SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECB301-ANALOG AND DIGITAL COMMUNICATION

III YEAR/ V SEMESTER

UNIT 1 – ANALOG COMMUNICATION

TOPIC – AMPLITUDE MODULATION

AMPLITUDE MODULATION

2.

19EC301 - Analog and Digital communication.

Unit-I - Analog communication

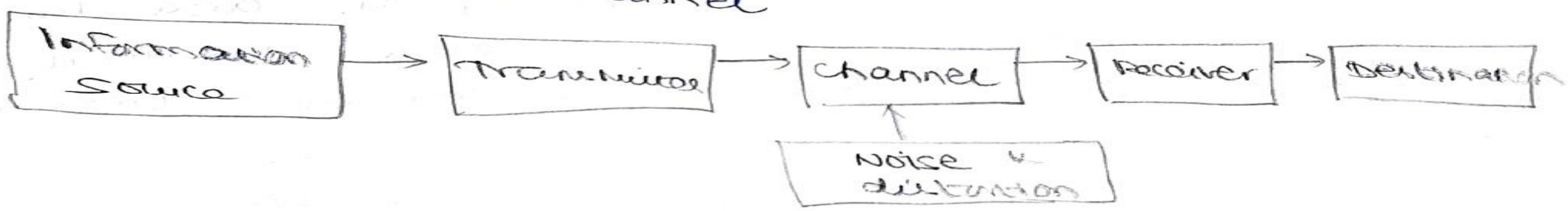
* Introduction to communication systems:

Communication is the process of establishing a connection b/w two points for information exchange.

Telecommunication : Long distance communication

communication components :

a) Transmitter
b) receiver
c) channel



without Modulation :

There are some disadvantages;

a) Large antenna heights
b) Short range of communication
c) signals get mixed up
d) Multiplexing is not possible.

* Modulation :

Modulation is defined as the process by which some parameter of the carrier signal (high freq signal) is varied in accordance with the instantaneous values of the modulating signal.

AM MATHEMATICAL REPRESENTATION

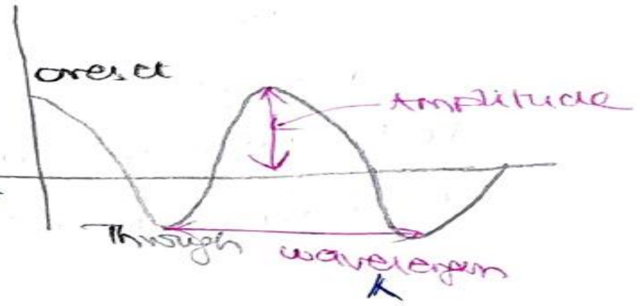
Frequency:

Number of cycles of a waveform per second. Unit is hertz.

Wavelength:

Distance b/w two points of similar cycles of a periodic wave

$$\lambda = \frac{c}{f} = \frac{3\times10^{8}\ m/s}{f}$$



Bandwidth:

Freq range through which information being transmitted.

*** AM (Amplitude Modulation):**

It is defined as the process by which amp of the carrier signal is varied in accordance with the instantaneous value of the modulating signal, but freq and phase remains constant.

Mathematical representation of an AM wave:

Let the modulating signal be,

$V_m(t) = V_m \cos \omega_m t$ — (1)

Carrier signal

$V_c(t) = V_c \cos \omega_c t$ — (2)

After modln, peak amplitude of modulated wave is expressed as,

$V_{AM}(t) = V_c + V_m(t)$ — (3)

Subst (1) in (3)

$V_{AM} = V_c + V_m \cos \omega_m t$

$\Rightarrow V_c\left(1 + \frac{V_m}{V_c} \cos \omega_m t\right)$

$$\boxed{V_{AM} = V_c(1 + m_a \cos \omega_m t)}$$ — (4)

AM FREQUENCY SPECTRUM

Where m_a = Modulation Index = $\frac{V_m}{V_c}$ — (2)

Hence AM wave is given by

$V_{AM}(t) = V_{AM} \cos \omega_c t$ — (5)

Subst (4) in (5)

$$V_{AM}(t) = V_c\,(1 + m_a \cos \omega_m t) \cdot \cos \omega_c t \quad \text{— (6)}$$

AM Freq spectrum and Bandwidth:

Although the modulation & carrier signal contains two frequencies f_c & f_m. The modulation process generates two new frequencies that are the sum & differences of f_c and f_m.

