Principle of Communications

Chapter 1 : Introduction

Q. 1 Explain an electronic communication system with the help of a block diagram.

Dec. 10, May 12, Dec. 12, Dec. 14

Ans. : The block diagram of the simplest possible communication system is as shown in Fig. 1.1.

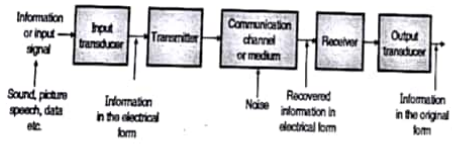

Fig. 1.1: Block diagram of the basic communication system

As seen from the Fig. 1.1, the elements of a basic communication system are transmitter, a communication medium (channel) and the receiver. When the transmitted signal is travelling from the transmitter to the receiver over a communication channel, noise gets added to it.

The elements of basic communication system are as follows :

1. Information or input signal
2. Input transducer
3. Transmitter
4. Communication channel or medium
5. Noise
6. Receiver
7. Output transducer

1. Information or Input signal

The communication systems have been developed for communicating useful information from one place to the other. This information can be in the form of a sound signal like speech or music, or it can be in the form of pictures (TV signals) or it can be data information coming from a computer.

2. Input transducer

The information in the form of sound, picture or data signals cannot be transmitted as it is. First it has to be converted into a suitable electrical signal. The input transducer block does this job. The input transducers commonly used in the communication systems are microphones, TV camera etc.

3. Transmitter

The function of the transmitter block is to convert the electrical equivalent of the information to a suitable form. In addition to that it increases the power level of the signal. The power level should be increased in order to increase the range of transmitted signal. The transmitter consists of the electronic circuits such as amplifier, mixer, oscillator and power amplifier.

4. Communication channel or medium

The communication channel is the path used for transmission of electronic signal from one place to the other. The communication medium can be conducting wires, cables, optical fibre or free space. Depending on the type of communication medium, two types of communication systems will exist. They are :

(i) Wired communication or line communication
(ii) Wireless communication or radio communication

1. Line communication

The line communication systems use the communication mediums like the simple wires or cables or optical fibers. The examples of such systems, are telegraph and telephone systems, cable T.V. etc. Due to physical connection from one point to the other, these systems cannot be used for the communication over long distances.

2. Radio communication

The radio communication systems use the free space as their communication medium. They do not need the wires for sending the information from one place to the other.

The radio or TV broadcasting, satellite communication are the examples of the wireless communication. These systems transmit the signal using a transmitting antenna in the free space.

The transmitted signal is in the form of electromagnetic waves. A receiving antenna will pick up this signal and feed it to the receiver. Radio communication can be used for the long distance communication such as from one country to the other or even from one planet to the other.

5. Noise

Noise is an unwanted electrical signal which gets added to the transmitted signal when it is travelling towards the receiver. Due to noise, the quality of the transmitted information will degrade. Once added, the noise cannot be separated out from the information. Hence noise is a big problem in the communication systems. (Specially analog communication systems). The noise can be either natural or manmade. The sources of natural noise are lightning or radiation from the sun and stars etc. The man made noise includes the noise produced by electrical ignition systems of the automobiles, welding machines, electric motors etc. Even though noise cannot be completely eliminated, its effect can be reduced by using various techniques.

6. Receiver

The process of reception is exactly the opposite process of transmission. The received signal is amplified, demodulated and converted into a suitable form. The receiver consists of electronic circuits like mixer, oscillator, detector, amplifier etc.

7. Output transducers

6. Digital communication is useful in military applications where only a few permitted receivers can receive the

of transmitted signal. The transmitter consists of the | etc.

7. Output transducers

The output transducer converts the electrical signal at the output of the receiver back to the original form i.e. sound or TV pictures etc.

The typical examples of the output transducers are loud speakers, picture tubes, computer monitor etc.

