**Introduction**

In radio transmission, it is necessary to send audio signal (*e.g*. music, speech etc.) from a broadcasting station over great distances to a receiver. This com-munication of audio signal does not employ any wire and is sometimes called *wireless*. The audio signal cannot be sent directly over the air for appreciable distance. Even if the audio signal is converted into electrical signal, the latter cannot be sent very far without employing large amount of power. The energy of a wave is directly pro-portional to its frequency. At audio frequencies (20 Hz to 20 kHz), the signal power is quite small and radiation is not practicable.

The radiation of electrical energy is practicable only at high frequencies *e.g*. above 20 kHz. The high frequency signals can be sent thousands of miles even with com-paratively small power. Therefore, if audio signal is to be transmitted properly, some means must be devised which will permit transmission to occur at high frequencies while it simultaneously allows the carrying of audio signal. This is achieved by superim-posing electrical audio signal on high frequency carrier. The resultant waves are known *as* *modu-lated* *waves* or *radio* *waves* and the process is called *modulation*. At the radio receiver, the audio signal is extracted from the modulated wave by the process called *demodulation*. The signal is then amplified and reproduced into sound by the loudspeaker. In this chapter, we shall focus our attention on the various aspects of modulation and demodulation.

As discussed earlier, a high frequency carrier wave is used to carry the audio signal. The question arises how the audio signal should be ‘‘added’’ to the carrier wave. The solution lies in changing some characteristic of carrier wave in accordance with the signal. Under such conditions, the audio signal will be contained in the resultant wave. This process is called modulation and may be defined as under :

*The* *process* *of* *changing* *some* *characteristic* *(e.g.* *amplitude,* *frequency* *or* *phase)* *of* *a* *carrier* *wave* *in* *accordance* *with* *the* *intensity* *of* *the* *signal* *is* *known* *as* **modulation**.

Modulation means to “change”. In modulation, some characteristic of carrier wave is changed in accordance with the intensity (*i.e*. amplitude) of the signal. The resultant wave is called modulated wave or radio wave and contains the audio signal. Therefore, modulation permits the transmission to occur at high frequency while it simultaneously allows the carrying of the audio signal.

**Need** **for** **modulation.** Modulation is extremely necessary in communication system due to the following reasons :

**(*i*)** ***Practical*** ***antenna*** ***length.*** Theory shows that in order to transmit a wave effectively, the length of the transmitting antenna should be approximately equal to the wavelength of the wave.

Now, wavelength = {Velocity of RF wave/ Frequency}

Velocity of RF wave = 3\*108m/s

As the audio frequencies range from 20 Hz to 20 kHz, therefore, if they are transmitted directly into space, the length of the transmitting antenna required would be extremely large. For instance, to radiate a frequency of 20 kHz directly into space, we would need an antenna length of 15,000 metres. This is too long antenna to be constructed practically. For this reason, it is imprac-ticable to radiate audio signal directly into space. On the other hand, if a carrier wave say of 1000 kHz is used to carry the signal, we need an antenna length of 300 metres only and this size can be easily constructed.

**(*ii*)** ***Operating*** ***range.*** The energy of a wave depends upon its frequency. The greater the fre-quency of the wave, the greater the energy possessed by it. As the audio signal frequencies are small, therefore, these cannot be transmitted over large distances if radiated directly into space. The only practical solution is to modulate a high frequency carrier wave with audio signal and permit the transmission to occur at this high frequency (*i.e*. carrier frequency).

**(*iii*)** ***Wireless*** ***communication.*** One desirable feature of radio transmission is that it should be carried without wires *i.e*. radiated into space. At audio frequencies, radiation is not practicable because the efficiency of radiation is poor. However, efficient radiation of electrical energy is pos-sible at high frequencies (> 20 kHz). For this reason, modulation is always done in communication systems.

**Types of Modulation**

As you will recall, modulation is the process of changing amplitude or frequency or phase of a carrier wave in accordance with the intensity of the signal. Accordingly, there are three basic types of modu-lation, namely ;

**(*i*)** amplitude modulation **(*ii*)** frequency modulation **(*iii*)** phase modulation

In India, amplitude modulation is used in radio broadcasting. However, in television transmis-sion, frequency modulation is used for sound signal and amplitude modulation for picture signal. Therefore, our attention in this chapter shall be confined to the first two most important types of modulation.

