance to noise and interference. Signal encoding converts the signal into a digital or binary form using a code or a pattern of bits to increse reliability, security, and data rate while enabling error detection and correction.

What is Interference?

The word "to disturb or detract from" refers to interference, a type of outside noise. Information signals from different sources can interfere with one another when they produce frequencies outside of their allotted bandwidth (known as harmonics). An identical wave will produce a wave with an amplitude larger than either wave's initial value if it occupies the same space so that its crests and troughs line up.
This is known as constructive interference.

The interference is more constructive the closer the waves are to being perfectly aligned in phase. Additionally, it's feasible for two or more waves to converge so that their crests or troughs meet, or vice versa. Destructive interference is the cause of this situation, and the amplitude that results is the difference in the values of the individual waves. The amplitudes of the waves cancel out if they are perfectly unaligned, or if the crest of one precisely meets the trough of the other. In this case, there is no wave at all. The majority of interference happens when a neighbouring channel's passband contains harmonics or cross-product frequencies from one source. For example, radio channel Interference where a channel is interfered with by adjacent radio channel’s frequencies.

Types of Interference

1. Adjacent-Channel Interference (ACI)

As seen in figure 2.7, it is the interference that is produced to the signal that is next to the desired signal in frequency. Inadequate filters on the receiver side permit the adjacent signal to blend in with the pass band. If the adjacent channel signal strength rises, Base Station will have more difficulty differentiating between the strong mobile signal and the actual mobile signal.

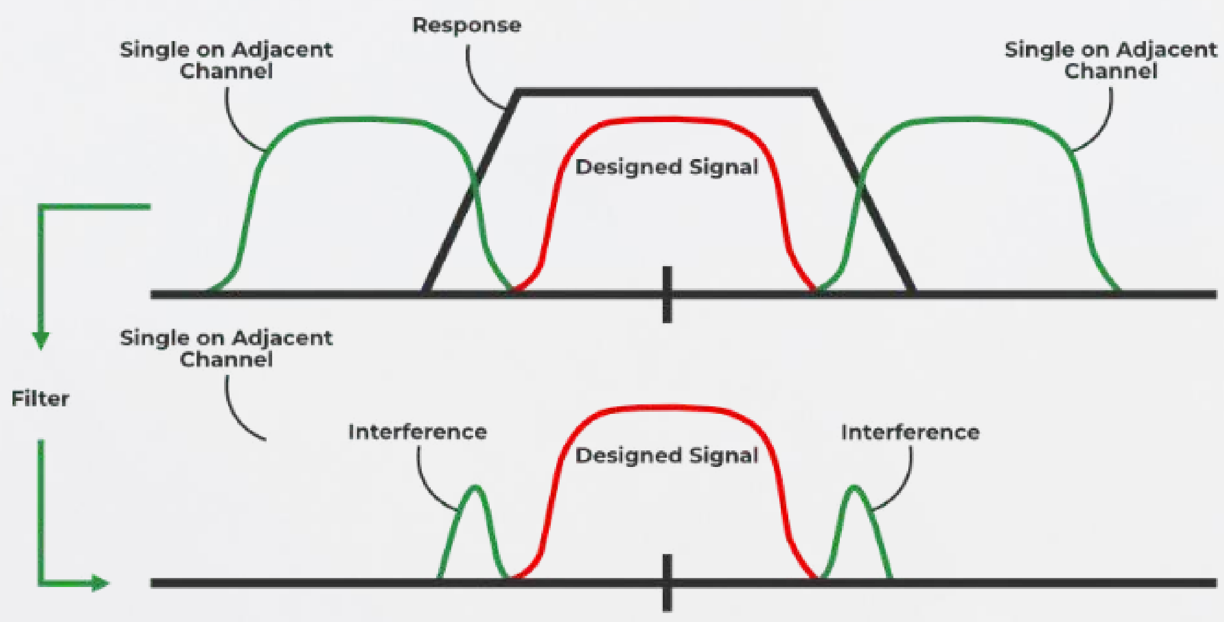


Fig 2.7 Adjacent - Channel Interference

The following are the causes of adjacent channel interference:

- Because several channels that are near to one another use comparable frequencies for communication.
- Power emission from an adjacent channel that is not relevant.

The following elements help to lessen adjacent channel interference:

- Proper filtering
- Careful Channel Assignments
- By managing the space between two adjacent cells that should remain constant.

2. Co-Channel Interference (CCI) or Crosstalk

Cells that use the same frequency within a specific coverage area are referred to as co-channel cells. Co-channel interference is the term for interference caused by these cells. To minimise co-channel interface and ensure adequate isolation, cells in co-channel interference are grouped as closely as possible. Because there is less co-channel interference when the co-channel reuse ratio is increased, the transmission quality is improved. When a radio transmitter uses the same frequency as another, this is an example of co-channel interference.

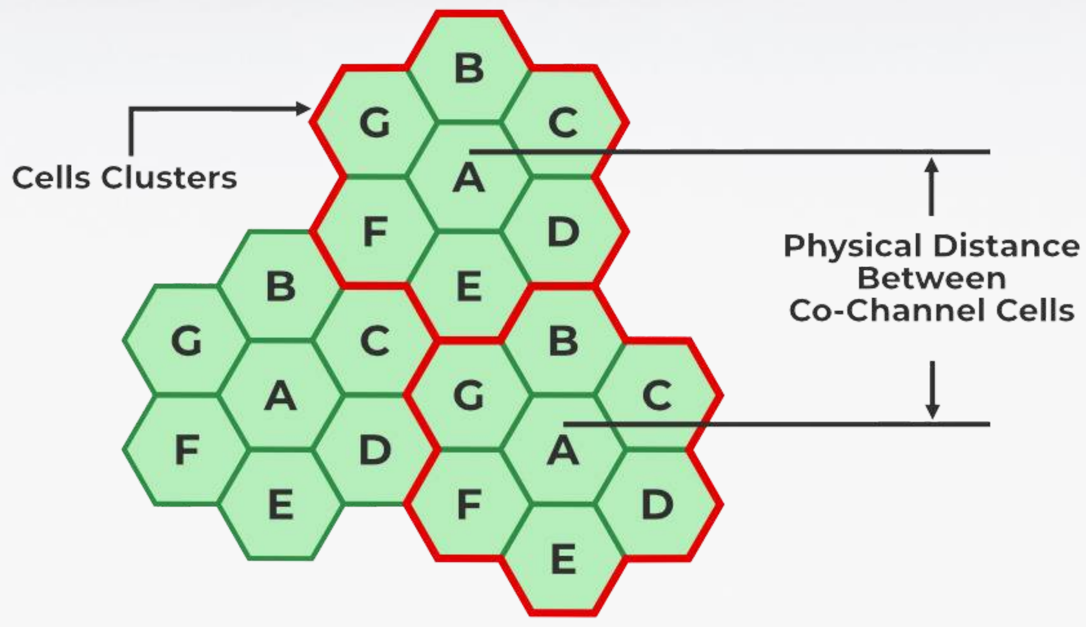


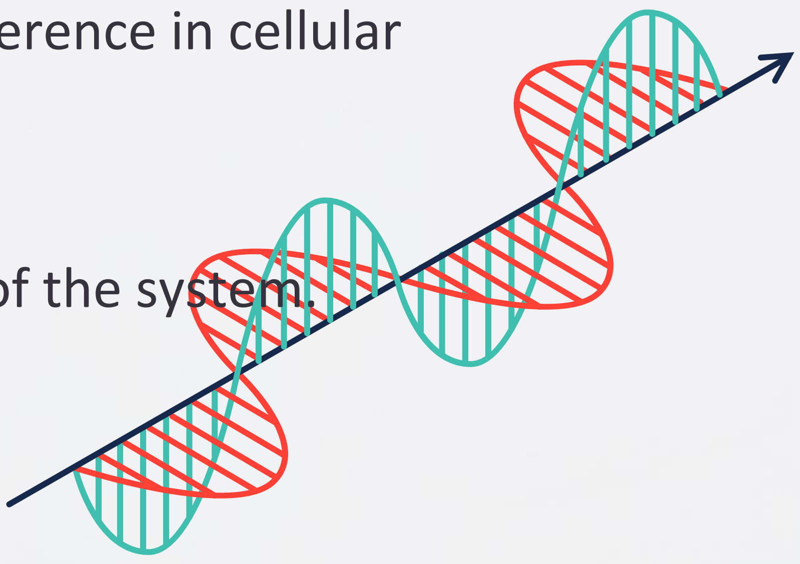
Fig 2.8 Cell in mobile communciation

The following are the causes of co-channel interference:

- Poor weather conditions
- Inadequate frequency scheduling

The following are some strategies for minimizing co-channel interference in cellular communication:

- Careful design and execution.
- The technique of frequency reuse boosts the overall capacity of the system.



3. Electromagnetic Interference (EMI)

- It is a disturbance that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an external source.
- Any signal or emission that seriously impairs, obstructs, or frequently interrupts a licenced radio communications service, or that is radiated in free space or conducted along power or signal leads is considered electromagnetic interference, or EMI. It can also jeopardise the operation of radio navigation or other safety services.
- Television, cellular services, radar, air traffic control, pagers, AM/FM commercial broadcast, and Personal Communication Services (PCS) are a few examples of radio communications services.
- The electromagnetic environment is influenced by these authorised radio services, unlicensed radio services like WLAN or Bluetooth, and inadvertent radiators like digital devices like computer systems.

4. Inter-carrier interference (ICI)

It is commonly known that Intercarrier Interference (ICI) impairs the efficiency of Orthogonal Frequency Division Multiplexing (OFDM) communications. It is caused by Doppler spread resulting from channel time-variation, carrier frequency offsets (CFOs), and, to a lesser degree, sampling frequency offsets (SFOs). Inter-Carrier Interference (ICI) resulting from frequency offset simulation is depicted in Figure 2.9 below.