The spectrum is found by expand (6)

$V_{AM}(t) = V_c\,(1 + m_a \cos \omega_m t) \cdot \cos \omega_c t$

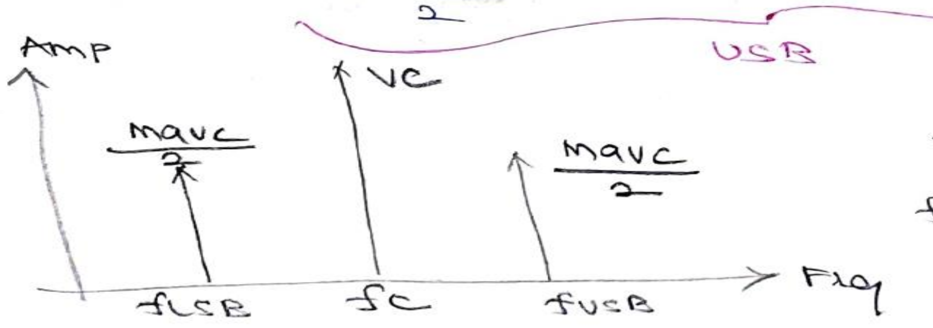
$\Rightarrow V_c \cdot \cos \omega_c t + m_a V_c \cos \omega_m t \cdot \cos \omega_c t$

wkt

$$\cos \omega_m t \cdot \cos \omega_c t = \frac{\cos(\omega_c - \omega_m)t + \cos(\omega_c + \omega_m)t}{2}$$

$$V_{AM}(t) = V_c \cos \omega_c t + \frac{m_a V_c}{2}\left[\cos(\omega_c - \omega_m)t + \cos(\omega_c + \omega_m)t\right]$$

$$V_{AM}(t) = \underbrace{V_c \cos \omega_c t}_{\text{carrier}} + \underbrace{\frac{m_a V_c}{2} \cos(\omega_c - \omega_m)t}_{\text{LSB}} + \underbrace{\frac{m_a V_c}{2} \cos(\omega_c + \omega_m)t}_{\text{USB}}$$



$f_{LSB} = (f_c - f_m)$

$f_{USB} = (f_c + f_m)$

AM BANDWIDTH

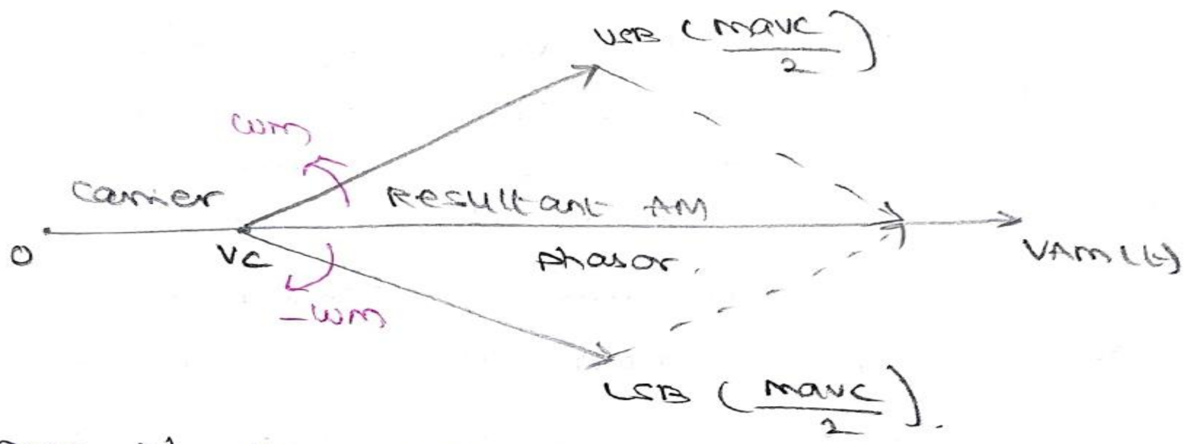
Bandwidth of AM:

$$B = f_{USB} - f_{LSB}$$

$$\Rightarrow f_c + f_m - (f_c - f_m) = 2f_m.$$

$$B = 2f_m \text{ Hz}$$

Phasor representation of AM wave with carrier:



Phasor of the USB rotates in anticlock wise direction at an angular frequency of ω_m. and phasor for the LSB rotates in clock wise at the angular frequency $-\omega_m$.