Q. 2 What are the advantages and disadvantages of digital communication. Also draw block diagram of PCM and explain it. May 14

Ans. :

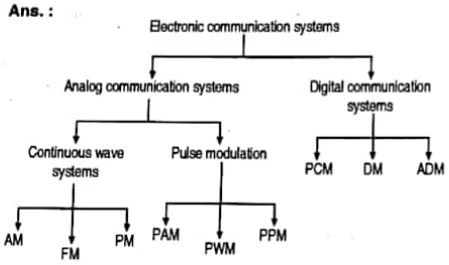

Fig. 1.2 : Classification based on analog or digital communication

Digital communication :

Definition : The modulation system or technique in which the transmitted signal is in the form of digital pulses of constant amplitude, constant frequency and phase is called as digital modulation system.

Examples : Pulse Code Modulation (PCM), Delta Modulation (DM), Differential PCM (DPCM) and Adaptive Delta Modulation (ADM) are the examples of digital modulation. In the PCM and DM, a train of digital pulses is transmitted by the transmitter.

All the pulses are of constant amplitude, width and position. The information is contained in the combination of the transmitted pulses.

Advantages of Digital Communication :

Some of the advantages of digital communication are as follows :

1. Due to the digital nature of the transmitted signal, the interference of additive noise does not introduce many errors. So digital communication has a better noise immunity.
2. Due to the channel coding techniques used in digital communication, it is possible to detect and correct the errors introduced during the data transmission.
3. Repeaters can be used between transmitter and receiver to regenerate the digital signal. This improves the noise immunity further.
4. Due to the digital nature of the signal, it is possible to use the advanced data processing techniques such as digital signal processing, image processing, data compression etc.
5. TDM (Time Division Multiplexing) technique can be used to transmit many voice channels over a single common transmission channel.
6. Digital communication is useful in military applications where only a few permitted receivers can receive the transmitted signal.
7. Digital communication is becoming simpler and cheaper as compared to the analog communication due to the invention of high speed computers and Integrated Circuits (ICs).

Disadvantages of Digital Communication

Some of the important disadvantages of digital communication are :

1. The bit rates of digital systems are high. Therefore, they require a larger channel bandwidth as compared to analog systems.
2. Digital modulation needs synchronization in case of synchronous modulation.

Q. 3 Define the term : Modulation. May 16

Ans.:

In the **Modulation** process, two signals are used namely the **modulating signal** and the **carrier.** The modulating signal is nothing but the base and signal or information signal while carrier is a high frequency sinusoidal signal.

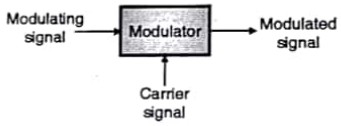

Fig. 1.3 : Modulation

Q. 4 Explain the need of modulation. Dec. 11

Ans. : A question may be asked as, when the baseband signals can be transmitted directly why to use the modulation ?

The answer is that the baseband transmission has many limitations which can be overcome using modulation. It is as explained below.

In the process of modulation, the baseband signal is "translated" i.e. shifted from low frequency side to high frequency side of the frequency spectrum.

This frequency shift is proportional to the frequency of carrier. The modulation process has the following advantages :

Q. 5 Write Short Notes on : International standards for communication systems and assignments. May 10, Dec. 11

Ans. :

1. Wireless communication systems use the atmosphere as the transmission channel.
2. The interference and propagation conditions are mainly dependent on the transmission frequency.
3. It is possible to use any type of modulation such as AM, FM, SSB, PSK, FSK etc.
4. However in order to regulate the things, and to minimize the interference, government regulations specify the following :
   1. Modulation type
   2. Bandwidth
   3. Power
   4. Type of information that can be transmitted over the designated frequency bands.

transmit many voice channels over a single common transmission channel.