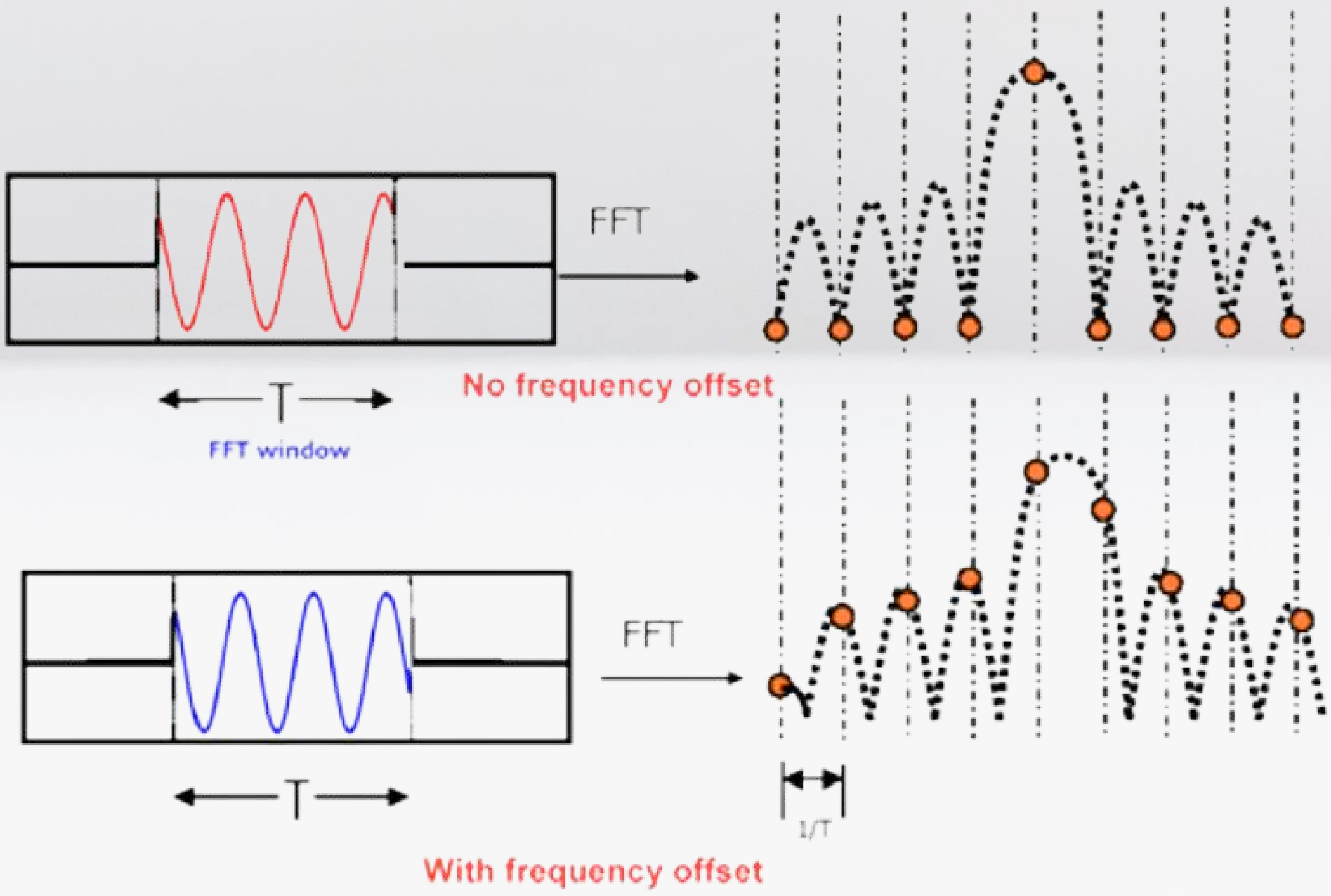


Fig 2.9 : Inter-Carrier Interference

Remember Noise, Distortion and Interference

NOISE	DISTORTION	INTEFERENCE
• Noise defined as the unwanted modulation signal that gets superimposed with the information signal. • The quality of the signal that the receiver receives will decrease if there is noise.	• Distortion defined as any unexpected change in the shape of any waveform. • In this case signal is no longer pure but it has additional frequency components that are known as harmonics.	• Form of external noise. • Is the phenomenon that occurs when two waves meet while traveling along the same medium.

2.2 What is the Signal to Noise Ratio and how is it computed?

Signal-to-noise ratio or SNR, is defined as the ratio of the signal's power - the desired information - to the signal's undesired power, or the noise from the surrounding environment. In the domains of science and engineering, SNR is also a measurement parameter that contrasts the level of the intended signal with the level of background noise. SNR, or signal-to-noise ratio, is expressed in terms of decibels (dB), which is the standard unit of measurement.

SNR is a key component of measurement quality; a high SNR ensures clean acquisitions with minimal noise-induced distortions. The capacity to obtain the desired results will improve with higher SNR, higher signal quality, and improved signal standout.

Why is Signal to Noise Ratio Important?

You can better understand what is meant by an unwanted signal or noise by looking at the comparison from earlier. It would be almost hard to comprehend the other person in your conversation, as you can also imagine. Furthermore, under such circumstances, we would classify this as a signal-to-noise problem, or the equivalent of a signal-to-noise ratio that is too low. Imagine for a moment that other signals are interfering with your desired signal, which is critical data with a tight or limited tolerance for errors. Once more, this would make it exponentially harder for the receiver to interpret the desired signal. In conclusion, this is why it's critical to have a high signal-to-noise ratio. Additionally, in certain situations, this may also indicate whether a device works or not, and in every scenario, it impacts the efficiency of both the transmitter and the receiver.

The SNR values compared to requirements are as follows:

- 5 dB to 10 dB: This is below what's required to make a connection because the noise level is almost identical to the desired signal (helpful information).
- 10 dB to 15 dB: This is the standard minimum required to create an unstable connection.
- 15 dB to 25 dB: This is usually regarded as the lowest level of acceptable poor connectivity.
- 25 dB to 40 dB: This is regarded as being excellent.
- 41 dB or higher: This is regarded as excellent.

Signal to Noise Ratio Formula

One way to calculate the signal-to-noise ratio is to compare the signal's power to the noise's power. As a result, a unitless ratio is produced, with more signal present in values larger than one and more noise present in values less than one. The SNR in decibels is then calculated by multiplying the ratio by 10 and placing it in a logarithmic function of base 10.

1 SNR (unit less):

$$SNR = \frac{S}{N} = \frac{P_S}{P_N}$$

$$SNR = \frac{V_S^2/R_{in}}{V_N^2/R_{out}}$$

where;

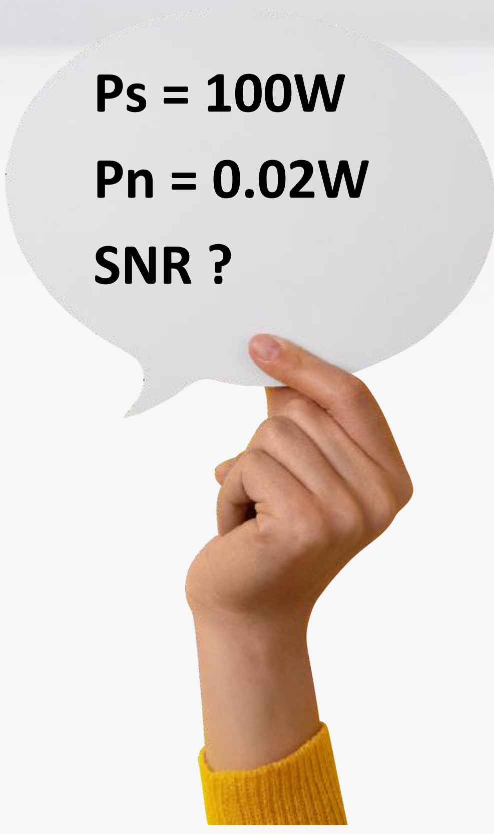
S = signal power (watts)
N = noise power (watts)
Vs = signal voltage (volts)
Vn = noise voltage (volts)
Rin = input resistance (ohms)
Rout = output resistance (ohms)

2 SNR (dB):

$$SNR(dB) = 10\log\left(\frac{S}{N}\right) \qquad SNR(dB) = 10\log\left(\frac{V_S^2/R_{in}}{V_N^2/R_{out}}\right)$$

EXAMPLE

1. For an amplifier with an output signal power of 100W and an output noise power of 0.02W, determine the signal to noise power ratio.



$$SNR = \frac{S}{N} = \frac{P_S}{P_N}$$

$$= \frac{100\text{ W}}{0.02\text{ W}}$$

$$= 5000.$$

2. For an amplifier with an output signal voltage of 4V, and output noise voltage of 0.005V and an input and output resistance of 50Ω, determine the signal-to-noise power ratio.

$$\text{SNR} = \frac{V_S^{2}/R_{in}}{V_N^{2}/R_{out}}$$

$$= \frac{4^2/50}{0.005^2/50}$$

$$= 640{,}000.$$

3. An amplifier has the output signal voltage 6V and output of noise voltage 0.006V. If the input resistance is 50 Ω and the output resistance is 75 Ω, calculate the signal to noise power ratio in dB.

$$SNR = \frac{V_S^{2}/R_{in}}{V_N^{2}/R_{out}}$$

$$SNR = \frac{6^2/50}{0.006^2/75}$$

$$= 1.5 \times 10^6$$

$$SNR(dB) = 10log\left(\frac{S}{N}\right)$$

$$SNR(dB) = 10\ log\ 1.5\ \times 10^6$$
$$= 61.76\ \text{dB}$$

Vs = 6V
Vn = 0.006V
Rin = 50Ω
Rout = 75Ω
SNR (db)?

4. A power amplifier with a 40-dB gain has noise power of 100 W. What is the signal power?

$$SNR(dB) = 10log\left(\frac{S}{N}\right)$$

$$40\ dB = 10log\ \text{SNR}$$

$$\frac{40}{10}\ \text{dB} = log\ \text{SNR}$$

$$\text{SNR} = 10^{\frac{40}{10}}$$

$$\text{SNR} = 10{,}000$$

$$\text{antilog} = 10^{x}$$

SNR (db) = 40 dB
Pn = 100W
Ps = ?

$$SNR = \frac{P_S}{P_N}$$

$$10{,}000 = \frac{P_S}{100}$$

$$P_S = 1000{,}000\ @\ 1\text{MW}$$

The following are the SNR requirements versus SNR values:

- 5 dB to 10 dB: is below the minimum level to establish a connection, due to the noise level being nearly indistinguishable from the desired signal (useful information).
- 10 dB to 15 dB: is the accepted minimum to establish an unreliable connection.
- 15 dB to 25 dB: is typically considered the minimally acceptable level to establish poor connectivity.
- 25 dB to 40 dB: is deemed to be good.
- 41 dB or higher: is considered to be excellent.

Important

Signal to Noise Ratio Formula

The signal-to-noise ratio can be computed as the ratio of the power of the signal over the power of the noise. This produces a unitless ratio where a value less than one has more noise and a value greater than one has more signal. The ratio is then placed in a logarithmic function of base 10 and multiplied by 10 to get the SNR in decibels (dB).

1 SNR (unit less):

$$SNR = \frac{S}{N} = \frac{P_S}{P_N}$$

$$SNR = \frac{V_S^{\,2}/R_{in}}{V_N^{\,2}/R_{out}}$$

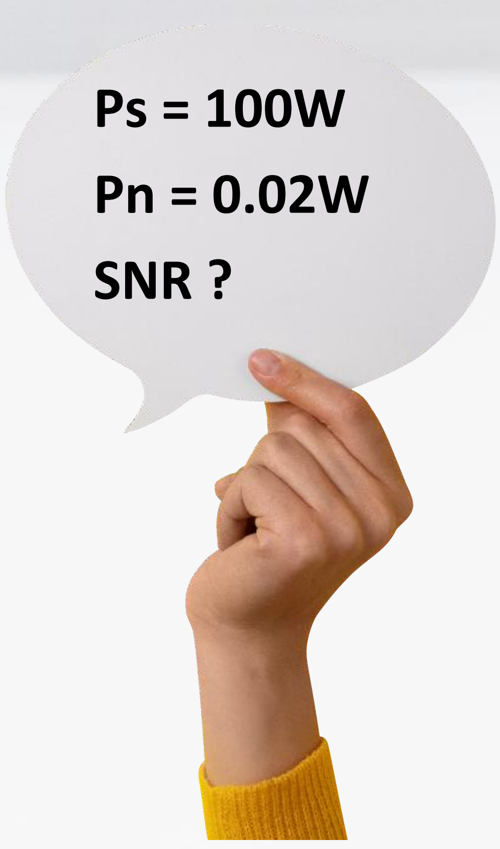
where;
S = signal power (watts)
N = noise power (watts)
Vs = signal voltage (volts)
Vn = noise voltage (volts)
Rin = input resistance (ohms)
Rout = output resistance (ohms)

2 SNR (dB):

$$SNR(dB) = 10\log\left(\frac{S}{N}\right) \qquad SNR(dB) = 10\log\left(\frac{V_S^{\,2}/R_{in}}{V_N^{\,2}/R_{out}}\right)$$

EXAMPLE

1. For an amplifier with an output signal power of 100W and an output noise power of 0.02W, determine the signal to noise power ratio.



$$SNR = \frac{S}{N} = \frac{P_S}{P_N}$$

$$= \frac{100\text{ W}}{0.02\text{ W}}$$

$$= 5000.$$

Important Noise Factor and Noise Figure Formula

The figures of merit Noise Factor (F) and Noise Figure (NF) show how much the signal-to-noise ratio decreases as a signal travels through a circuit or set of circuits. Lower values of these figures of merit indicate better performance, and they are used to assess an amplifier's or radio receiver's performance.

