1.2 AMPLITUDE MODULATION

It is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal. AM is used for commercial broadcasting of audio and video signals.

Applications of AM: 1. Two-way mobile radio, Audio and video broadcast

AM VOLTAGE DISTRIBUTION

The modulating signal is represented as, $e_m(t) = E_m \sin\omega_m t$

The carrier signal is represented as, $e_c(t) = E_c \sin\omega_c t$

According to the definition, the amplitude of the carrier signal is changed after modulation.

$$E_{AM} = E_c + e_m(t) = E_c + E_m \sin\omega_m t \text{ ----- (1)}$$

$$= E_c [1 + (E_m/E_c) \sin\omega_m t] \text{ -------------(2)}$$

$$E_{AM} = E_c(1 + m_a \sin\omega_m t) \text{ -----------------(3)}$$

Depth of Modulation/Modulation Index:

Coefficient of modulation and percent modulation:

If is defined as the ratio of maximum amplitude of the message signal to the maximum amplitude of thecarrier signal.

$$m_a = \frac{E_m}{E_c}$$

Percent modulation is indicated as M

$$M = \frac{E_m}{E_c} \times 100 \quad \text{or} \quad M = m_a \times 100$$

Relationship between m, E_m & E_c

From the figure.

$E_m = ½ (E_{max} - E_{min})$ $E_C = ½ (E_{ma} + E_{min})$

$$M = \frac{\frac{1}{2}(E_{max} - E_{min})}{\frac{1}{2}(E_{max} + E_{min})} \times 100 = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100$$

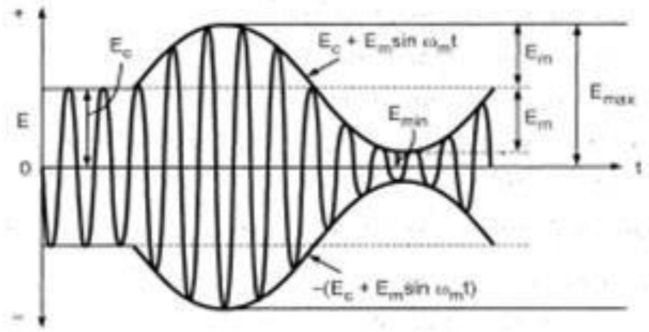


Figure : 1.2.1 Modulation Waveform

Where $m_a = E_m/E_c$ Where m_a is the modulation index (or) depth of modulation. The value E_m must be less than value of E_c to avoid distortion in the modulated signal. Hence maximum value of m_a will be equal to 1. When m_a is expressed in percentage it is called percentage modulation.

But the instantaneous amplitude of modulated signal,

i.e at any time $e_{AM}(t) = E_{AM} \sin\omega_c t$ --------------------------- (4)

Substitute equation (3) in (4)

$e_{AM}(t) = E_c (1 + m_a \sin\omega_m t)\sin\omega_c t$

$= E_c \sin\omega_c t + m_a E_c \sin\omega_m t$

$\sin\omega_c t$(1) (2)

<u>Frequency spectrum and Bandwidth of AM Waveform</u>

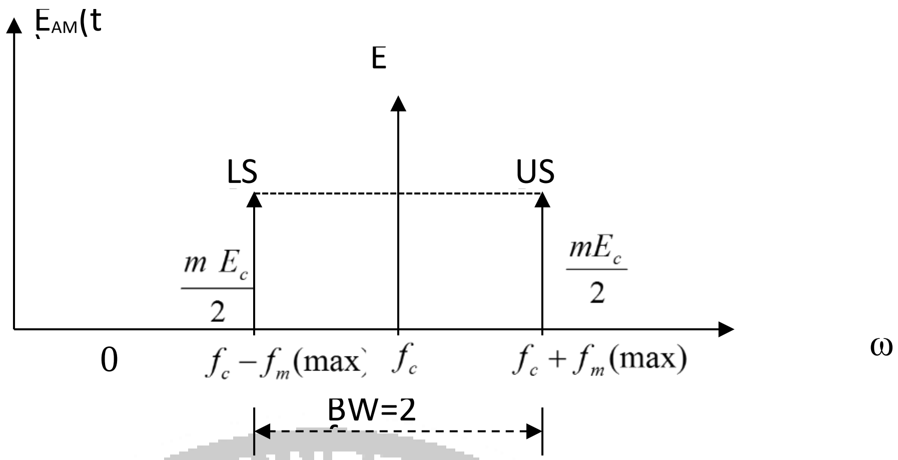


Figure 1.2.2 Frequency spectrum and Bandwidth of AM Waveform

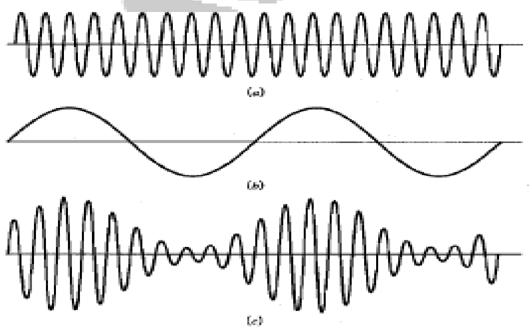
- The figure shows the frequency spectrum of Am.
- It extends from f_c -f_m (max) to f_c + f_m (max).
- The band of frequencies b/w f_c and f_c - f_m (max) is called lower side band [LSB] and any frequency within this band is called lower side frequency [LSF].
- The band of frequencies b/w f_c and f_c + f_m (max) is called upper side band [USB] and any frequency within this and is called upper side frequency [USF]

Bandwidth of AM.