Modulation Index & % Modulation:

$$m_a = \frac{V_m}{V_c} \qquad \% m_a = \frac{V_m}{V_c} \times 100$$

Calculation of m_a from AM waveform:

$$V_m = \frac{V_{max} - V_{min}}{2}, \quad V_c = \frac{V_{max} + V_{min}}{2}$$

$$m_a = \frac{\left(\frac{V_{max} - V_{min}}{2}\right)}{\left(\frac{V_{max} + V_{min}}{2}\right)} \Rightarrow \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

AMPLITUDE MODULATION

(3)

Degree of Modulation:

* Under Modulation, $m_a < 1$, when $V_m < V_c$
* Over Modulation $m_a > 1$, when $V_m > V_c$
* Critical Modulation $m_a = 1$, when $V_m = V_c$.

AM Power Relation:

P_t = Carrier power + Power in LSB + Power in USB

$\Rightarrow P_{carr} + P_{LSB} + P_{USB}$

$\Rightarrow \frac{V^2_{carr}}{R} + \frac{V^2_{LSB}}{R} + \frac{V^2_{USB}}{R}$

$P = I^2 R$

$P = \frac{V^2}{R}$

(i) Carrier Power:

$V_{carr} = 0.707 V_c$

$P_c = \frac{V^2_{carr}}{R}$

$\Rightarrow \frac{(0.707 V_c)^2}{R} \Rightarrow \frac{\left(\frac{V_c}{\sqrt{2}}\right)^2}{R} \Rightarrow \frac{V_c^2}{2R}$

$$\boxed{P_c = \frac{V_c^2}{2R}}$$

(ii) Power in Sidebands:

$P_{LSB} = P_{USB} = \frac{(0.707 V_{SB})^2}{R}$

where V_{SB} is the peak volt of USB and LSB.

$V_{SB} = \frac{m_a V_c}{2}$

$P_{LSB} = P_{USB} = \frac{\left(0.707 \frac{m_a V_c}{2}\right)^2}{R}$

$\Rightarrow \frac{\left(\frac{1}{\sqrt{2}} \cdot \frac{m_a V_c}{2}\right)^2}{R} \Rightarrow \frac{m_a^2 V_c^2}{8R} = \frac{m_a^2}{4} \cdot P_c$

$$\boxed{P_{LSB} = P_{USB} = \frac{m_a^2}{4} \cdot P_c}$$

AM-TRANSMISSION EFFICIENCY

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

$\Rightarrow \frac{V_c^2}{2R} + \frac{m_a^2 V_c^2}{8R} + \frac{m_a^2 V_c^2}{8R}$

$\Rightarrow \frac{V_c^2}{2R}\left(1 + \frac{m_a^2}{4} + \frac{m_a^2}{4}\right)$

$P_t = \frac{V_c^2}{2R}\left(1 + \frac{m_a^2}{2}\right) \Rightarrow P_c\left(1 + \frac{m_a^2}{2}\right)$

Transmission Efficiency:

$\eta = \frac{\text{Power in SB}}{P_t}$

$\Rightarrow \frac{\left(\frac{m_a^2 V_c^2}{8R} + \frac{m_a^2 V_c^2}{8R}\right)}{\frac{V_c^2}{2R}\left\{1 + \frac{m_a^2}{2}\right\}}$

$\Rightarrow \frac{\frac{V_c^2}{2R}\left(\frac{m_a^2}{4} + \frac{m_a^2}{4}\right)}{\frac{V_c^2}{2R}\left(1 + \frac{m_a^2}{2}\right)} \Rightarrow \frac{\left(\frac{m_a^2}{2}\right)}{\left(\frac{2 + m_a^2}{2}\right)}$

$\eta \Rightarrow \frac{m_a^2}{2 + m_a^2} \Rightarrow \% \eta = \frac{m_a^2}{2 + m_a^2} \times 100$

If $m_a = 1$, then 100 % Modulation takes place,

$\% \eta = \frac{1}{2+1} \times 100 = \frac{1}{3} \times 100 = 33.33 \%$

Hence only 33.33 % of energy is used & remaining power is wasted by the carrier signal along with sidebands.

ADVANTAGES AND DISADVANTAGES OF AM

(4)

Advantages;

* Simple Modulator & demodulators
* Low cost
* AM can travel a long dist
* It covers larger than FM.

Dis Adv;

* Power waste take place
* Poor performance if noise more

Application;

a) Radio broad casting
b) Picture transmission in TV system.

* Classification of AM:

Amplitude Modulation

- DSB with full carrier AM
- DSBSC AM
- SSB-SC AM
- VSB-AM.

Double side band suppressed carrier:

* In this the transmitted wave consists of only upper and lower side bands.
* Txed power is saved here through the supression of the carrier wave.

Txn BW → $2f_m$

Expression for DSB-SC

Modulation signal

$$v_m(t) = V_m \cos \omega_m t \quad \text{--- (1)}$$

THANK YOU