The degradation of a device's signal to noise ratio is measured by its noise factor, which is unitless. The noise figure, on the other hand, converts noise factor into an equivalent decibel noise figure (dB).

1 Noise Factor (F) :

$$F = \frac{\textbf{Input}\ \text{signal - to - noise power ratio}}{\textbf{Output}\ \text{signal - to - noise power ratio}}$$

$$F = \frac{SNR_{in}}{SNR_{out}} = \frac{S_{in}/N_{in}}{S_{out}/N_{out}} \text{(unitless)}$$

2 Noise Figure (dB):

$$NF(dB) = 10\log F$$

$$NF(dB) = 10\log\left(\frac{SNR_{in}}{SNR_{out}}\right)$$

$$NF(dB) = 10\log\left(\frac{S_{in}/N_{in}}{S_{out}/N_{out}}\right)$$

OR

$$NF\ (dB) = SNR_{IN}\ (dB) - SNR_{OUT}\ (dB)$$

EXAMPLE

1. Given the following parameters for a non-ideal amplifier, determine a) Noise Factor b) Noise Figure.

SOLUTION

Find Noise Factor using the formula given:

$$F = \frac{\textbf{Input}\ \text{signal - to - noise power ratio}}{\textbf{Output}\ \text{signal - to - noise power ratio}}$$

$$F = \frac{SNR_{in}}{SNR_{out}} = \frac{S_{in}/N_{in}}{S_{out}/N_{out}} \text{(unitless)}$$

$$F = \frac{Ps_{in}/Pn_{in}}{Ps_{out}/Pn_{out}}$$

$$F = \frac{2 \text{ x } 10^{-10}/2 \text{ x } 10^{-18}}{2 \text{ x } 10^{-4}/5 \text{ x } 10^{-12}}$$

$$= \frac{1 \text{ x } 10^{8}}{25 \text{ x } 10^{6}}$$

$$= 4$$

Noise Figure :

$$\text{NF}\ (dB) = 10\ log\text{F}$$

$$= 10\ log\ 4$$

$$= 6.02 \text{ dB}$$

2. Given the input signal to noise power ratio of a non-linear amplifier is 100,000 and it's output signal to noise power ratio is 15,000. Determine its Noise Figure.

$$F = \frac{\text{SNR}_{\text{ in}}}{\text{SNR}_{\text{ out}}}$$

$$F = \frac{100{,}000}{15{,}000}$$

$$= \mathbf{6.667}$$

$$\text{NF}\ (dB) = 10\ log\text{F}$$

$$= 10\ log\ 6.667$$

$$= 8.240 \text{ dB}$$

REVIEW TOPIC 2

Question 1:
An unwanted signal from other sources than the transmitted signal source. It is a signal that does not convey any information.

A. Noise
B. Distortion
C. Interference
D. Attenuation

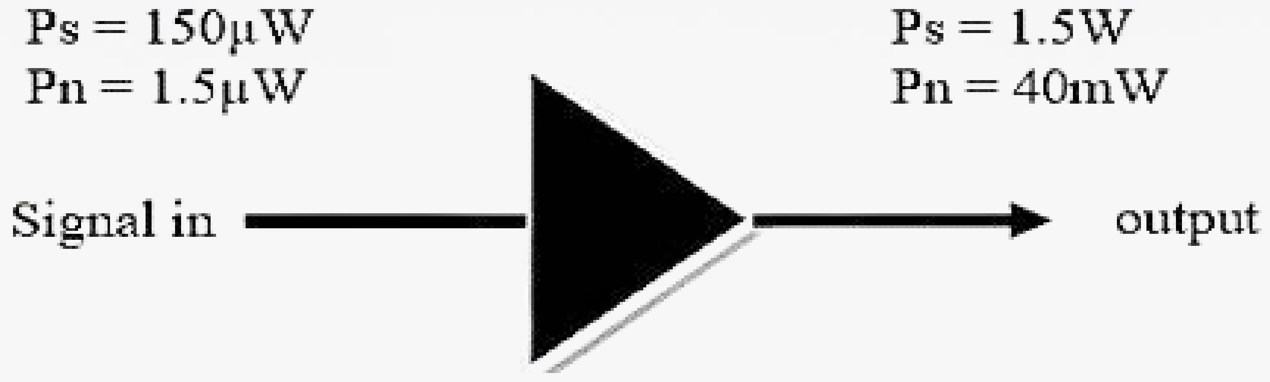
Question 2:
External noise is the noise that is generated outside the device. The following statements describe the external noise **EXCEPT**.

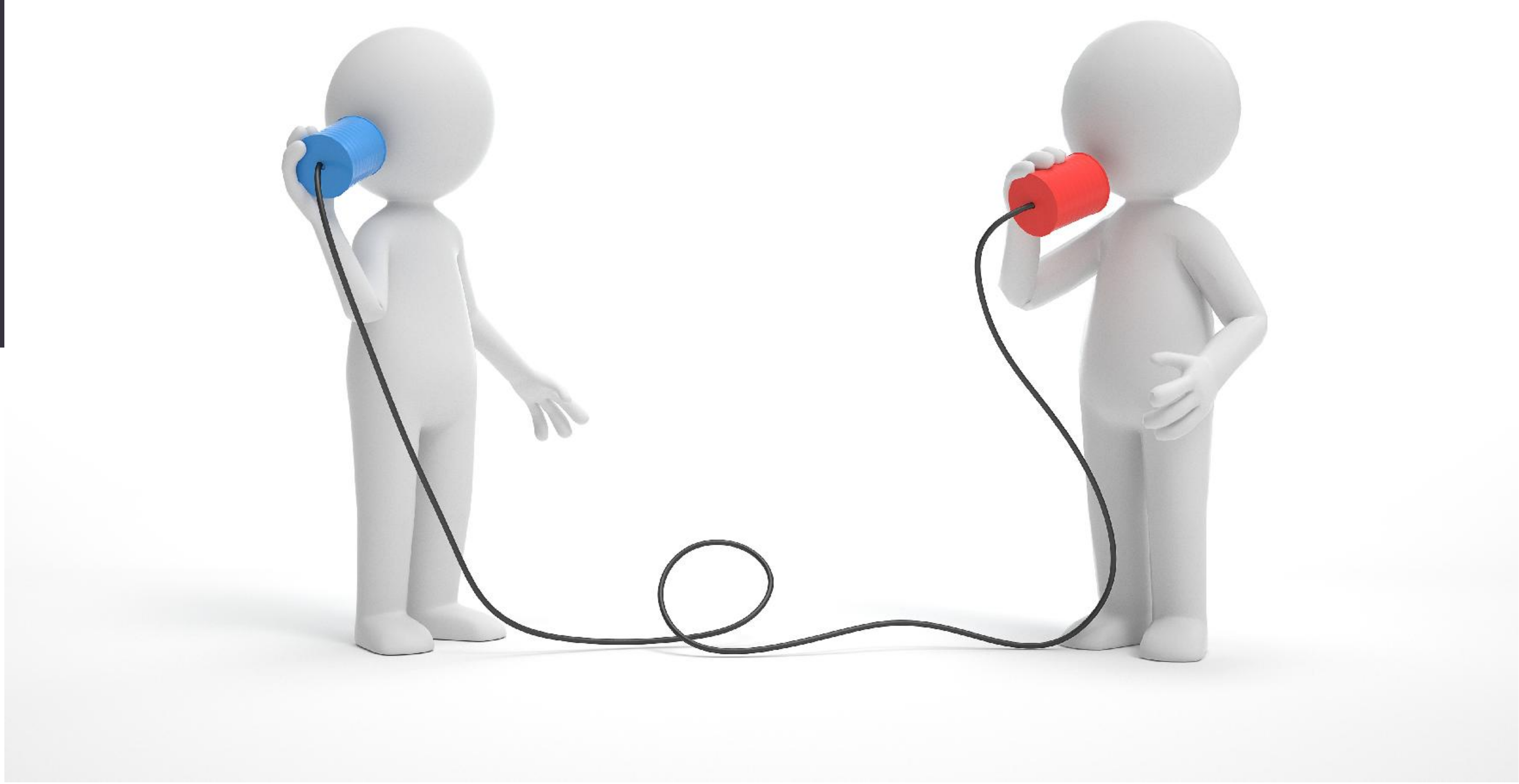
A. Atmospheric noise
B. Thermal noise
C. Man-made noise
D. Space Noise

Question 3:
The noise at the input is 4 x 10^-18 W. Calculate the input signal power to the system that has Noise Figure 5 dB and the Signal to Noise ratio (unitless) at the output is equal to 25 x 10^6 W.

Question 4:
Calculate the output signal-to-noise power ratio (SNR) for an amplifier with and input signal-to-noise power ratio of 21.4 dB and Noise Figure of 5.4 dB.

Question 5:
Refer to the diagram below, calculate the Noise Figure and Noise Factor.





Topic 3

Frequency Spectrum, Bandwith and Wavelength

3.1 Frequency Spectrum, bandwidth and wavelength
3.2 Information Capacity and Shannon's Limit Formula

Heinrich Rudolf Hertz
1857 - 1894

"I do not think that the wireless waves I have discovered will have any practical application."
-Heinrich Hertz

Contributions -- Heinrich Rudolf Hertz

He proved the Theory of Electromagnetism brought by Scottish physicist James Maxwell.

He concluded that light and heat are electromagnetic radiations. He showed that the velocity and length of the electromagnetic waves can be measured.

"Hertzian waves" are electromagnetic waves that were named after him, which are now known as radio waves.

He proved that electromagnetic waves can transport electricity. Also, he proved that it contained properties of light, especially that it travels at the speed of light.

3.1 What is frequency Spectrum?

The frequency spectrum of a signal is the range of frequencies contained by a signal. The spectrum is a continuous range of electromagnetic radiation waves. It extends from the longest radio waves to the shortest X-rays and gamma rays as shown in figure 3.1.

