ANALOG COMMUNICATION

Modulation

It is the process of placing the message signal over some carrier signal to make it suitable for transmission.

Need for Modulation:

1. Size of antenna required for receiving the wave is reduced if signal is transmitted at high frequency.
2. Many number of signals can be transmitted simultaneously by selecting the carriers of different frequencies.
3. The interference of noise and other signals can be reduced by changing the frequency of transmission.
4. Integration of different communication system is possible.

Amplitude Modulation

Amplitude Modulated Signal:

AM may be defined as a system in which the maximum amplitude of the carrier wave is made proportional to the instantaneous value (amplitude) of the modulating or base band signal

$$x_m(t) = A_m \cos \omega_m t$$

$$x_c(t) = A_c \cos \omega_c t$$

$$x(t) = A_c[1 + K_a x_m(t)]\cos \omega_c t \qquad \text{where } \mu = K_a A_m$$

$$x(t) = A_c \cos \omega_c t + A_c K_a x_m(t) \cos \omega_c t$$

where μ = modulation index

$x_m(t) \rightarrow$ message signal

$$x(t) = A_c \cos \omega_c t + \mu A_c \cos \omega_m t \cos \omega_c t$$

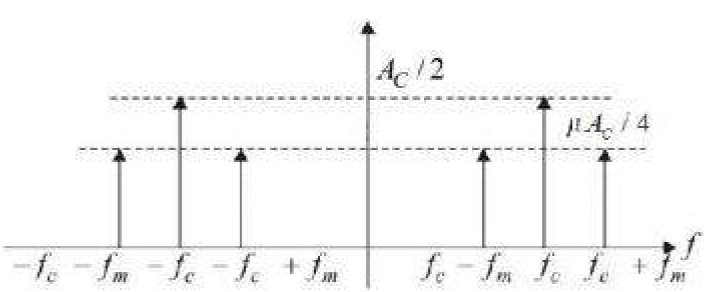
Frequency spectrum of AM wave:

Bandwidth = $2 f_m$

- Frequency band from f_c to $f_c + f_m$ is called as **upper sideband**
- Frequency band from $f_c - f_m$ to f_c is called as **lower sideband**

$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \qquad A_{max} = A_C[1 + \mu] \qquad A_{min} = A_C[1 - \mu]$$

A_{max} – maximum amplitude



A_{min} – minimum amplitude

Power Relations in AM wave:

$$P_{total} = P_{carrier} + P_{LSB} + P_{USB} \qquad P_{carrier} = \frac{A_c^2}{2} \quad P_{LSB} = P_{USB} = \frac{\mu^2 A_c^2}{8}$$

$$P_{total} = \frac{A_c^2}{2} + \frac{\mu^2 A_c^2}{8} + \frac{\mu^2 A_c^2}{8} \qquad P_{total} = \left(1 + \frac{\mu^2}{2}\right) P_c$$

Maximum power dissipated in AM wave is P_{AM}= 1.5 P_c for (not=) 1 and this is maximum power that amplifier can handle without distortion

Efficiency of Amplitude Modulated System:

$$\eta_{AM} = \frac{P_{SB}}{P_t} \times 100\% \qquad \boxed{\eta_{AM} = \left(\frac{\mu^2}{\mu^2 + 2}\right) \times 100\%}$$

For satisfactory modulation $0 \le \mu \le 1$

Current relations in AM wave:

$$P_t = \left(1 + \frac{\mu^2}{2}\right) P_c \qquad I_C \sqrt{1 + \frac{\mu^2}{2}}$$

Multi-tone Modulation:

When carrier is modulated simultaneously by more than one sinusoidal signal.

Resultant Modulation Index $\mu = \sqrt{\mu_1^2 + \mu_2^2 + \mu_3^2 \ldots\ldots\ldots\ldots}$

Double side Band Suppressed Carrier modulation DSB-SC:

$$s(t) = \mu A_c \cos \omega_c t \cos \omega_m t$$

$\mu \rightarrow$ modulation index $\qquad A_c \rightarrow$ carrier amplitude

In DSB-SC the carrier signal is suppressed at the time of modulation. Only side- bands are transmitted in modulated wave.

Bandwidth = $2 f_m$ $\qquad$ **Transmitted Power** $P_t = \frac{\mu^2}{2} P_c$

Power saving = 66.67% (for $\mu = 1$)

Single Sideband Modulation (SSB):

In this technique, along with modulation carrier one side band gets suppressed from AM modulated wave.

$s(t) = A_c m(t) \cos 2\pi f_c t \mp A_c \hat{m}(t) \sin 2\pi f_c t$

$\hat{m}(t)$ is Hilbert transform of message signal.

Bandwidth = f_m **Transmitter Power** $P_t = \frac{\mu^2}{4} P_C$

Power saving → 83.3%

Vestigial Sideband (VSB) modulation:

In this modulation one side band and vestige of another sideband is transmitted.

- It is used for transmission of video signal in television broadcasting
- It is also used for high speed data signal and facsimile.
- Vocal signal transmission of T.V. via F.M

AM Modulators:

For Generation of **AM or DSB/Full** carrier wave

A. Product Modulator

B. Square Law Modulator

C. Switching Modulator

For **Generation DSB-SC** wave

A. Filter method/frequency discrimination method

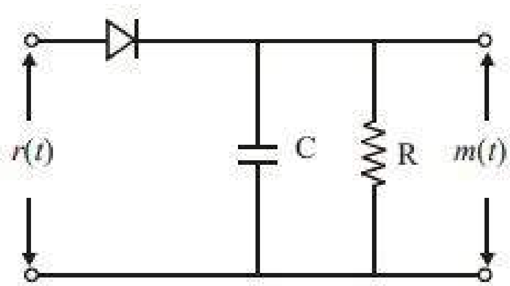
B. Phase shift method/Phase discrimination method

C. Third method/Weaver's method

Demodulation of Amplitude Modulate wave:

A. Synchronous or coherent detection

B. Envelop detector Envelop Detector:



r(t) is received signal and m(t) is message signal and for better reception RC must be selected such as

f_c = carrier frequency w is bandwidth of message signal

To avoid diagonal clipping $\frac{1}{RC} > \frac{\mu \omega_m}{\sqrt{1-\mu^2}}$

Key points:

Demodulation of AM signal is simpler than DSB-SC and SSB systems, Demodulation of DSB-SC and SSB is rather difficult and expensive.

It is quite easier to generate conventional AM signals at high power level as compared to DSB-SC and SSB signals. For this reason, conventional AM systems are used for broad casting purpose.

The advantage of DSB-SC and SSB systems over conventional AM system is that the former requires lesser power to transmit the same information.

SSB scheme needs only one half of the bandwidth required in DSB-SC system and less than that required in VSB also.

SSB modulation scheme is used for long distance transmission of voice signals because it allows longer spacing between repeaters

***