2. Bandwidth
3. Power
4. Type of information that can be transmitted over the designated frequency bands.

5. The frequency assignments and technical standards are set internationally by the International Telecommunications Union (ITU).
6. The ITU is a specialized agency of United Nations (U.N.) and its head quarters is in Geneva Switzerland.
7. The ITU is has been structred into three parts :
   1. The Radio communication sector (ITU – R)
   2. The Telecommunications standardization section (ITU-T)
   3. The Telecommunications development sector (ITU-D)
8. The ITU-R sector provides frequency assignments and ensures that the EM spectrum is utilized efficiently.
9. The ITU-T sector checks the technical, operating and traffic problems. It recommends worldwide standards for the Public Telecommunications Network (PTN) and related radio systems.
10. The ITU-D sector provides technical assistance specially for the developing countries.
11. In 1992 ITU was organized into two main sector :
    1. The International Telegraph and Telephone Consultive Committee (CCITT).
    2. The International Radio Consultative Committee (CCIR).
12. All the member nations of ITU are free to decide the spectral usage and standards to be adopted in their territory by abiding the overall frequency plan and standards adopted by ITU.
13. Generally each nation establishes an agency to look after the administration of radio frequency assignments in their country. For example, in U.S. they have FCC i.e. Federal Communication Commission (FCC).
14. The FCC has subdivided the international frequency standards so as to accommodate 70 different categories of services and 9 million transmitters.

Q. 6 Explain types of communication channels.

Dec. 14, May 10

Ans. :

1. A communication channel provides the connection between the transmitter and receiver.
2. Different types of channels are as follows :
   1. Wireline channels
   2. Fiber optic channels
   3. Wireless Electromagnetic channels.
   4. Underwater Acoustic channels
   5. Storage channels

1. Wireline Channels

(i) These channels use the pair of wires that carry the signal in the electrical form.

(ii) The telephone network is the best example of wireline channel. Fig. 1.4 shows the frequency spectrum allocated to various wireline channels.

(iii) The wireline channels are used for the transmission of voice as well as data information.

(iv) The examples of wireline channels are the twisted pair wire lines and coaxial cables. They are also called as guided electromagnetic channel.

2. Fiber Optic Channels

(i) The optical fiber can work as a channel. The information which is to be transmitted is converted into light and then passed over the optical fiber to the receiver.

(ii) At the receiver the light is converted back to signal by means of an optical detector.

(iii) Fig. 1.5 shows the basic optical fiber link.

(iv) The light source or modulator used in transmitter is either an LED or LASER. Information is transmitted by varying (modulating) the intensity of light source with the information signal.

(v) The propagating light is amplified periodically along the transmission path to compensate for the attenuation of signal.

(vi) At the receiver, the light intensity is detected by the optical detector such as a photodiode.

(vii) In future the fiber optic channels will replace all the wireline channels in the telephone network.

3. Wireless Electromagnetic Channels

(i) In radio communication systems, the transmitter radiates its output in the form of electromagnetic waves using the transmitting antenna.

(ii) These waves travel towards the receiver through free air which acts as a communication channel.

(iii) In the electromagnetic spectrum, various frequency bands are allotted for different applications.

(iv) The propagation of EM waves can take place by means of one of the following types :
   1. Ground wave propagation.
   2. Sky wave propagation.
   3. Space wave propagation (Line of Sight or LOS)

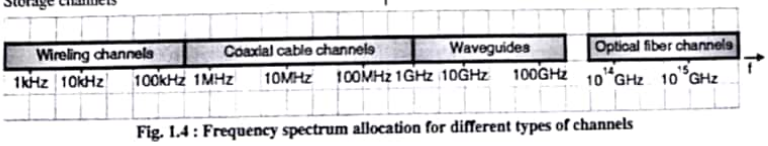

Fig. 1.4 : Frequency spectrum allocation for different types of channels

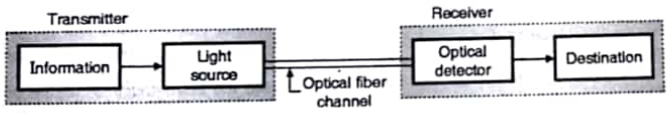

Fig. 1.5 : Fiber optic link

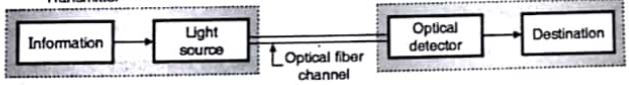

Fig. 1.5 : Fiber optic link

(v) Fig. 1.6 shows the relation between frequency and the type of propagation.

(vi) Ground wave propagation is dominant mode of propagation in the frequency band as 30 kHz to 3 MHz.

