ANALOG Communication

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1

Introduction

1.1 WHAT IS COMMUNICATION?

It is the study of the fundamental concept and principles of transferring information from one place to another. This involves the process of transmission, reception, and processing of information between locations. The source can be in a continuous form as in the case of analog signals or in a digital form.

As in the case of discrete signals, all forms of information, however, should be converted into an electrical signal before being sent via some medium. The medium can be a wire, a coaxial cable, a waveguide, an optical fibre, or atmosphere as in the case of radio and TV broadcasting. The medium is sometimes called a channel.

The first communication system was telegraphy followed by telephony and then the wireless system, which was used to broadcast radio programmes.

Invention of transistors and later integrated circuits, LSI, and VLSI has made the design and development of low-power, small-size, lightweight, high-speed, and reliable communication systems possible. Introduction of fibre optic cable as a medium resulted in providing an extremely high bandwidth and making possible transmission of voice, data, and picture over the same channel. The world is witnessing a significant growth in the field of communication in the form of cellular or mobile phones and high-speed communication networks with the help of powerful and faster computers. Today the world has become smaller, thanks to the modern advancement in communication engineering.

Initial communication systems were analog but present-day communication systems are mostly digital.

1.2 MODULATION AND ITS TYPES

The original information is mostly not in the form that is suitable for transmission. If the distance is quite small, this problem never arises. In this case, we call the transmission as baseband transmission. However, for a long distance, original information has to be transformed into some other form so that it is most suitable for transmission. The process of impressing such information onto a high-frequency component, called carrier, is known as *modulation*.

1.2.1 Need for Modulation

Suppose you are on the 36th floor of a building and your friend is standing down on the ground floor. Now you want to convey some information to him. (Assume that no mobile phone is available with you or him.) If you write this information on a piece of paper and drop it down to him through the balcony or window, chances are that it may not reach him. This is due to the fact that this piece of paper containing the information is so light that it will float in the air and drift away and will never reach your friend. To ensure that the message reaches him, just wrap this piece of paper around a small stone and drop it. Due to the weight of the stone and the gravity, the stone just drops down straight and your friend can pick it up. He takes the piece of paper containing the information and throws the stone. Precisely the same method is followed when we transmit a signal over a long distance. The original low-frequency signal is impressed onto a high-frequency signal called carrier (since this carries the low-frequency information) and transmitted over a long distance. On the receiver end, this signal is received and the carrier is removed and discarded and the low-frequency signal containing the information is retained.

We can summarize the need for modulation as follows.

- To translate the frequency of a low-pass signal to a higher band so that the spectrum of the transmitted bandpass signal matches the bandpass characteristics of the channel.
- For efficient transmission, it has been found that the antenna dimension has to be of the same order of magnitude as the wavelength of the signal being transmitted. Since $C = \lambda f$ for a typical low-frequency signal of 2 kHz, the wavelength works out to be 150 km. Even assuming the height of the antenna half the wavelength, the height works out to be 75 km, which is impracticable.
- To enable transmission of a signal from several message sources simultaneously through a single channel employing frequency division multiplexing.
- To improve noise and interference immunity in transmission over a noise channel by expanding the bandwidth of the transmitted signal.

1.2.2 Frequency Translation

We have seen that the modulation process shifts the modulating frequency to a higher frequency, which in turn depends on the carrier frequency, thus producing upper and lower sidebands. Hence, signals are upconverted from low frequencies to high frequencies and downconverted from high frequencies to low frequencies in the receiver. The process of converting a frequency or a band of frequencies to another location in the frequency spectrum is called *frequency translation*.

1.2.3 Types of Modulation

Depending on whether the amplitude, frequency, or phase of the carrier is varied in accordance with the modulation signal, we classify the modulation as amplitude modulation, frequency modulation, or phase modulation. The method of converting information into pulse form and then transmitting it over a long distance is called *pulse modulation*.

1.3 TRANSMITTER

The message as it arrives may not be suitable for direct transmission. It may be voice signal, music, picture, or data. The signals, which are not of electrical nature, have to be converted into electrical signals. Hence the need for transducer arises. Examples are microphone for speech and camera for pictures. The electrical signals thus generated are called modulating signals. These signals modulate a carrier and this modulated carrier is transmitted. The type of modulation depends on systems. They may be of high level or low level. They can also be any variation or a combination of these. Figure 1.1 shows a typical transmitter.

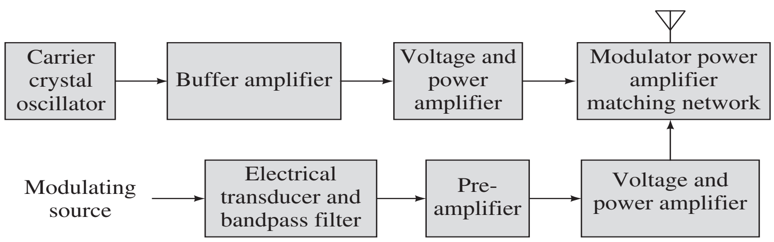

Fig. 1.1 Block diagram of a typical transmitter

The information to be transmitted comes out as an electrical signal from the transducer. This signal is bandlimited through a bandpass filter and is connected to a preamplifier, then to a voltage and power amplifier and finally is given as one of the inputs to the modulator. The other input to the modulator is the carrier, which is generated normally from a crystal oscillator and is then connected to a buffer amplifier and a voltage and power amplifier before connecting to the modulating input. The output of the modulator is connected to a power amplifier and this signal is coupled to the antenna through a matching network to avoid reflection, etc. The power of the transmitter depends on the range of the transmission.