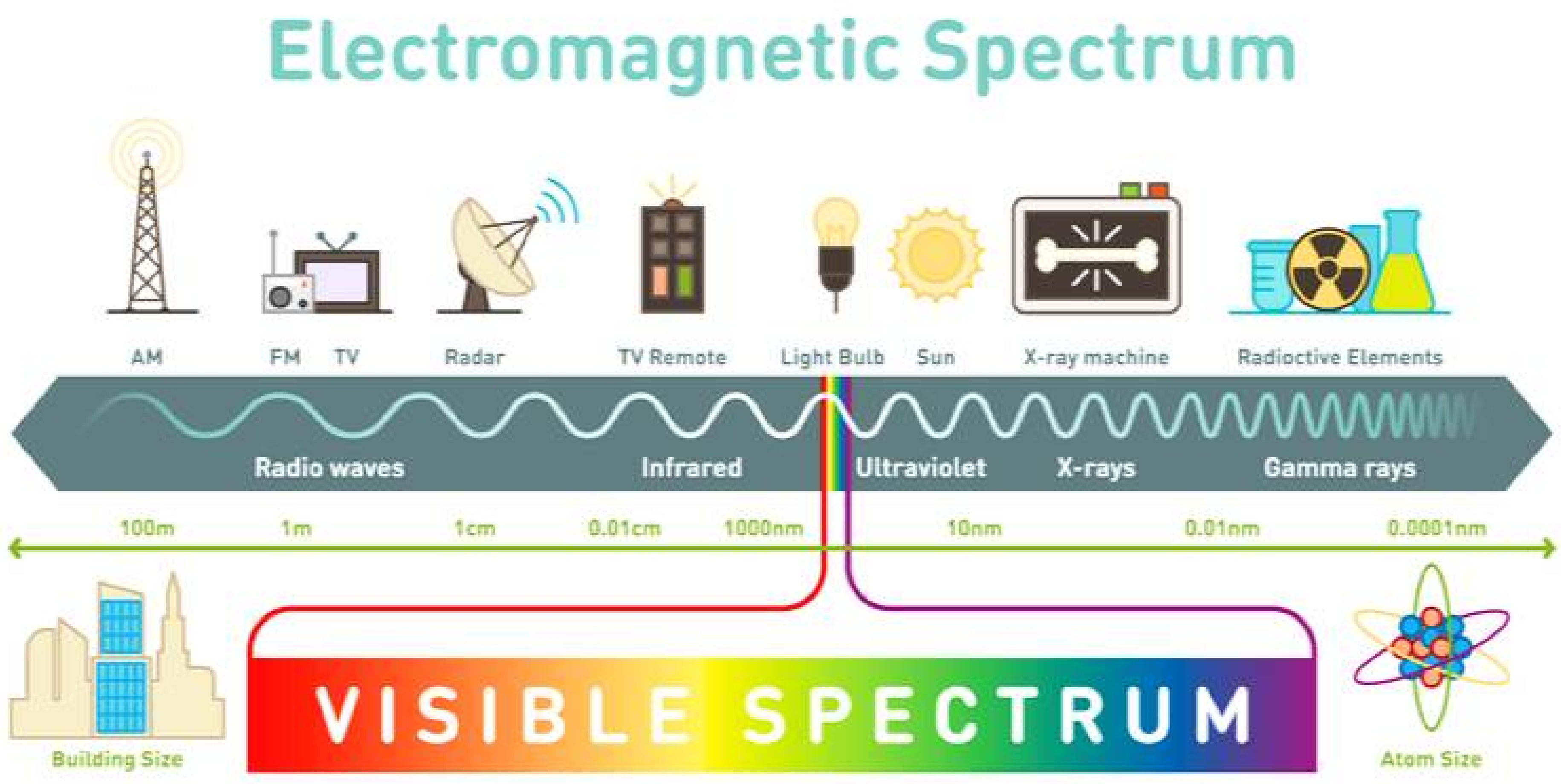


Fig 3.1 : Frequency Spectrum

Introducing radio spectrum

The electromagnetic spectrum is made up of many different types of waves, such as light, infrared, and X-ray waves, of which radio waves are only one component. Wireless information transmission is made possible by radio spectrum usage for a wide range of commonplace applications, including baby monitors, GPS, radar, and emergency services communications systems, as well as mobile phones, Wi-Fi, and television and radio broadcasting.

The process of converting original information into electromagnetic energy and transmitting it to a receiving station, where it is converted back to its original form, is how information is communicated between two or more locations.This electromagnetic energy is dispersed over a nearly limitless spectrum of frequencies. It is possible to communicate using visible light, infrared, microwaves, and radio waves. Radio and television programming are transmitted via radio waves. Mobile phones and satellite television both use microwaves for transmission. Information is transmitted from remote controls via infrared.

There are bands, ranges, or subsections within the electromagnetic frequency spectrum, and each band has its own name and boundary. The international organisation in charge of allocating frequencies and services across the entire frequency spectrum is the International Telecommunications Union (ITU). The following is a summary of the ITU band designations:

Table 3.1 : Frequency Band and Application

Frequency Band	Frequency	Wavelength	Application
Very Low Frequency (VLF)	3 - 30 KHz	> 10000m	Telegraphy, human range frequency
Low Frequency (LF)	30-300 KHz	10000-1000m	Point to point, navigation
Medium Frequency (MF)	300K-3 MHz	1000-100m	AM radio broadcast, maritime/aeronautical mobile
High Frequency(HF)	3 - 30 MHz	100 - 10 m	Shortwave Broadcast Radio
Very high Frequency(VHF)	30 - 300 MHz	10 - 1 m	Low band: TV Band1- Channel 2-6, Mid band: FM radio, High Band: TV Band 2- Channel 7-13
Ultra High frequency (UHF)	300M - 1GHz	1 m - 10 cm	Mobile phone, Channel 14 - 70
Super High frequency (SHF)	3-30 GHz	0.01-0.001 m	Satellite communication, C-band, x- band, Ku-band, Ka-band.
Extremely High Frequency (EHF)	30 - 300 GHz	0.01m	Satellite, radar system, IR, UV, X-rays, Gamma Rays.

Infrared

- Signals in the **0.3 THz to 300 THz** range are known as infrared frequencies, and they are not usually referred to as radio waves.
- The term "infrared" describes electromagnetic radiation that is typically connected to heat. Infrared signals find application in electronic photography, astronomy, and heat-seeking guidance systems.

Visible Light

- Electromagnetic frequencies that are visible to humans **(0.3 PHz to 3 PHz)** are included in visible light.
- Optical fibre systems, which have recently emerged as the main transmission medium for electronic communications systems, are utilised with light wave communications.

Ultraviolet rays, X rays, Gamma rays, and Cosmic rays

- There is minimal use for cosmic, gamma, X, and ultraviolet radiation in electronic communications.
- Shorter wavelengths and higher energies characterise ultraviolet, X, and gamma rays. Since these shorter wavelengths are so tiny, they can interact with human skin, cells, and even specific areas of cells.
- The Sun emits ultraviolet radiation, which causes burns and tans on skin. UV radiation is also emitted by "hot" objects in space.
- Gamma ray: Physicians use gamma-ray imaging to see inside your body. X-ray: A dentist uses X-rays to image your teeth, and airport security uses them to see through your bag as shown in figure 3.2.

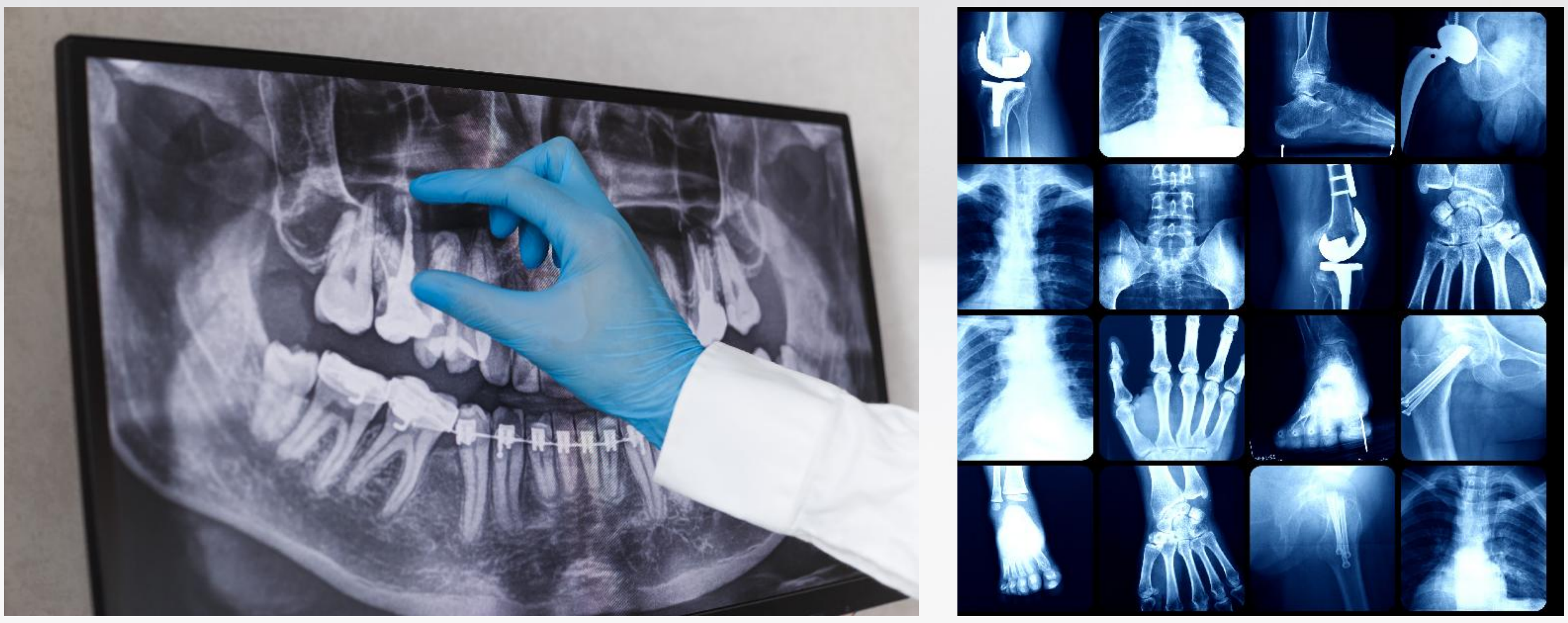


Figure 3.2 : Examples of X-Ray Aplplication

Figure 3.3 below show the application of Electromagnetic Frequency Spectrum.