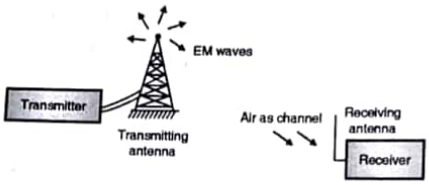

Fig. 1.6 : Wireless electromagnetic channel

4. Underwater Acoustic Channels

(i) The EM waves can not propagate over long distances underwater except at extremely low frequencies. But transmission at such low frequencies is very expensive because large and powerful transmitters are required to be used.

(ii) The underwater communication is required when oceans are being explored. The data collected by the sensors placed underwater should be transmitted first to the surface and then to the data collection center.

(iii) The attenuation of EM waves in water is expressed in terms of the skin depth which is defined as the distance over which a signal is attenuated by 1/e.

(iv) For sea waters the skin depth is given by

$$\delta = \frac{50}{\sqrt{f}}$$

where f is frequency in Hz and δ = Depth in metres.

(v) If f = 10 kHz then the skin depth δ = 2.5m. In contrast the acoustic (sound) signals can propagate over a distance of tens or hundreds of kilometres.

(vi) A shallow water acoustic channel is a multipath channel that means signal get propagated over multiple paths, due to signal reflections from bottom and surface of sea. These multipath signals undergo different delays. These delayed signals tend to partially cancel each other which results in the signal fading.

(vii) In addition to this there will be frequency dependent attenuation. This attenuation is proportional to square of the signal frequency. The noise on the acoustic channels is made by the fish, various mammals in the sea and men near harbours.

(viii) However it is still possible to design and implement an efficient and highly reliable acoustic communication system, for the transmission of digital signals over long distances.

5. Storage Channels

(i) The information storage and retrieval systems are very important when the data is being handled.

(ii) The magnetic tapes, digital audio and video tapes, magnetic disks are used for storing large amount of computer data.

(iii) Optical disks are used for storing the computer data, music and video information. All these data storing systems can be characterised as **storage channels.**

(iv) The process of storing data is equivalent to transmission whereas the process of retrieval is equivalent to reception.

(v) Noise is generated by the electronic components and interference from the adjacent tracks.

Q. 7 Explain digital communication system in details.

Dec. 06, Dec. 14, May 15

Ans.: Two of the most commonly used digital communication systems are PCM (Pulse Code Modulation) and DM (Delta Modulation).

Fig. 1.7 shows the block diagram of a digital communication system. In this diagram three basic signal processing operations have been included. They are :

1. Source coding
2. Channel coding and
3. Modulation.

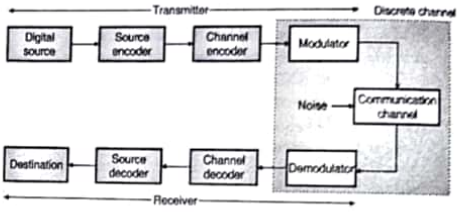

Fig. 1.7 : Digital communication system

The source of information is assumed to be digital. If it is analog then it must be converted first to digital.

1. Source coding

In source coding the source encoder converts the digital signal generated at the source output into another signal in digital form. Source encoding is used to reduce or eliminate redundancy for ensuring an efficient representation of the source output. Different source coding techniques are PCM, DM, ADM etc.

The conversion of signal from one form to the other is called as mapping. Such a mapping is usually one as to one. Due to elimination of redundancy the source coding provides an efficient representation of the source output.

2. Channel coding

Channel encoding is done to minimize the effect of channel noise. This will reduce the number of errors in the received data and will make the system more reliable. Channel coding technique introduces some redundancy. The channel encoder maps the incoming digital signal into a channel input.

3. Modulation

Modulation is used for providing an efficient transmission of the signal over the channel. The modulator can use any of the CW digital modulation techniques such as ASK (amplitude shift keying's), FSK (frequency shift keying) or PSK (phase shift keying). The demodulator is used for demodulation.

Q. 8 State the advantages of digital communication over analog communication. Justify each point.

Dec. 06, May 16

attenuation. This attenuation is proportional to square of the signal frequency. The noise on the acoustic channels is made by the fish, various mammals in the sea and men near harbours.

(viii) However it is still possible to design and implement an efficient and highly reliable acoustic communication system, for the transmission of digital signals over long distances.