The Bandwidth of Am wave is equal to the difference b/w the highest upper side frequency and lowest lower side frequency.

- B = f_c + f_m (max) – [f_c - f_m (max)]
- = f_c + f_m (max) - f_c + f_m (max) BW = 2f_m (max)

AM Waveform



a) Message signal

b) Carrier signal

c) Amplitude modulated signal.

Figure 1.2.3 AM Waveform

The shape of modulated waveform is known as **AM envelope.**

<u>Phasor representation of AM</u>

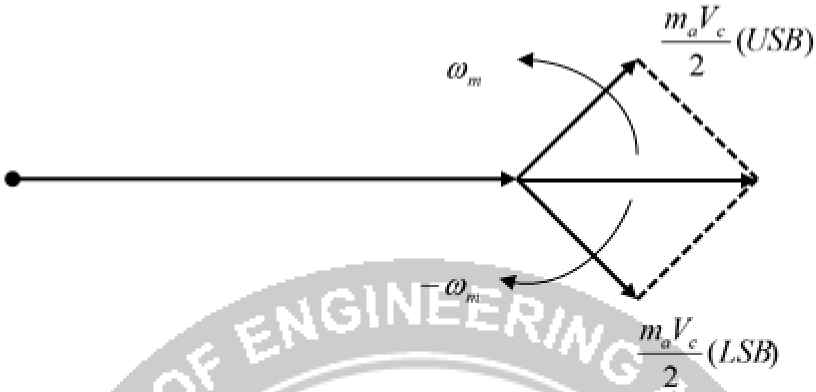


Figure 1.2.4 Phasor representation of AM

Based on the modulation index modulation can be either,

(i). Critical Modulation

(ii). Over Modulation

(iii). Under Modulation

- When $E_m = E_c$ modulation goes to 100% this situation is known as critical modulation.
- $E_m < E_c$ leads to under modulation.
- $E_m > E_c$ leads to over modulation.

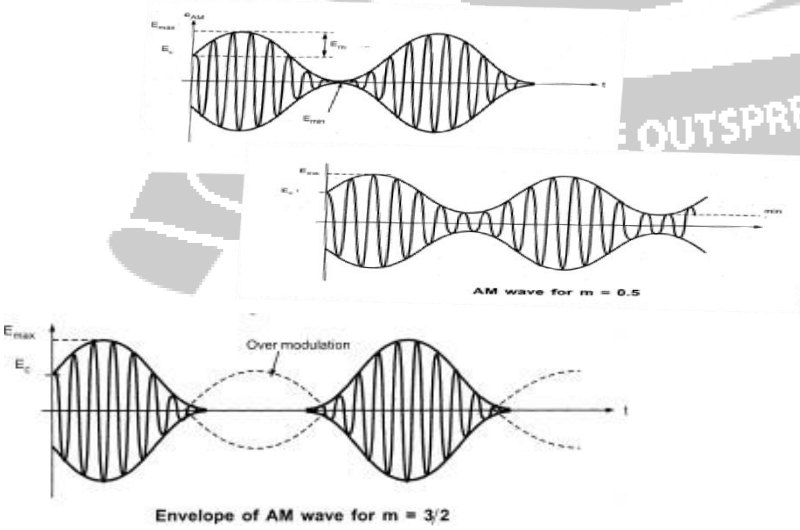


Figure : 1.2.5 Types of Modulation

AM POWER DISTRIBUTION

- The modulated wave contains three terms such as carrier wave, LSB, USB.
- The modulated wave contains more power than the unmodulated carrier. Total Power in modulated wave will be,

$$P_t = P_C + P_{USB} + P_{LSB}$$

i.e. total power P_t of AM wave is the sum of carrier power and side band power.

P_C - Carrier power, P_{USB} - Upper Side Band power, P_{LSB} - Lower Side Band power

Advantages, Disadvantages and Applications of AM (DSBFC)

Advantages

1. Simple and inexpensive receivers. Easy to detect with simple equipment even if the signal is not verystrong
2. Narrow bandwidth than FM
3. Wider coverage
4. Well-established, mature art used for broadcasting almost exclusively

Disadvantages

1. Received signal affected by electrical storms and other radio frequency interference
2. Receivers able to reproduce frequencies up to 5 MHz or less
3. Inefficient use of transmitter power

Applications

1. Low quality form of modulation that is used for commercial broadcast of both audio and video signals.
2. Two way mobile radio communications such as citizen band (CB) radio.
3. Aircraft communication in the VHF frequency range.