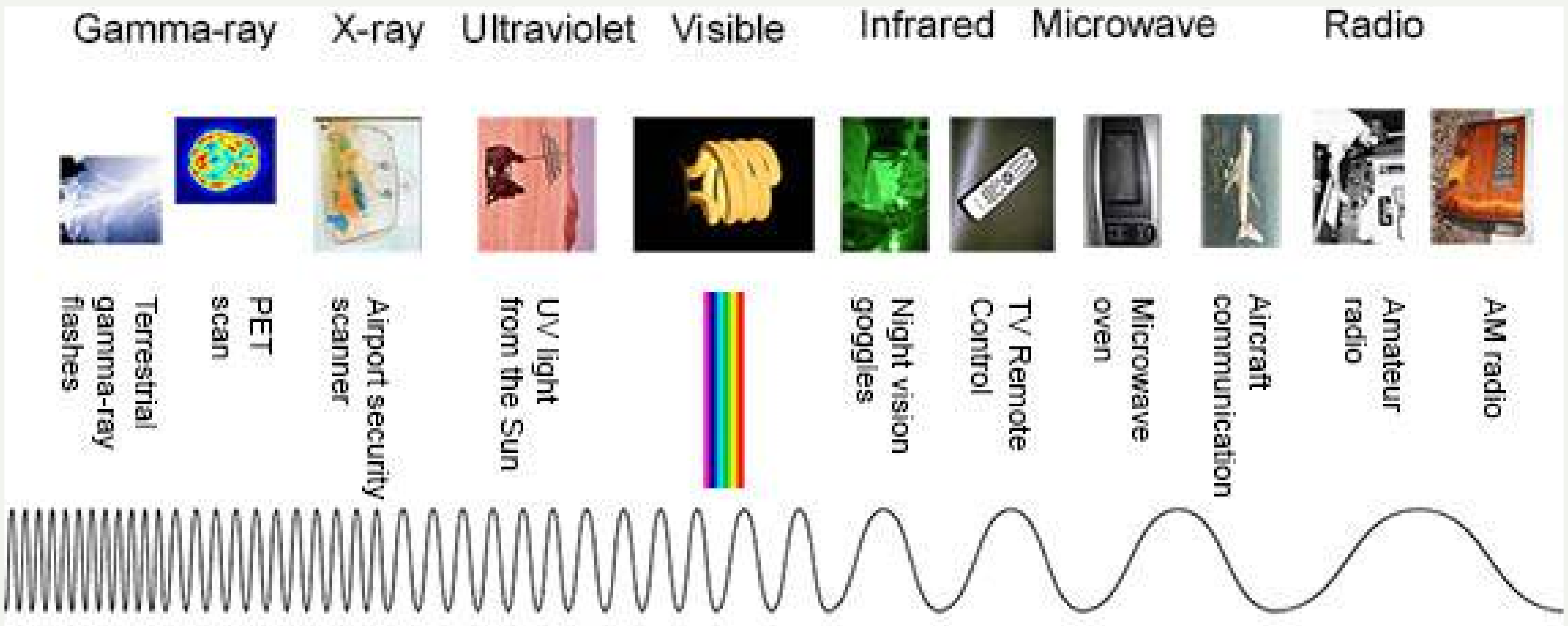


Fig 3.3 : Frequency Spectrum

BANDWIDTH (BW)

- The range of frequencies, or the difference between the highest and lowest frequencies, is known as bandwidth (BW).

- The range of frequencies that make up a frequency spectrum is known as its bandwidth. The difference between an information signal's highest and lowest frequencies is all that makes up the signal's bandwidth.

Formula

BW (Hz) = frequency range

= fmax – fmin

- Keep in mind that a channel's bandwidth directly corresponds to its data rate. A signal's bandwidth varies depending on its type, as these examples illustrate.
- The frequency range and bandwidth of the signal are displayed in Table 3.2.

FUN FACT

Table 3.2 : Type of Signal Frequency

Type of the signal	Frequency range (Hz)	Bandwidth (Hz)
Voice (speech)	300-3400	3100
Music signal	20-15000	14,980
TV (picture) signal	0-5Mega	5 MHz
Digital data	300-3400 (using telephone line)	3100

- Different methods are used to calculate the bandwidth of digital and analog signals. The range of frequencies that can flow through a channel in analog technology is known as the bandwidth.
- While digital signals are measured in terms of bit rate (bits per second, bps), analogue signals are measured in terms of frequency (Hz). Furthermore take note of the fact that the signal's bandwidth and the channel's bandwidth differ.

DID YOU KNOW ?

BANDWIDTH OF A CHANNEL

- The medium that the input signal travels through is called a channel. The range of frequencies that a channel can carry in an analogue signal is referred to as its bandwidth. The maximum bit rate - that is, the number of bits per second-that a channel can support in terms of a digital signal is known as its bandwidth.
- Information loss occurs if the medium's bandwidth is not larger than the bandwidth of the signal that needs to be transmitted. Table 3.2 illustrates how different channel types have varying bandwidths.

FUN FACT

Table 3.3 : Type of the channel frequency

Type of the channel	Frequency range (Approx.)
Twisted pair	1MHz – 100 MHz)
Coaxial cable	0 – 750 MHz
Microwave	1 GHz-30 GHz
Satellite	1 GHz – 40 GHz
Fibre optics	180 THz – 330 THz

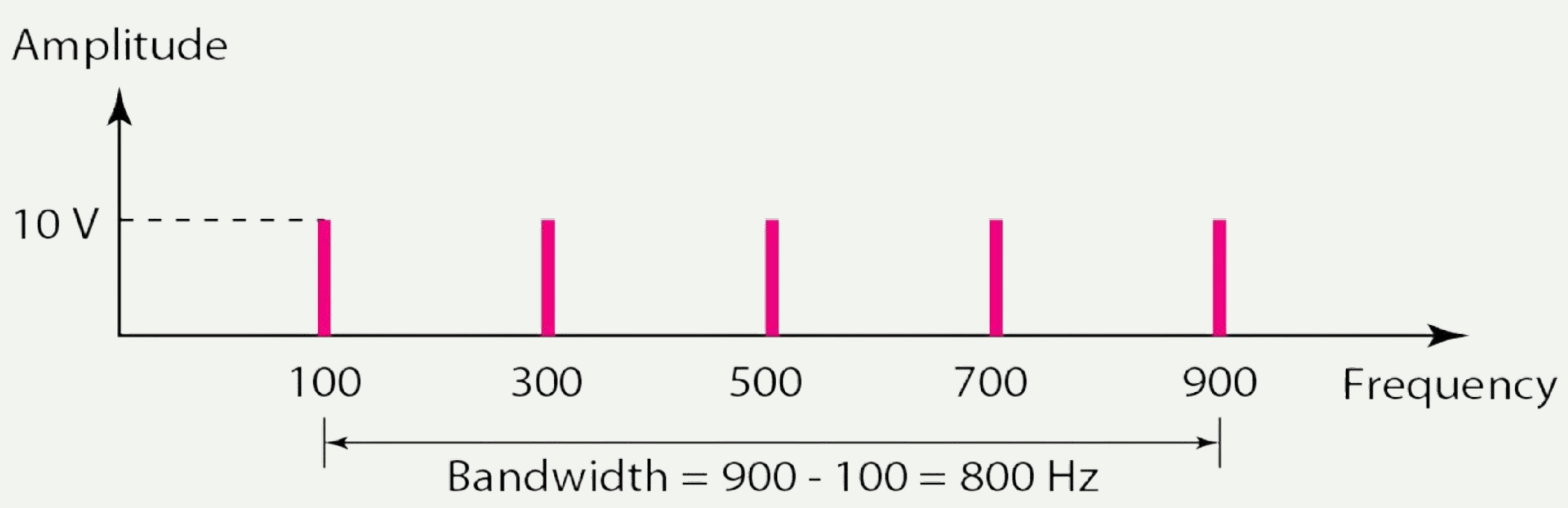
How to calculate Bandwidth?

EXAMPLE

If a periodic signal is decomposed into five sine waves with frequencies of 100, 300, 500, 700, and 900 Hz, what is its bandwidth? Draw the spectrum, assuming all components have a maximum amplitude of 10 V.

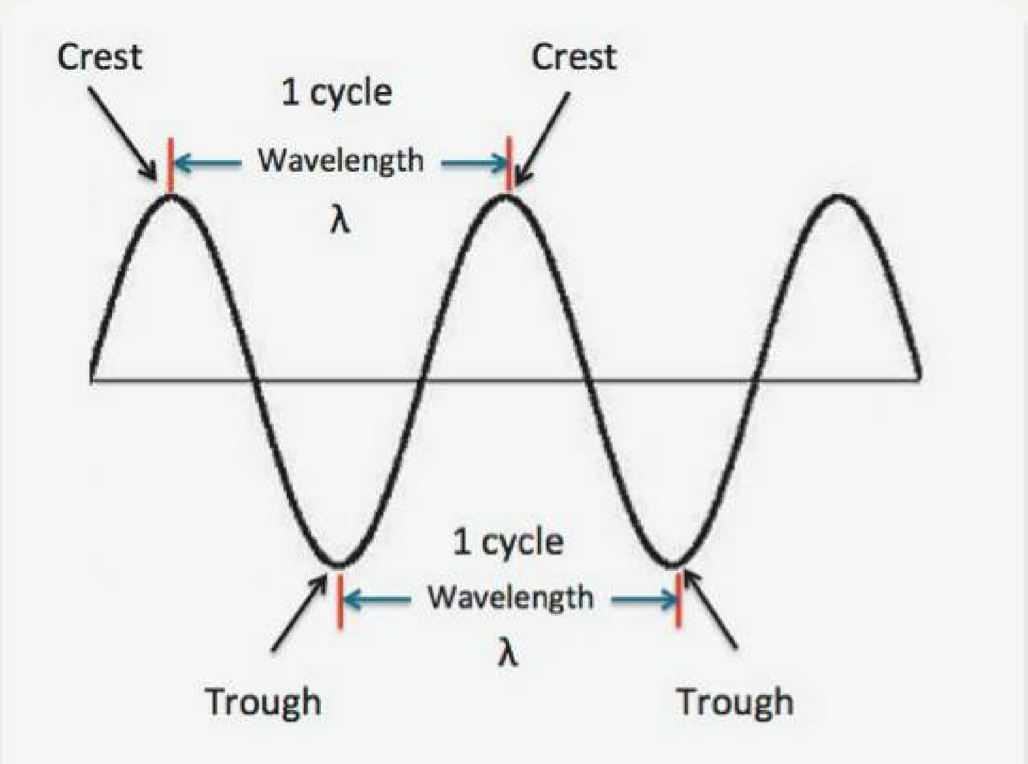
Solution

Let fh be the highest frequency, fL the lowest frequency, and B the bandwidth.



WAVELENGTH (λ)

DEFINITION: Wavelength is the length of one cycle (or one oscillation) of a waveform.



Crest, Trough and Wavelength

The relationship among frequency f, light velocity c, and wavelength λ is expressed mathematically as :

$$\lambda = \frac{c}{f}$$

where;

λ = wavelength (meter)

c = velocity of light (3×10^8 m/s)

f = frequency (Hz)

From above equation, wavelength is inversely proportional to the frequency of the wave and directly proportional to the velocity of propagation.

EXAMPLE

1. Find the wavelength if a signal has a frequency of 27 MHz.

$$\lambda = \frac{C}{f}$$

$$\lambda = \frac{3\ X\ 10^8}{27\ X\ 10^6}$$

$$= 11.11 \text{ m}$$

2. A signal with a wavelength of 1.5 m has a frequency of________________

$$\lambda = \frac{C}{f}$$

$$f = \frac{3\ X\ 10^8}{1.5}$$

$$= 200 \text{ MHz}$$

3. A signal travels a distance of 75 ft. in the time it takes to complete 1 cycle. What is it's frequency?

Unit for wavelength is in meter, we need to convert feet into meter, 1 m = 3.2 ft

$$\therefore\ 75\ \text{ft} \times \frac{1\ \text{m}}{3.2\ \text{ft}}$$

$$= 23.4\ \text{m}$$

$$\lambda = \frac{C}{f}$$

$$f = \frac{3\ X\ 10^8}{23.4}$$

$$f = 12.820\ \text{Mhz}$$

3.2 Understand Information Capacity

Information capacity is a measure of how much information can be propagated through a communications system. It is a function of bandwidth and transmission time. Information capacity represents the number of independent symbol that can be carried through a system in a given unit of time. The most basic digital symbol used to represent information is the binary digit or bit.

