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**LEARNING OBJECTIVES**

After studying this chapter the learner should be to

1. Understand difference among the various communication systems

2. Identify the different functional parts in a communication system and learn the working of the same

3. Accepts the limitations of communication systems and learns the methods to overcome those limitations

4. Understands modulation and its advantages

5. Understands signals in frequency domain and importance of Fourier transform

6. Able to differentiate propagation of EMW for different applications.

**1. INTRODUCTION**

This course introduces electrical communication systems, including analysis methods, design principles, and hardware considerations. We begin with a descriptive overview that establishes a perspective for the chapters that follow.

Communication system conveys information from its source to a destination some distance away. There are so many different applications of communication systems that we cannot attempt to cover every type. Nor can we discuss in detail all the individual parts that make up a specific system. A typical system involves numerous components that run the gamut of electrical engineering-circuits, electronics, electromagnetic signal processing, microprocessors, and communication networks, to name a few of the relevant fields. Moreover, a piece-by-piece treatment would obscure the essential point that a communication system is an integrated whole that really does exceed the sum of its parts.

We therefore approach the subject from a more general viewpoint. Recognizing that all communication systems have the same basic function of information transfer, we'll seek out and isolate the principles and problems of conveying information in electrical form. These will be examined in sufficient depth to develop analysis and design methods suited to a wide range of applications.

**2. ANALOG AND DIGITAL MESSAGE**

An **analog** message is a physical quantity that varies with time, usually in a smooth and continuous fashion. Examples of analog messages are the acoustic pressure produced when you speak, the angular position of an aircraft gyro, or the light intensity at some point in a television image. Since the information resides in a time varying waveform, an analog communication system should deliver this waveform with a specified degree of **fidelity.**

A **digital** message is an ordered sequence of symbols selected from a finite set of discrete elements. Examples of digital messages are the letters printed on this page, a listing of hourly temperature readings, or the keys you press on a computer keyboard. Since the information resides in discrete symbols, a digital communication system should deliver these symbols with a specified degree of **accuracy** in a specified amount of time.

**3. ELEMENTS OF COMMUNICATION SYSTEMS**



Figure 1.1-2 depicts the elements of a communication system, omitting transducers but including unwanted contaminations. There are three essential parts of any communication system, the transmitter, transmission channel, and receiver. Each part plays a particular role in signal transmission, as follows.

The **transmitter** processes the input signal to produce a transmitted signal suited to the characteristics of the transmission channel. Signal processing for transmission almost always involves **modulation** and may also include **coding.**

The **transmission channel** is the electrical medium that bridges the distance from source to destination. It may be a pair of wires, a coaxial cable, or a radio wave or laser beam. Every channel introduces some amount of transmission **loss** or **attenuation,** so the signal power progressively decreases with increasing distance.

The **receiver** operates on the output signal from the channel in preparation for delivery to the transducer at the destination. Receiver operations include **amplification** to compensate for transmission loss, and **demodulation** and **decoding** to reverse the signal-processing performed at the transmitter. **Filtering** is another important function at the receiver, for reasons discussed next

Various unwanted undesirable effects crop up in the course of signal transmission. Attenuation is undesirable since it reduces signal **strength** at the receiver. More serious, however, are distortion, interference, and noise, which appear **as** alterations of the signal **shape.** Although such contaminations may occur at any point, the standard convention is to blame them entirely on the channel, treating the transmitter and receiver as being ideal. Figure 1.1-2 reflects this convention.

**Distortion** is waveform perturbation caused by imperfect response of the system to the desired signal itself. Unlike noise and interference, distortion disappears when the signal is turned off. If the channel has a linear but distorting response, then distortion may be corrected, or at least reduced, with the help of special filters called **equalizers.Noise** refers to random and unpredictable electrical signals produced by natural processes both internal and external to the system. When such random variations are superimposed on an information-bearing signal, the message may be partially corrupted or totally obliterated. Filtering reduces noise contamination, but there inevitably remains some amount of noise that cannot be eliminated. This noise constitutes one of the fundamental system limitations.