**Amplitude Modulation**

*When* *the* *amplitude* *of* *high* *frequency* *carrier* *wave* *is* *changed* *in* *accordance* *with* *the* *intensity* *of* *the* *signal,* *it* *is* *called* **amplitude** **modulation***.*

In amplitude modulation, only the amplitude of the carrier wave is changed in accordance with the intensity of the signal. However, the frequency of the modulated wave remains the same *i.e*. carrier frequency. Fig. shows the principle of amplitude modulation. Fig. 1 (*i*) shows the audio electrical signal whereas Fig. 1 (*ii*) shows a carrier wave of constant amplitude. Fig. 1(*iii*) shows the amplitude modulated (AM) wave. Note that the amplitudes of both positive and negative half-cycles of carrier wave are changed in accordance with the signal. For instance, when the signal is increas-ing in the positive sense, the amplitude of carrier wave also increases. On the other hand, during negative half-cycle of the signal, the am-plitude of carrier wave decreases. Amplitude modulation is done by an electronic circuit called *modulator*.

The following points are worth noting in amplitude modulation :

**(*i*)** The amplitude of the carrier wave changes according to the intensity of the signal.

**(*ii*)** The amplitude variations of the carrier wave is at the signal frequency *fs*.

**(*iii*)** The frequency of the amplitude modulated wave remains the same *i.e*. carrier frequency *fc*.

**Frequency Modulation (FM)**

*When* *the* *frequency* *of* *carrier* *wave* *is* *changed* *in* *accordance* *with* *the* *intensity* *of* *the* *signal,* *it* *is* *called* **frequency** **modulation** **(FM)**.

In frequency modulation, only the frequency of the carrier wave is changed in accordance with the signal. However, the amplitude of the modulated wave remains the same *i.e*. carrier wave ampli-tude. The frequency variations of carrier wave depend upon the instantaneous amplitude of the signal as shown in Fig. 2. (*iii*). When the signal voltage is zero as at *A*, *C*, *E* and *G*, the carrier frequency is unchanged. When the signal approaches its positive peaks as at *B* and *F*, the carrier frequency is increased to maximum as shown by the closely spaced cycles. However, during the negative peaks of signal as at *D*, the carrier frequency is reduced to minimum as shown by the widely spaced cycles.

The process of frequency modulation (FM) can be made more illustrative if we

consider numerical values. Fig. 16.13 shows the FM signal having carrier frequency *fc*= 100 kHz. Note that FM signal has constant amplitude but varying frequencies above and below the carrier frequency of 100 kHz (= *fc*). For this reason, *fc*(= 100 kHz) is called *centre* *frequency*. The changes in the carrier frequency are produced by the audio-modulating signal. The amount of change in frequency from *fc*(= 100 kHz) or *frequency* *deviation* depends upon the amplitude of the audio-modulating signal. The frequency deviation increases with the increase in the modulating signal and vice-versa. Thus the peak audio voltage will produce maximum frequency deviation.

The following points about frequency modulation (FM) may be noted carefully :

**(*a*)** The frequency deviation of FM signal depends on the amplitude of the modulating signal.

**(*b*)** The centre frequency is the frequency without modulation or when the modulating voltage is zero.

**(*c*)** The audio frequency (*i.e.* frequency of modulating signal) does not determine frequency deviation.

Comparison of FM and AM.

The comparison of FM and AM is given in the Table below.

|  |  |  |
| --- | --- | --- |
| **S.** **No** | **FM** | **AM** |
| 1. | The amplitude of carrier remains constant with modulation. | The amplitude of carrier changes with modulation. |
| 2. | The carrier frequency changes with modulation. | The carrier frequency remains constant with modulation. |
| 3. | The carrier frequency changes according to the strength of the modulating signal. | The carrier amplitude changes according to the strength of the modulating signal. |
| 4. | No. of FM radio Stations are less | No. of AM radio stations are more |
| 5 | It has better resistance to Noise. Hence it offers better SNR | It has poor resistance to noise. Hence its SNR is low |
| 6 | The circuit is complex | The circuit is simple |









