speaker fo...

18·2 Modulation

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 characteristics 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 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.

$$\text{Now, wavelength} = \frac{\text{velocity}}{\text{frequency}}$$

$$= \frac{3 \times 10^8}{\text{frequency (Hz)}} \text{ metres}$$

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 $3\times10^8/20\times10^3 = 15{,}000$ metres. This is too long antenna to be constructed practically. For this reason, it is impracticable 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 frequency 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 possible at high frequencies (>20 KHz). For this reason, modulation is always done in communication systems.

18.3 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 types of modulation, namely ;

(*i*) amplitude modulation

(*ii*) frequency modulation

(*iii*) phase modulation.

In India, amplitude modulation is used in radio broadcasting. However, in television transmission, 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.

18.4 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. 18·2 shows the principle of amplitude modulation. Fig. 18·2 (*i*) shows the audio electrical signal whereas Fig. 18·2 (*ii*) shows a carrier wave of constant amplitude. Fig. 18·2 (*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 increasing in the positive sense, the amplitude of carrier wave also increases. On the other hand, during negative half-cycle of the signal, the amplitude of carrier wave decreases. Amplitude modulation is done by an electronic circuit called *modulator*.

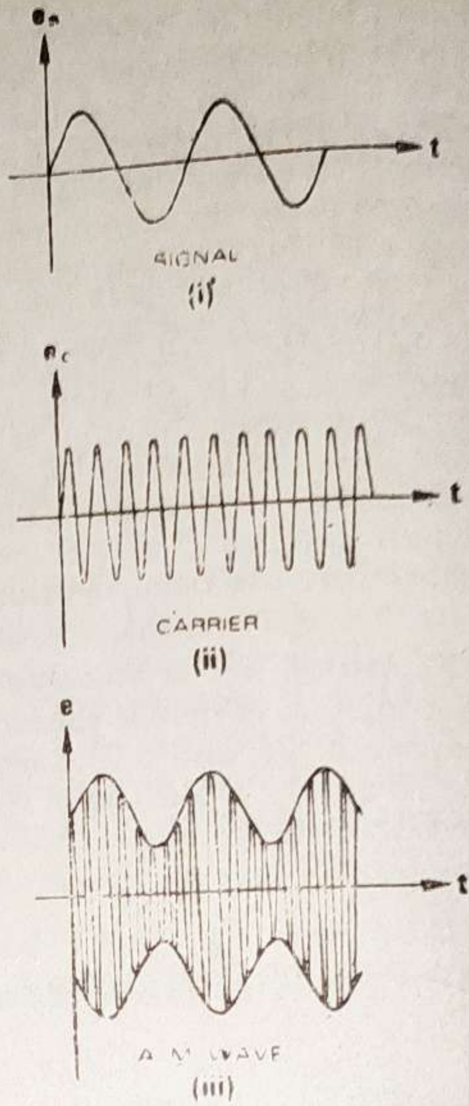

Fig. 18·2

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 f_s.

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

18·5 Modulation factor

An important consideration in amplitude modulation is to describe the depth of modulation *i.e.* the extent to which the amplitude of carrier wave is changed by the signal. This is described by a factor called modulation factor which may be defined as under :

The ratio of change of amplitude of carrier wave to the amplitude of normal carrier wave is called the **modulation factor** *m i.e.*

Modulation factor,

$$m = \frac{\text{Amplitude change of carrier wave}}{\text{Normal carrier wave (unmodulated)}}$$

The value of modulation factor depends upon the amplitude of carrier and signal. Fig. 18·3 shows amplitude modulation for different values of modulation factor m.

(*i*) When signal amplitude is zero, the carrier wave is not modulated as shown in Fig. 18·3 (*i*). The amplitude of carrier wave remains unchanged.

