

MODULE - II

Communication Engg.

ANALOG SIGNAL TRANSMISSION AND RECEPTION:-

- Introduction to Modulation .
- Amplitude Modulation (AM)
- Angle Modulation
- Radio and Television broadcasting

Introduction to Modulation :-

By hearing this term what comes to our mind - ??

- i) What is modulation ?
- ii) Why we need modulation ?
- iii) Classification of modulation / Types of modulation .

* MODULATION :-

→ It is the fundamental requisite of communication systems .

→ Definition :- The process in which the some of the characteristics of Carrier Signal are varied in accordance with amplitude part of baseband Signal is known as Modulation .

Some of the characteristics of Carrier Signal are - Amplitude , Frequency , Phase .

Baseband Signal / Modulating Signal / message signal -

Signals containing information or intelligence to be transferred are referred as modulating signal .

After modulation, the resulting signal is called modulated signal.

Carrier Signal :- The signal which carries the information from transmitter to receiver side is called as Carrier signal.

→ It contains very high amount of frequency components as compared to baseband signal.

* Why MODULATION ?

We need modulation process for 3 reasons :-

- i) Frequency Multiplexing
- ii) Antenna Height
- iii) Narrow - banding.

i) Frequency Multiplexing :-

→ Multiplexing is the process in which several message signals are transmitted through a single communication channel.

The channel may be a pair of wires or free space.

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→ When, some amount of baseband frequencies are transmitted then there is a possibility that the baseband signal spectrum are overlapping with each other and the individual signals aren't detected properly at receiver side.

→ Before modulation height of antenna is 30 Km which is impracticable to construct and instal.

→ But this height of antenna can be reduced by modulation technique.

Then after modulation the baseband signal frequency is translated to 10 KHz.

→ Now height of antenna = $h = \frac{c}{2f}$

$$= \frac{c}{2f}$$

$$= \frac{3 \times 10^8}{2 \times 10^4 \times 10^3}$$

$$= \frac{3 \times 10^8}{2 \times 10^4 \times 10^6}$$

$$= 15 \text{ m.}$$

→ This antenna height (15 m) can be practically achieved.

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iii) Narrow Banding :-

Example :-

Take a wideband signal whose frequency is ranging from (50 KHz - 10 KHz) wideband signal.

Carrier frequency (f_c) = 1 MHz.

Band edge ratio = ratio of lowest frequency to highest frequency range.

In order to overcome, we need Modulation process.

→ Modulation means frequency translation, means in order to separate individual signals Spectrum we need different no of carrier signals frequencies, so that the incoming baseband signal spectrums are separated and can easily be detected at receiver side.

→ The above process (translation process) is known as Frequency Division Multiplexing (FDM)

ii) Antenna height :-

Height of antenna denoted by $h = \frac{\lambda}{2}$

Again we know $\lambda = c/f$

→ The message signal is radiated by an antenna.

→ Let's, before modulation, consider a baseband signal of frequency = 5 kHz.

Now the height of antenna is $h = \frac{\lambda}{2}$

$$h = \frac{c}{2f}$$

$$= \frac{3 \times 10^8}{2 \times 5 \times 10^3}$$

$$h = 30 \text{ Km.}$$

AMPLITUDE MODULATION

Definition :- The process in which amplitude part of carrier signal is varied / changing in accordance with the instantaneous value of the baseband signal is known as amplitude modulation.

→ Let's consider a carrier signal as

$$c(t) = A \cos \omega_c t \quad \text{--- (1)}$$

Here A = Amplitude part of carrier signal.

ω_c = Angular frequency of carrier signal.

→ Now Consider a baseband signal as $x(t)$

→ Now the equation of standard Amplitude modulated signal is given as

$$\boxed{\text{AM} = x(t) \cos \omega_c t + A \cos \omega_c t} \quad \text{--- (2)}$$

Here $x(t)$ = baseband signal

$x(t) \cos \omega_c t$ = Double Sideband Suppressed Carrier Signal
(DSB - SC)