Finally, it should be noted that Fig. 1.1-2 represents one-way or **simplex** (SX) transmission. Two-way communication, of course, requires a transmitter and receiver at each end. A **full-duplex** (FDX) system has a channel that allows simultaneous transmission in both directions. A **half-duplex** (HDX) system allows transmission in either directions but not at the same time.

**4. LIMITATIONS OF COMMUNICATION SYSTEMS**

An engineer faces two general kinds of constraints when designing a communication system. On the one hand are the **technological problems,** including such diverse considerations as hardware availability, economic factors, federal regulations, and so on. These are problems of feasibility that can be solved in theory, even though perfect solutions may not be practical. On the other hand are the **fundamental physical limitations,** the laws of nature as they pertain to the task in question. These limitations ultimately dictate what can or cannot be accomplished, irrespective of the technological problems. The fundamental limitations of information transmission by electrical means are **bandwidth** and **noise.**

The concept of bandwidth applies to both signals and systems as a measure of **speed.** When a signal changes rapidly with time, its frequency content, or **spectrum,** extends over a wide range and we say that the signal has a large bandwidth. Similarly, the ability of a system to follow signal variations is reflected in its usable frequency response or **transmission bandwidth.** Now all electrical systems contain energy-storage elements, and stored energy cannot be changed instantaneously. Consequently, every communication system has a finite bandwidth B that limits the rate of signal variations.

Communication under real-time conditions requires sufficient transmission bandwidth to accommodate the signal spectrum; otherwise, severe distortion will result. Thus, for example, a bandwidth of several megahertz is needed for a TV video signal, while the much slower variations of a voice signal fit into B = 3 kHz. For a digital signal with *r* symbols per second, the bandwidth must be B $\geq $*rl2.* In the case of information transmission without a real-time constraint, the available bandwidth determines the maximum signal speed. The time required to transmit a given amount of information is therefore inversely proportional to B.

We measure noise relative to an information signal in terms of the **signal-to noise power ratio** *SIN.* Thermal noise power is ordinarily quite small, and *SIN* can be so large that the noise goes unnoticed. At lower values of *SIN,* however, noise degrades fidelity in analog communication and produces errors in digital communication. These problems become most severe on long-distance links when the transmission loss reduces the received signal power down to the noise level. Amplification at the receiver is then to no avail, because the noise will be amplified along with the signal.

Taking both limitations into account, Shannon (1948)i stated that the rate of information transmission cannot exceed the **channel capacity.**

*C* = B log (1 + ***S*/N***)*

This relationship, known as the **Hartley-Shannon law,** sets **an** upper limit on the performance of a communication system with a given bandwidth and signal-to noise ratio.

**5. MODULATION AND BENEFITS**

The primary purpose of modulation in a communication system is to generate a modulated signal suited to the characteristics of the transmission channel. Actually, there are several practical benefits and applications of modulation briefly discussed below.

**Modulation for Efficient Transmission** Signal transmission over appreciable distance always involves a traveling electromagnetic wave, with or without a guiding medium.The efficiency of any particular transmission method depends upon the frequency of the signal being transmitted. By exploiting the frequency-translation property of CW modulation, message information can be impressed on a carrier whose frequency has been selected for the desired transmission method.

As a case in point, efficient **Line-of-sight radio** propagation requires antennas whose physical dimensions are at least 1/10 of the signal's wavelength. Unmodulated transmission of an audio signal containing frequency components down to 100 Hz would thus call for antennas some 300 Km long. Modulated transmission at 100 MHz, as in FM broadcasting, allows a practical antenna size of about one meter.

**Modulation to Overcome Hardware Limitations** The design of a communication system may be constrained by the cost and availability of hardware, hardware whose performance often depends upon the frequencies involved. Modulation permits the designer to place a signal in some frequency range that avoids hardware limitations. A particular concern along this line is the question of **fractional bandwidth,** defined as absolute bandwidth divided by the center frequency. Hardware costs and

complications are minimized if the fractional bandwidth is kept within 1-10 percent. Fractional-bandwidth considerations account for the fact that modulation units are found in receivers as well as in transmitters.