Amplitude change of carrier = 0

Amplitude of normal carrier = A

$$\therefore \quad \textbf{Modulation factor,} \quad m = \frac{0}{A} = 0 \text{ or } 0\%$$

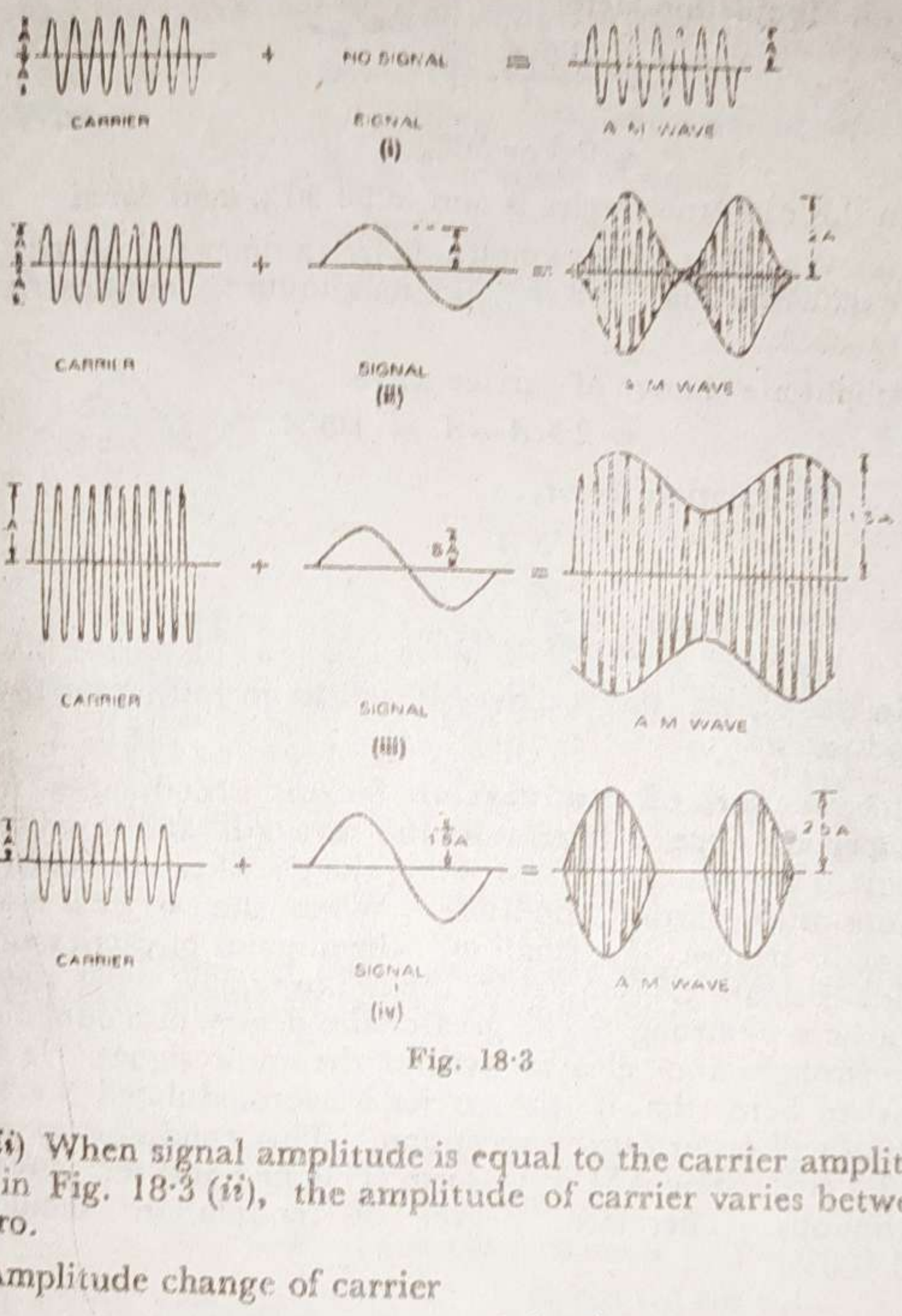

Fig. 18·3

(*ii*) When signal amplitude is equal to the carrier amplitude as shown in Fig. 18·3 (*ii*), the amplitude of carrier varies between $2A$ and zero.