The Shannon capacity theorem defines the maximum amount of information, or data capacity, which can be sent over any channel or medium. Usually expressed as bit rate.

Shannon's Limit

"Information is the resolution of uncertainty." ~ Claude Shannon

Claude Elwood Shannon
(April 30, 1916 – February 24, 2001)

- An American mathematician, electrical engineer, computer scientist and cryptographer known as the "father of information theory".
- He is credited alongside George Boole for laying the foundations of the Information Age.

- In 1948, Claude E. Shannon developed a useful relationship among Information Capacity (I) of a communication channel, Bandwidth (BW), and signal to noise ratio (S/N).
- The higher the signal-to-noise ratio, the better the performance and the higher the information capacity.
- Mathematically stated, the Shannon Limit for information capacity is;

$$I = B\ \log_2\left(1+\frac{S}{N}\right)$$

or

$$I = 3.32\ B\ \log_{10}\left(1+\frac{S}{N}\right)$$

EXAMPLE

1. A standard telephone circuit has a signal-to-noise power ratio of 1000W and a bandwidth of 2.7kHz. Calculate the Shannon limit for information capacity.

Information Capacity,

$$I = 3.32\ B\ \text{Log}\,(1 + \text{SNR})$$

$$I = 3.32\ (2700)\ \text{Log}\,(1 + 1000)$$

$$= 26.9\ \text{Kbps}$$

2. For a standard telephone circuit has an output signal power of 100W, an output noise power of 0.01W, and a bandwidth of 2.7kHz. Determine its information capacity.

Information capacity , I = 3.32 B log SNR

Need to find SNR ,

$$\text{SNR} = \frac{S}{N} = \frac{P_S}{P_N}$$

$$\text{SNR} = \frac{P_S}{P_N}$$

$$\text{SNR} = \frac{100}{0.01}$$

$$\text{SNR} = 10000$$

Information capacity , I = 3.32 B log SNR

= 3.32 (2700) Log (1+10000)

= 35.856 Kbps

3. A standard telephone circuit has a signal-to-noise power ratio of 30 dB. Calculate the Shannon limit for information capacity.

For a standard telephone circuit , frequency between 300 Hz - 3400 Hz . Therefore bandwidth ,

$$B = F_H - F_L$$

$$B = 3400 - 3100$$

$$= 3100\ \text{Hz.}$$

$$\text{SNR (dB)} = 10 \log \text{SNR}$$

$$30\ \text{dB} = 10 \log \text{SNR}$$

$$\text{SNR} = 10^3$$

$$= 1000$$

Information Capacity,

$$I = 3.32\ B\ \text{Log}\,(1 + \text{SNR})$$

$$I = 3.32\ (3100)\ \text{Log}\,(1 + 1000)$$

$$= 30.880\ \text{Kbps}$$

REVIEW TOPIC 3

Question 1:
Which section of the frequency spectrum do VLF, LF, HF, VHF, UHF, SHF, and EHF fall under?

A. X-Ray
B. Infra - Red
C. Radio Frequency
D. Gamma

Question 2:
Which part of the electromagnetic spectrum has the highest frequency?

A. X-Ray
B. Ultra - Violet
C. Radio Frequency
D. Gamma

Question 3:
RF frequency spectrum range is from:

A. 30 MHz to 300 MHz
B. 3 MHz to 30 MHz
C. 300 MHz to 3 GHz
D. 3 Hz to 3 GHz

Question 4:
What is a characteristic of short wavelengths?

A. low frequency
B. penetrate less
C. have less energy
D. fewer waves per length

Question 5:
___________has longer wavelengths, penetrates more deeply, and produces more heat than visible light

A . Infrared
B. Visible
C. Ultraviolet
D. Green

Topic 4

Transmission Mode and Type of Communication System

4.1 Understand transmission mode
4.2 Know types of communication system

4.1 Transmission Mode

Transmission mode is the flow of information signal between two points. These modes direct the direction of flow of information signal. There are three modes of transmission for communications circuit:

3

a. Simplex

b. Half duplex

c. Full duplex

SIMPLEX

- The transmission medium allows information signals to flow only in one direction.
- Receive-only, transmit-only, and one-way-only are other names for simplex lines.
- As seen in Figure 4.1, some examples include radio and television broadcasts as well as workstations with monitors.

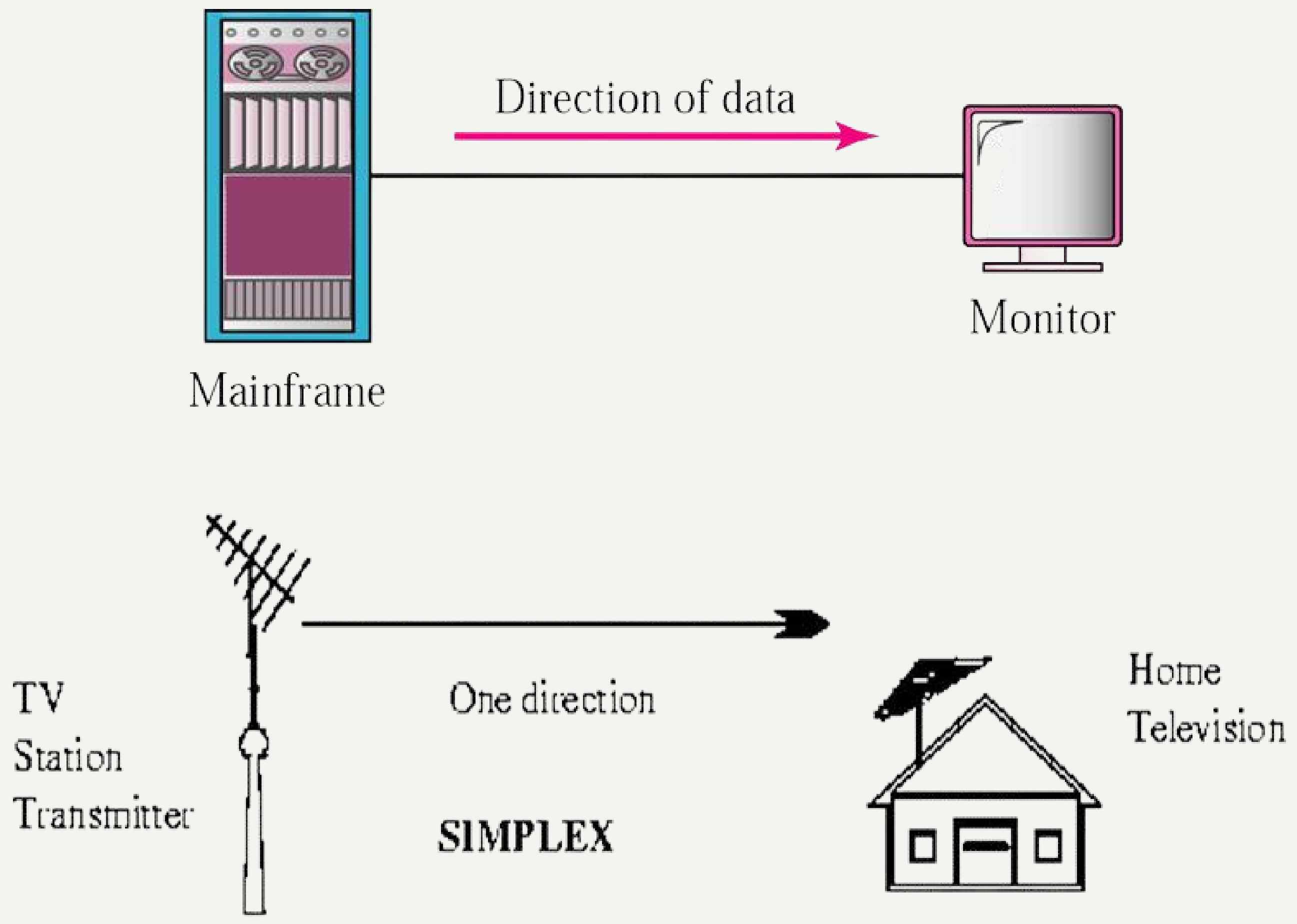


Figure 4.1 : Simplex transmission mode

HALF - DUPLEX

- On the transmission medium, an information signal can flow in both directions at once, but only in one.
- Another name for half-duplex communications lines is either-way or two-way alternate lines.
- As illustrated in Figure 4.2, a walkie-talkie conversation is an example of a half-duplex data flow. It is a turn-taking conversation. Nothing happens if they both speak at once.