It Likewise follows that signals with large bandwidth should be modulated on high-frequency carriers. Since information rate is proportional to bandwidth, according to the Hartley-Shannon law, we conclude that a high information rate requires a high carrier frequency. For instance, a *5* GHz microwave system can accommodate 10,000 times as much information in a given time interval as a 500 Hz radio channel. Going even higher in the electromagnetic spectrum, one optical laser beam has a bandwidth potential equivalent to 10 million TV channels.

**Modulation to Reduce Noise and Interference** A brute-force method for combating noise and interference is to increase the signal power until it overwhelms the contaminations. But increasing power is costly and may damage equipment. (One of the early transatlantic cables was apparently destroyed by high-voltage rupture in an effort to obtain a usable received signal.) Fortunately, FM and certain other types of modulation have the valuable property of suppressing both noise and interference.

**Modulation for Frequency Assignment** When you tune a radio or television set to a particular station, you are selecting one of the many signals being received at that time. Since each station has a different assigned carrier frequency, the desired signal can be separated from the others by filtering. Were it not for modulation, only one station could broadcast in a given area; otherwise, two or more broadcasting stations would create a hopeless jumble of interference.

**Modulation for Multiplexing** Multiplexing is the process of combining several signals for simultaneous transmission on one channel. **Frequency-division multiplexing (FDM)** uses CW modulation to put each signal on a different carrier frequency, and a bank of filters separates the signals at the destination. **Time-division multiplexing** (TDM) uses pulse modulation to put samples of different signals in nonoverlapping time slots.Applications of multiplexing include

FM stereophonic broadcasting, cable TV, and long-distance telephone.

A variation of multiplexing is **multiple access** (MA). Whereas multiplexing involves a assignment of the common communications resource (such as frequency spectrum) at the local level, MA involves the remote sharing of the resource. For example, code-division multiple access (CDMA) assigns a unique code to each digital cellular user, and the individual transmissions are separated by correlation between the codes of the desired transmitting and receiving parties. Since CDMA allows different users to share the same frequency band simultaneously, it provides another way of increasing communication efficiency.

**6. DATA AND SIGNALS**

In this section the material is in the form of power point handouts. Please refer the handouts.

**7. PROPAGATION OF EMW**

 (a). Ground Wave Propagation

* Ground wave propagation is used for propagation of frequencies below 2MHz.
* EMW tends to follow the contour of the earth. (i.e.) the wave propagates along the surface of the earth.
* This is the propagation mode used in AM broadcasting.



 (b) Sky wave Propagation



* Long distance coverage is obtained by reflecting the wave at the ionosphere and at earth boundaries
* The transmitting station will have coverage area as shown in figure in black lines.
* Because of this ionosphere layer international broadcast stations like BBC can be heard from the other side of the world.

( C )Line of sight propagation

* LOS is used above 30 MHz. EMW propagates in a straight line
* This property is used for TV broadcasting and mobile communications .
* Demerit : Antennas need to be placed on tall towers.



**FOOD FOR THOUGHT**

**Activity-I**

Below listed are the names of great persons whom contributed to the field of Electronics and Communications

Research at least about 2 persons and highlight between these 2 persons, which person you like the most and why in your report.

(a) Jean Baptiste Joseph Fourier (b) Antoine Parseval (c) John R. Carson

(d) Friedrich Wilhelm Bessel (e) John William Strutt (f) Samuel B. Morse

(g) Emile Baudot (h) Georg Simon Ohm (i) Reginald Fessenden

(j) Stephen O. Rice (k) Claude Shannon (l) Alexander Graham Bell

(m) Hedy Lamarr (n) Claude Berrou (o) Lee de Forest

(p) Harold Nyquist (q) Andrei Andreyevich Markov (r) Reverend Thomas Bayes

(s) Gottfried Wilhelm Leibniz (t) Carl Friedrich Gauss (u) Pierre Simon Laplace

(v) Christian Doppler (w) Norbert Wiener (x) David Hilbert

(y) Gordon Moore (z) Euclid of Alexandria

**Activity –II**

Study the historical chronology events of communications and highlight which event is most liked by you and why.

**Note**

The report for the above activities should have at most 2 -3 pages and their references.

Sample report available on request.

**References for this chapter**

1. Communication systems by Bruce Carlson

2. Data communications and Networking by Forouzan

3. Digital and analog communication systems by Couch.