Amplitude change of carrier

$$= 2A - A = A$$

$\therefore$ Modulation factor,

$$m = \frac{\text{Amplitude change of carrier}}{\text{Amplitude of normal carrier}}$$

$$= \frac{A}{A}$$

$$= 1 \text{ or } 100\%$$

In this case, the carrier is said to be 100% modulated.

(*iii*) When the signal amplitude is one-half the carrier amplitude as shown in Fig, 18·3 (*iii*), the amplitude of carrier wave varies between 1·5 A and 0·5 A.

Amplitude change of carrier

$$= 1·5\ A - A = 0·5\ A$$

∴ Modulation factor,

$$m = \frac{0·5\ A}{A}$$

$$= 0·5 \text{ or } 50\%$$

In this case, the carrier is said to be 50% modulated.

(*iv*) When the signal amplitude is 1·5 times the carrier amplitude as shown in Fig. 18·3 (*iv*), the maximum value of carrier wave becomes 2·5 A.

Amplitude change of carrier wave

$$= 2·5\ A - A = 1·5\ A$$

∴ Modulation factor,

$$m = \frac{1·5\ A}{A}$$

$$= 1·5 \text{ or } 150\%$$

In this case, the carrier is said to be 150% modulated *i.e.* overmodulated.

18·10 Frequency modulation

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

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 amplitude. The frequency variations of carrier wave depends upon the instantaneous amplitude of the signal as shown in Fig. 13·6 (*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.

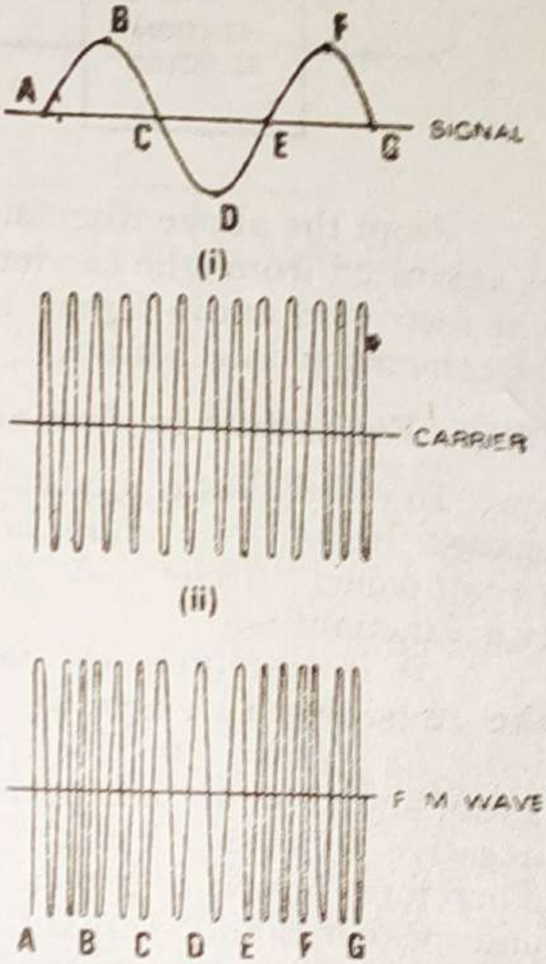

Fig. 18·6

Advantages :

(*i*) It gives noiseless reception. As discussed before, noise is a form of amplitude variations and a FM receiver will reject such signals.

(*ii*) The operating range is quite large.

(*iii*) It gives high-fidelity reception.

(*iv*) The efficiency of transmission is very high.