1.4 RECEIVER

Many types of receivers are available in communication systems. A typical receiver is shown in Fig. 1.2. The type of receiver depends on the type of modulation, carrier frequency, the strength of signal received, etc. Most of the modern-day receivers are of superheterodyne type. The received signal from the antenna is fed to an RF amplifier and is given as one of the inputs to a mixer. The other input is the local oscillator, which can be tuned to different frequencies. The output of the mixer is the intermediate frequency, which is fixed irrespective of the frequency of the received signal. This is fed to an intermediate frequency amplifier and to a demodulator. The detector output is given to an audio/video amplifier depending on the original information and is fed to a loudspeaker or a video display unit as the case may be.

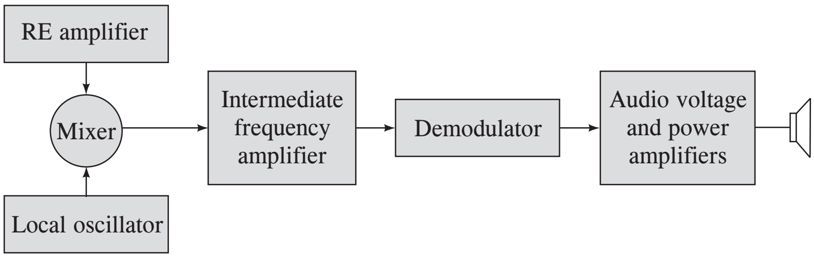

Fig. 1.2 Block diagram of a typical receiver

1.5 DIGITAL COMMUNICATION SYSTEM

So far, we have described the electrical communication system in rather a broad sense on the assumption that the message signal is a continuous time varying waveform. Such waveform is called *analog signal*. These signals can be transmitted over the communication channel by modulating a carrier that is demodulated at the receiver end. Such a communication system is called an *analog communication system.*

An analog source may be converted into a digital form and this message can be transmitted as digital data. At the receiver, these digital data are converted back into analog signals. There are numerous advantages with this type of transmission. Signal fidelity is better controlled. Digital transmission allows us to regenerate the digital signal in long-distance transmission, thus eliminating the effects of noise at each regeneration point. But in the case of an analog transmission, the noise added is amplified along with the signal. Another advantage in digital transmission is removal of redundancy, which is inherent in analog systems. In digital systems, redundancy is removed prior to the modulation, which results in conserving bandwidth. They are also cheaper to implement. Figure 1.3 gives the block diagram of a basic digital communication system transmitter.

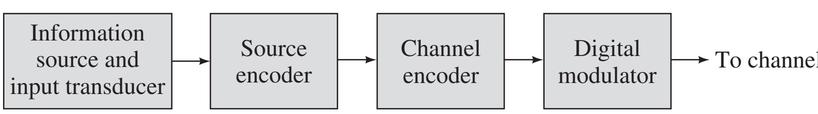

Fig. 1.3 Block diagram of a digital communication transmitter

The analog input is converted into a sequence of binary digits by a source encoder, which is generally an analog-to-digital converter. We normally represent the message signal with as few binary digits as possible. This helps obtain the output with little or no redundancy. The process of efficiently converting the output of either an analog or a digital source into a sequence of binary digits is called *source encoding* or *data compression*. The source encoded outputs, which are a sequence of binary digits, are called *information sequence*. This is passed on to the channel encoder. The channel encoder is introduced in a controlled manner. Some redundancy in the binary information sequence can be used at the receiver to overcome the effects of noise and interference encountered in the transmission of signal through the channel. Thus, the added redundancy serves to increase the reliability of the received data and improves the fidelity of the received signal. The redundancy in the information sequence aids the receiver in decoding the desired information sequence. The binary sequence at the output of the channel encoder is passed through the digital modulator, which serves as the interface to the communication channel.

At the receiving end, the digital demodulator processes the received waveform and passes it onto a channel decoder. The channel decoder output is connected to the source decoder, which is generally a digital-to-analog converter, and the original analog signal is obtained. Figure 1.4 gives the receiver block diagram.

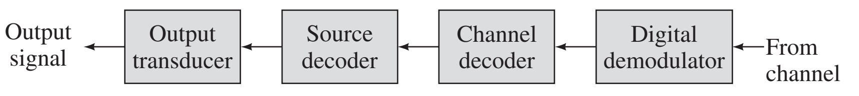

Fig. 1.4 Block diagram of a digital communication receiver

It has to be kept in mind that in all communication systems, the transmitter and receiver must be in agreement with the modulation method used.

1.6 MULTIPLEXING OF SIGNALS

When it is required to transmit more signals on the same channel, baseband transmission fails, as in the case of audio signals being broadcast from different stations on the same channel. The reason for this is the interference between each audio signal due to their frequencies being more or less the same. To avoid this, either frequency division multiplexing or time division multiplexing is employed.

1.6.1 Frequency Division Multiplexing

In this method, various carrier frequencies, which are quite apart, are chosen and these carriers get modulated by different baseband signals. Thus, the modulated carriers are transmitted over the same channel. At the receiver, tunable bandpass filters are used to separate each modulated carrier and then demodulate it to recover the baseband signal. This method of transmitting several channels simultaneously is known as *frequency division multiplexing* (FDM).

Here the bandwidth of the channel is shared by various signals without any overlapping.

1.6.2 Time Division Multiplexing

In this method, several signals are transmitted over a time interval. Each signal is allotted a time slot and it gets repeated cyclically. The only difference compared to FDM is that the signals are to be sampled before sending. Hence, the signals will be in the form of pulse trains. At the receiver, there will be a synchronizer to recover each signal.