Storage Channels

) The information storage and retrieval systems are very important when the data is being handled.

i) The magnetic tapes, digital audio and video tapes, magnetic disks are used for storing large amount of computer data.

i) Optical disks are used for storing the computer data, music and video information. All these data storing systems can be characterised as **storage channels.**

2. Channel coding

Channel encoding is done to minimize the effect of channel noise. This will reduce the number of errors in the received data and will make the system more reliable. Channel coding technique introduces some redundancy. The channel encoder maps the incoming digital signal into a channel input.

3. Modulation

Modulation is used for providing an efficient transmission of the signal over the channel. The modulator can use any of the CW digital modulation techniques such as ASK (amplitude shift keying's), FSK (frequency shift keying) or PSK (phase shift keying). The demodulator is used for demodulation.

Q. 8 State the advantages of digital communication over analog communication. Justify each point.

Dec. 06, May 16

Ans. :

Advantages of digital Communication

1. Due to the digital nature of the transmitted signal, the interference of additive noise does not introduce many errors. So digital communication has a better noise immunity.
2. Due to the channel coding techniques used in digital communication, it is possible to detect and correct the errors introduced during the data transmission.
3. Repeaters can be used between transmitter and receiver to regenerate the digital signal. This improves the noise immunity further and also extends the range of communication.
4. Due to the digital nature of the signal, it is possible to use the advanced data processing techniques such as digital signal processing, image processing, data compression etc.
5. TDM (Time Division Multiplexing) technique can be used to transmit many voice channels over a single common transmission channel. Thus digital telephony is possible to achieve.
6. Digital communication is suitable in military applications where only a few permitted receivers can receive the transmitted signal.
7. Digital communication is becoming simpler and cheaper as compared to the analog communication due to the invention of high speed computers and Integrated Circuits (ICs).

Q. 9 Compare analog and digital communication system. May 09, Dec. 10, May 14

Ans. :

Sr. No.	Analog modulation	Digital modulation
1.	Transmitted modulated signal is analog in nature.	Transmitted signal is digital i.e. train of digital pulses.
2.	Amplitude, frequency or phase variations in the transmitted signal represent the information or message.	Amplitude, width or position of the transmitted pulses is constant. The message is transmitted in the form of code words.
3.	Noise immunity is poor for AM, but improved for FM and PM.	Noise immunity is excellent.
4.	It is not possible to separate out noise and signal. Therefore repeaters cannot be used.	It is possible to separate signal from noise. So repeaters can be used.
5.	Coding is not possible.	Coding techniques can be used to detect and correct the errors.
6.	Bandwidth required is lower than that for the digital modulation methods.	Due to higher bit rates, higher channel bandwidths is needed.
7.	FDM is used for multiplexing.	TDM is used for multiplexing.
8.	Not suitable for transmission of secret information in military applications.	Due to coding techniques, it is suitable for military applications.
9.	Analog modulation systems are AM, FM, PM, PAM, PWM etc.	Digital modulation systems are PCM, DM, ADM, DPCM etc.

Chapter 2 : Fourier Transform

Q. 1 What are the energy signals and power signals ? May 10, May 14

Ans. :

Power signal :

A signal is called as a power signal if its "average normalized power" is non-zero and finite. It has been observed that almost all the periodic signals are power signals.

Energy signals :

A signal having a finite non-zero total normalized energy is called as an energy signal. It has been observed that almost all the non-periodic signals defined over a finite period, are energy signals. As these signals are defined over a finite period, they are called as time limited signals.

Q. 2 What is convolution of signals ? May 15

Convolution can be performed in time as well as frequency domain. The convolution of two functions x (t) and y (t) is defined as,

$$\text{Convolution : } x(t) * y(t) = \int_{-\infty}^{\infty} x(\tau) \cdot y(t-\tau)\, d\tau \qquad \ldots(1)$$

Equation (1) is called as convolution integral. Note that the independent variable here is "t" which is same as the independent of the functions x (t) and y (t) which are being convolved.

The integration is always performed with respect to a dummy variable such as τ and t is treated as a constant as far as the integration is concerned.

The process of convolution involves following operations of y (τ) while the signal x (τ) remains unchanged :

1. Folding or time reversal to obtain y (– τ).