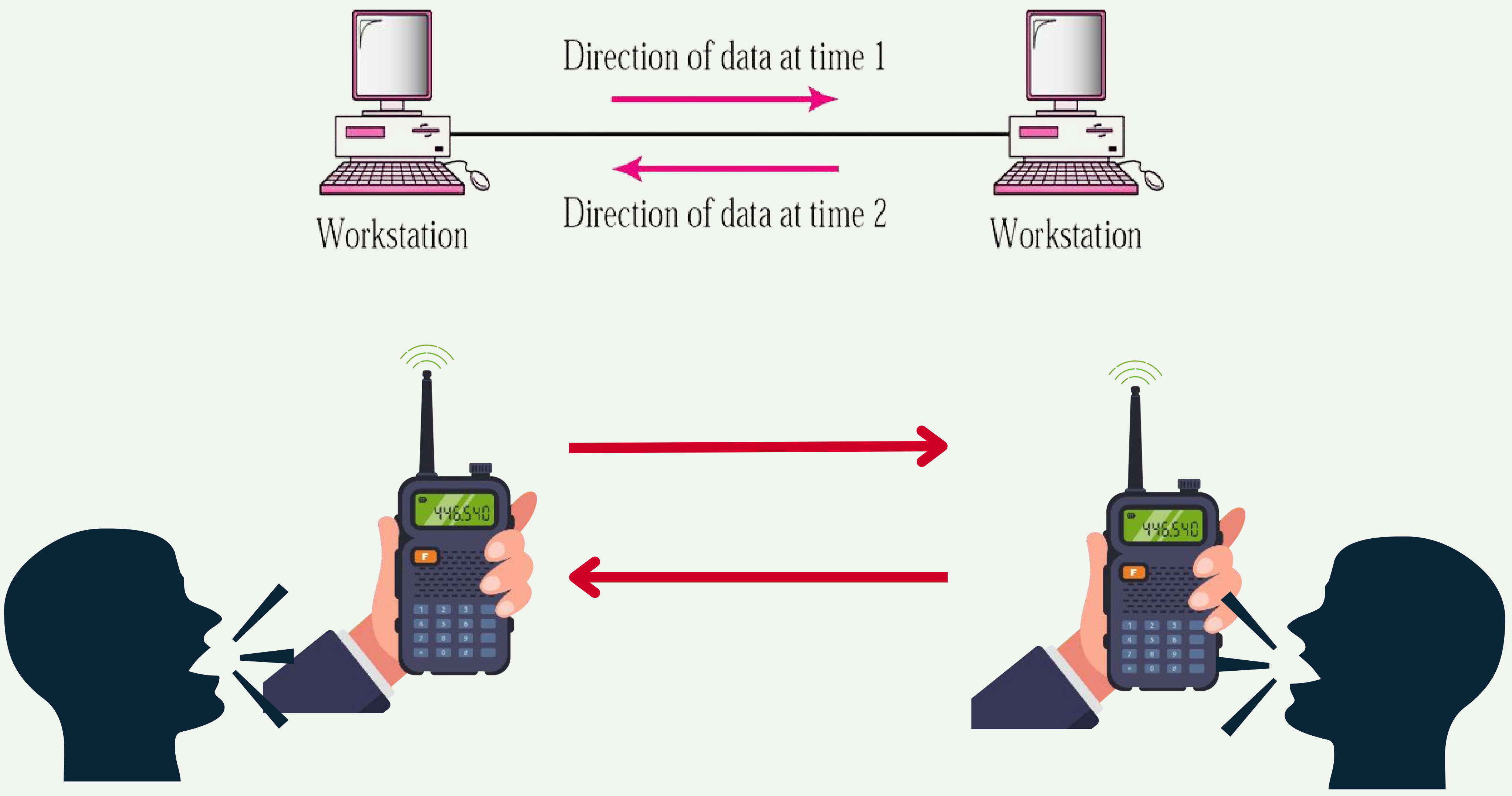


Figure 4.2 : Half Duplex transmission mode

FULL - DUPLEX

- Signals of information flow simultaneously in both directions.
- They must be between the same two stations.
- Other names for full duplex lines include two-way simultaneous, duplex, or both-way lines.
- As an illustration, a local phone call and a web chat are shown in Figure 4.3.

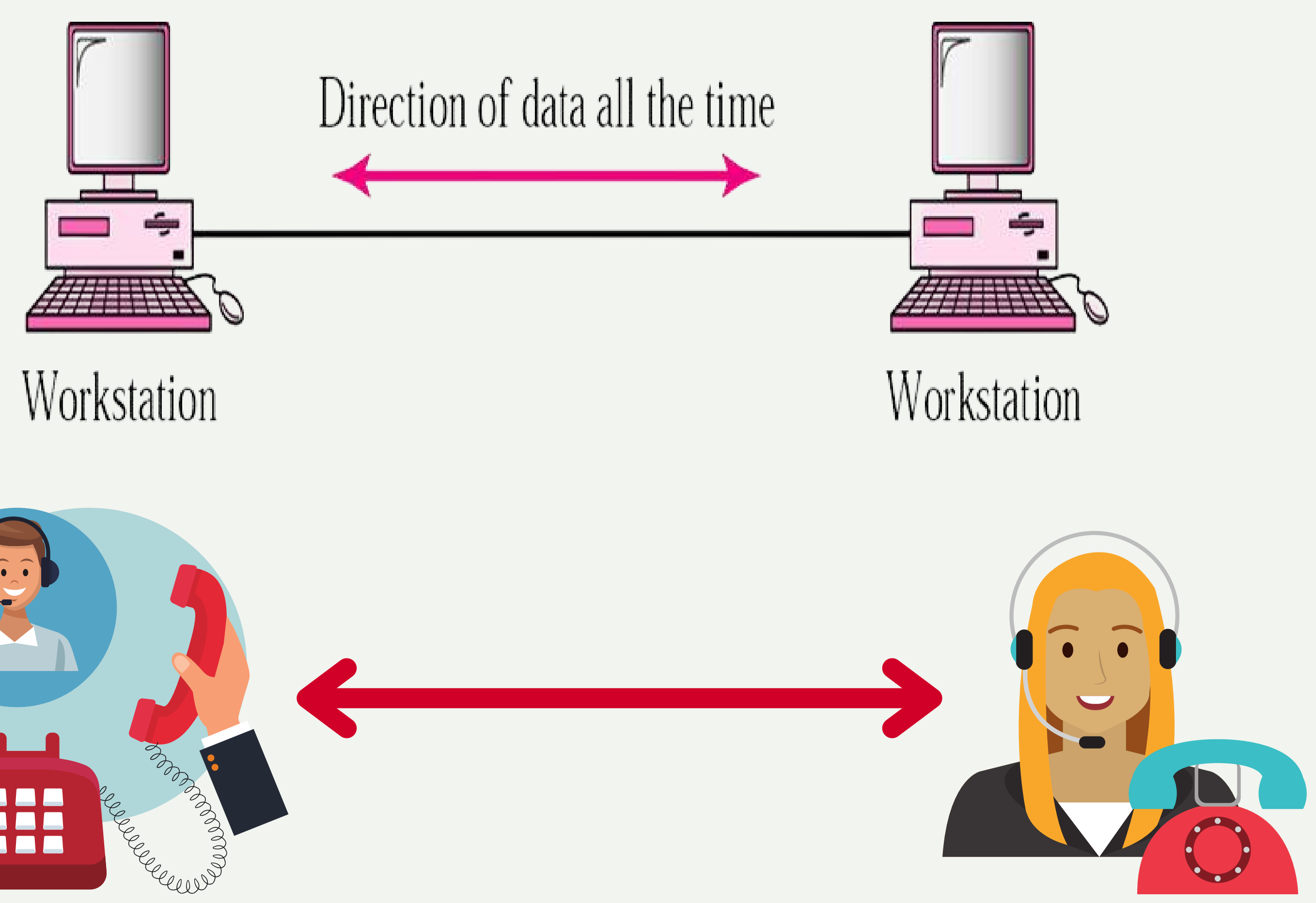


Figure 4.3 : Full Duplex transmission mode

TYPES of COMMUNICATION SYSTEM

Based on their physical configuration and the characteristics of the signals they send, communication systems can be divided into different groups. A communication system can be of four types.

1. **Broadcast Communication System**
2. **Mobile Communication System**
3. **Fixed Communication System**
4. **Data Communication System**

BROADCAST COMMUNICATION SYSTEM

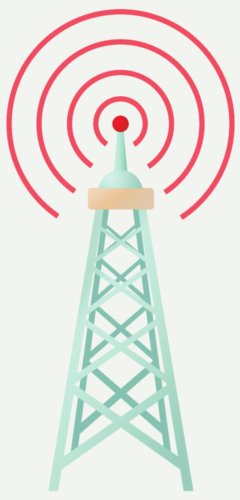
- A wireless audio and video signal transmitted to a receiver through a medium such as television or radio is called a broadcast.
- It's a signal transmission technique that allows several recipients to receive from a single sender.
- A form of communication known as broadcast is known as simplex (one-way data flow).
- Since there is no communication between the content creator and the user, the value of the communications won't be significantly impacted by even a small delay in the content delivery.

Historically, there have been several different types of electronic broadcasting media:

- Telephone broadcasting (1881)
- Radio broadcasting (1906)
- Television broadcasting (telecast) (1925)
- Cable radio (1928)
- Satellite television (1974) and Satellite radio (1990)
- Webcasting of video/television (1993) and audio/radio (1994) streams.

MOBILE COMMUNICATION

- A mobile communication system uses microwave signals to transmit, receive, and emit voice and data information wirelessly.
- As an illustration, use your hand phone to text or talk on the phone.
- Full Duplex communication is used, which allows data to flow in two directions at once.
- Making use of the Global System for Mobile (GSM) standards, which were created by the European Telecommunications Standards Institute (ETSI).



FIXED COMMUNICATION

- Fixed Communication uses a fixed line to enable communication in both directions. It is a full-duplex (FDX) or occasionally full duplex system." Utilizing Public Switching Telephone Network (PSTN), a set of standards created by the Telecommunication Standardisation Sector (ITU-T).
- Landline phone networks are one example.

What is PSTN?

- The Public Switched Telephone Network is abbreviated as PSTN. The phrase "PSTN" describes the conventional phone network that is utilised for voice-based communications. In order to connect people reliably using standard phone numbers, it consists of numerous interconnected carriers.

- Common names for this phone network include analogue, landlines, fixed lines, or Plain Old Telephone Service (POTS). There has been widespread usage of this system since the late 1800s. The Central Office switches that subscriber lines are connected to make up the PSTN, or Public Switched Telephone Network, as depicted in Figure 4.4. The subscriber line (phone number) connected to a specific port is programmed into the CO switch.

- The called subscriber line may be directly connected to the other switch, or it may route the call via an interoffice trunk to another switch if the called number is not on the local switch.

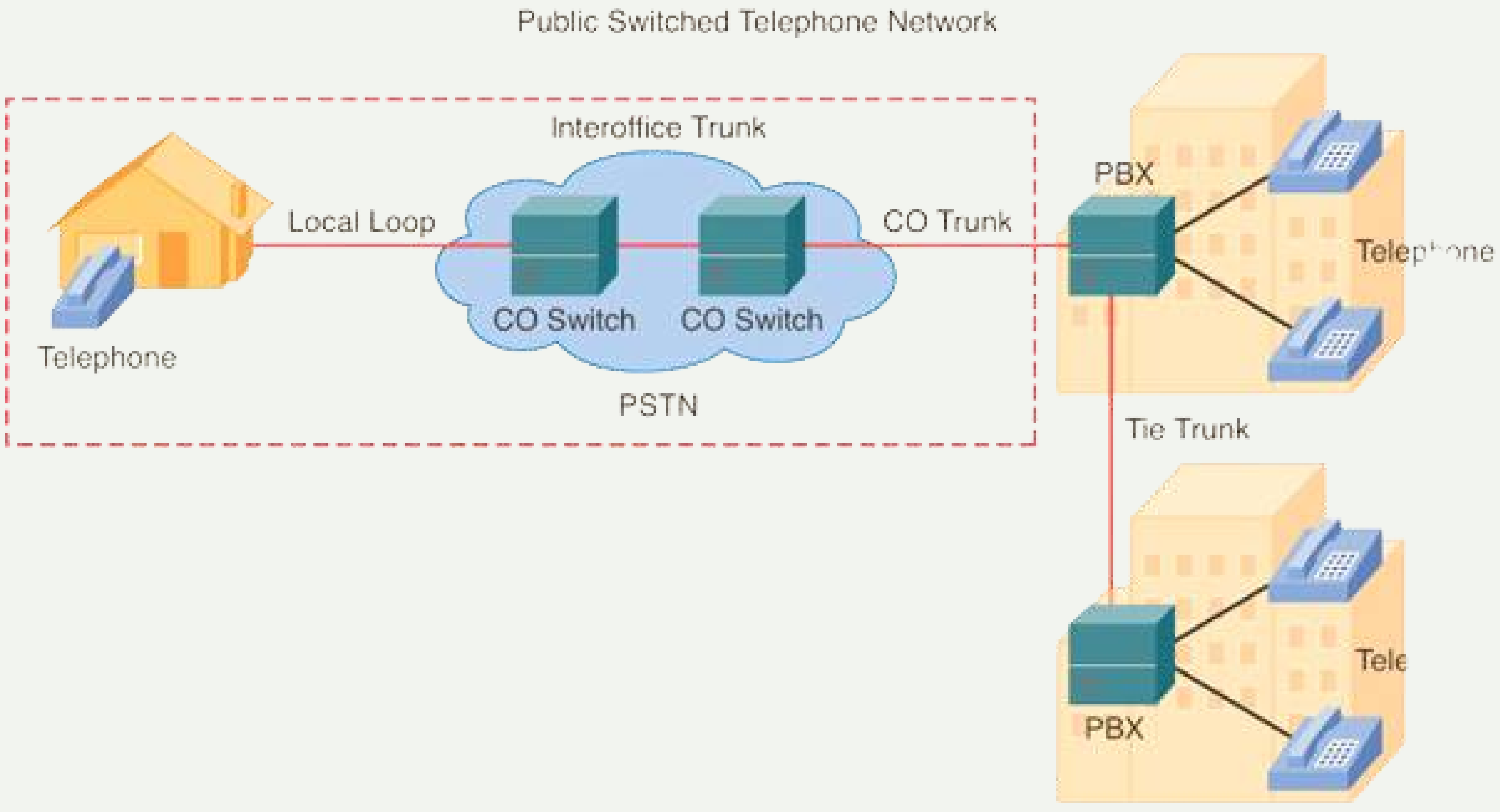


Figure 4.4 : Public Switching Telephone Network

DATA COMMUNICATION

- Data communication is the process of sending digital information, usually in binary form, between two or more points. Binary ones and zeros are examples of simple data, but data can also contain complex information like digital audio or video.
- As an illustration, consider computer communications, where a lot of data is transferred between computers and peripheral devices.