18·11 Demodulation

The process of recovering the audio signal from the modulated wave is known as **demodulation** *or* **detection.**

At the broadcasting station, modulation is done to transmit the audio signal over larger distances to a receiver. When the modulated wave is picked up by the radio receiver, it is necessary to recover the audio signal from it. This process is accomplished in the radio receiver and is called demodulation.

18·12 Essentials in demodulation

In order that a modulated wave is audible, it is necessary to change the nature of modulated wave. This is accomplished by a circuit called *detector*. A detector circuit performs the following two functions :—

(*i*) *It rectifies the modulated wave i.e.* negative half of the modulated wave is eliminated. As shown in Fig. 18·8 (*i*), a modulated wave has positive and negative halves exactly equal. Therefore, average current is zero and speaker cannot respond. If the negative half of this modulated wave is eliminated as shown in Fig. 18·8 (*ii*), the average value of this wave will not be zero since the resultant pulses are now all in one direction. The average value is shown by the dotted line in Fig. 18·8 (*ii*). Therefore, the diaphragm will have definite displacement corresponding to the average value of the wave. It may be seen that shape of the average wave is similar to that of the modulation envelope. As the signal is of the same shape as the envelope, therefore, average wave shape is of the same form as the signal.

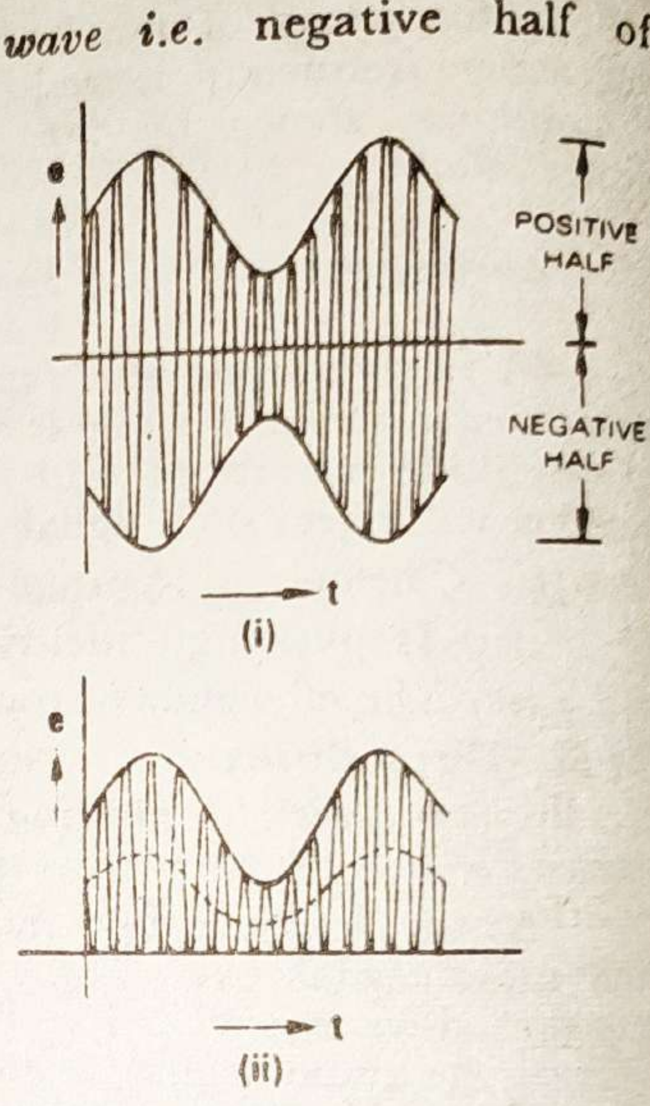

Fig. 18·8

(*ii*) ***It separates the audio signal from the carrier.*** The rectified modulated wave contains the audio signal and the carrier. It is desired to recover the audio signal. This is achieved by a filter circuit which removes the carrier frequency and allows the audio signal to reach the load *i.e.* speaker.