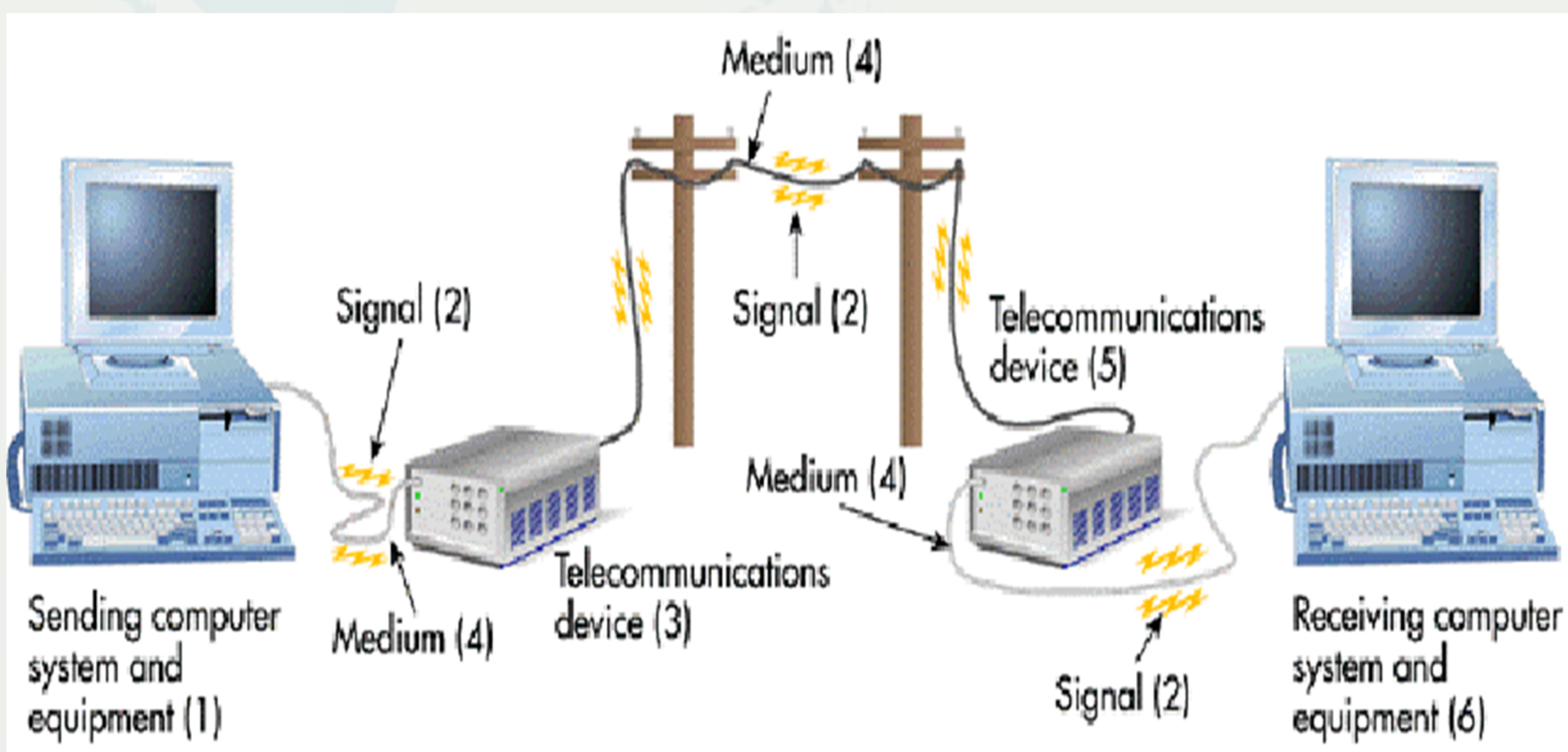


Figure 4.5 : Data Communication

Applications Of Data Communication

In data communications, virtual message sharing is referred to.
Figure 4.6 illustrates how data communications include both phone conversations and electronic communications like emails and instant messages.

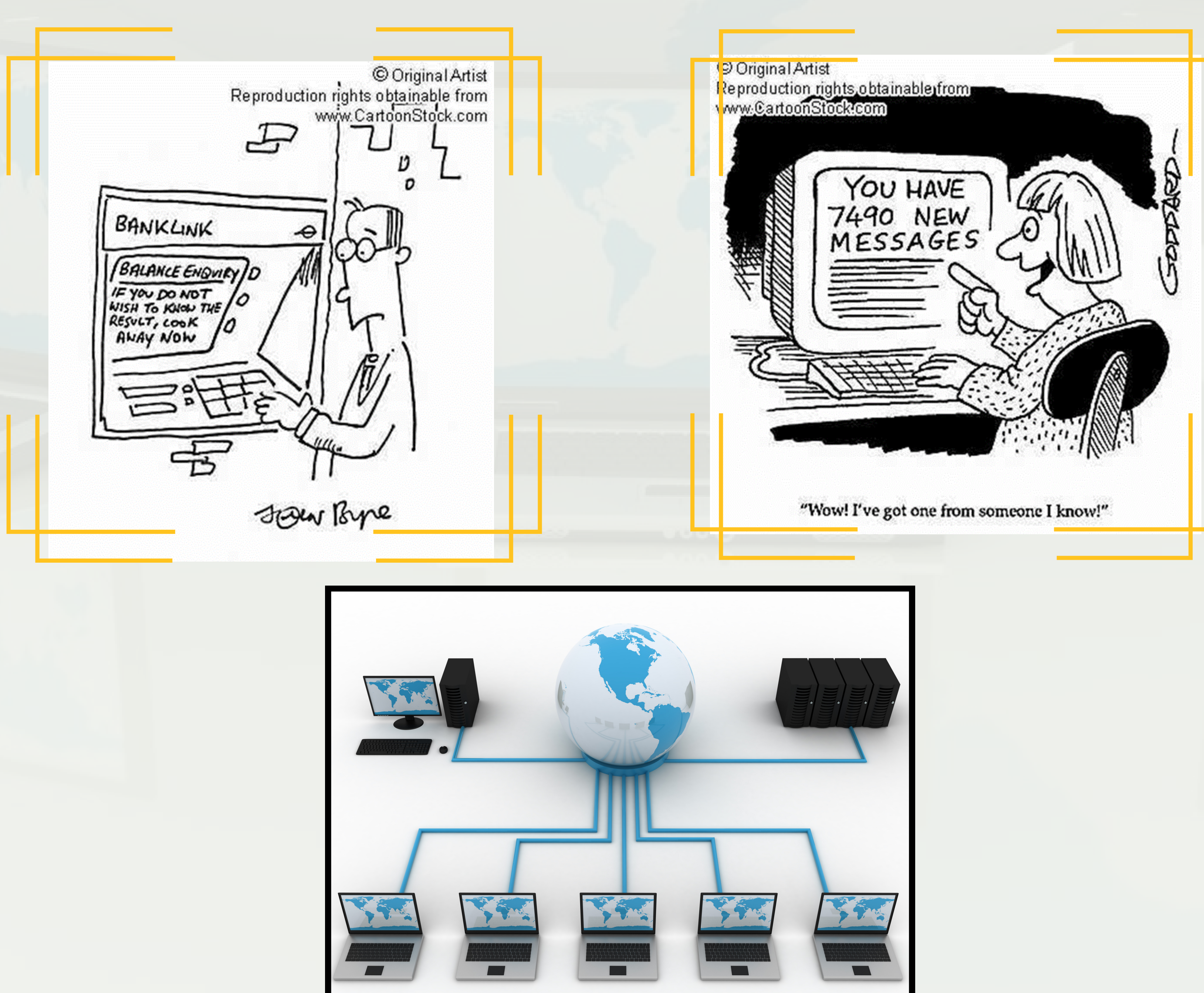


Figure 4.6 : Application of Data Communication

COMPARISON

Broadcast Communication System

- One way communication (Simplex)
- Using radio wave

Mobile Communication System

- Two way communication (Full Duplex)
- Using microwave

Fixed Communication System

- Information in analog signal (audio)
- Telephone-telephone

Data Communication System

- Information in digital signal
- Computer-computer

REVIEW TOPIC 4

Question 1:
Data Communication is______________________

A. transmission of language between two or more human
B. transmission of this system between two or more things
C. transmission of this digital data between two or more devices
D. None of the above

Question 2:
Which mode of transmission allows for communication in both directions simultaneously?

A. Half duplex
B. Simplex
C. Full duplex

Question 3:
What mode of communication supports transmission of data in one direction?

A. One-way
B. Half duplex
C. Simplex
D. Full duplex

Question 4:
Types of communication system **EXCEPT**__________

A. Data Communication
B. Fixed Communication
C. Broadcast Communication
D. Amplitude Modulation

Question 5:
What electromagnetic wave is used for mobile communications?

A. Radio
B. Microwave
C. Infra Red
D. Gamma

• Answer

TOPIC 1

1. **C**
2. **B**
3. **A**
4. **MODULATOR , MULTIPLEXING AND ENCODING**
5. **C**

TOPIC 2

1. **A**
2. **B**
3. **PS(IN) = 3.162 X 10^-10 W**
4. **SNR (OUT) = 16 DB**
5. **F = 2.67 , NF = 4.27 DB**

TOPIC 3

1. **C**
2. **D**
3. **D**
4. **B**
5. **A**

TOPIC 4

1. **C**
2. **C**
3. **C**
4. **D**
5. **B**

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Basic Communication System

The purpose of this eBook is to serve as a reference for students and other learners who want to understand the fundamental ideas behind communication system components. It also covers communication impairment, which has an impact on transmission modes, frequency spectrum, signal quality, and communication system types.

In order to improve students' knowledge and comprehension of the communication system, this eBook also contains questions.

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