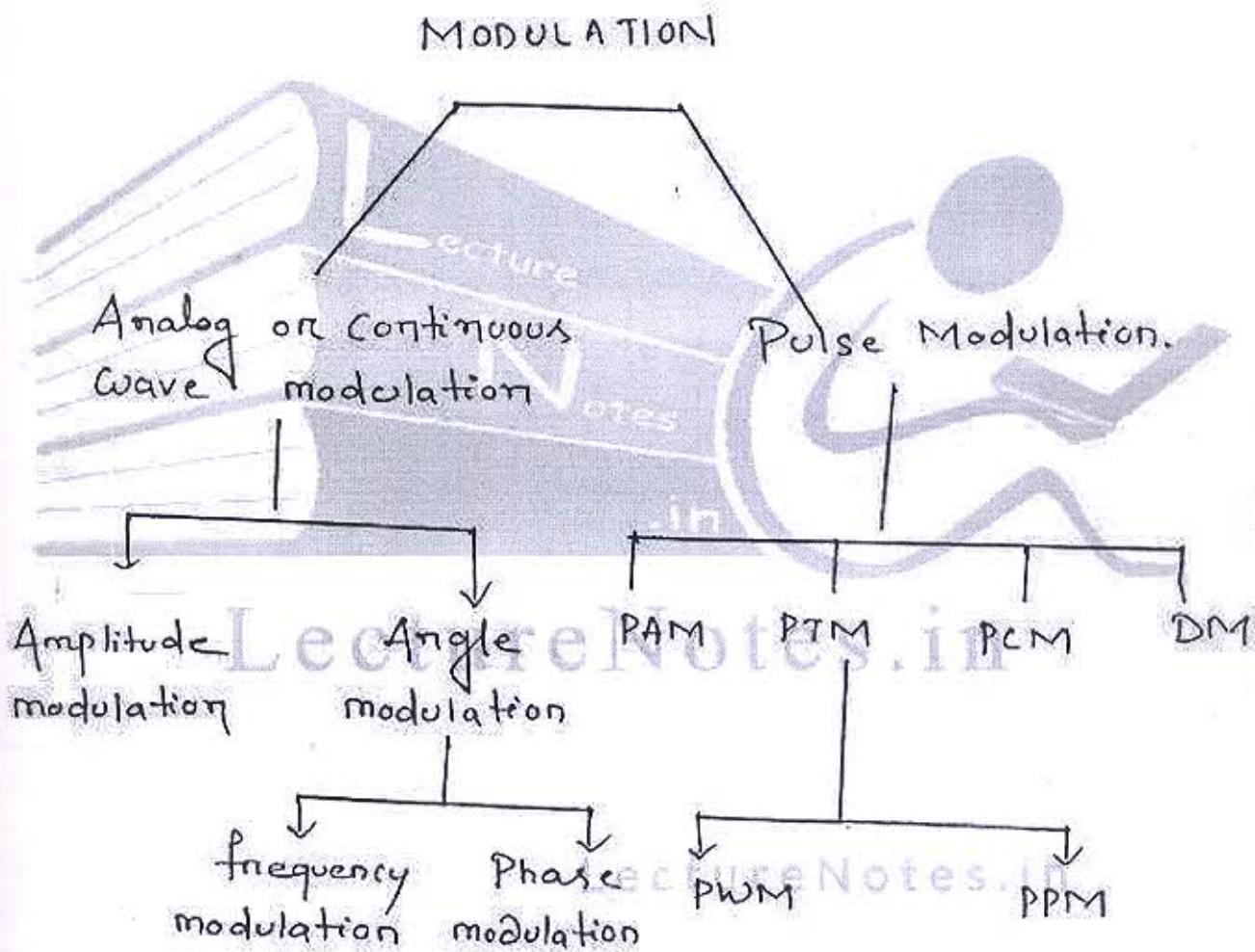
And the total term →

$x(t) \cos \omega_c t + A \cos \omega_c t \Rightarrow$ represents
Double sideband full carrier signal (DSB - FC).

$$= \frac{50 + 1\text{MHz}}{10\text{KHz} + 1\text{MHz}} \approx 1$$

\Rightarrow Band edge ratio give the concept of narrow banding once signal is converted then the need for wide band antenna is totally vanishing from the concept of wide band signal.

* CLASSIFICATION OF MODULATION :-



PAM - Pulse Amplitude Modulation.

DM - Delta modulation

PTM - Pulse Time Modulation.

PCM - Pulse Code Modulation

PWM - Pulse Width Modulation.

PPM - Pulse Position Modulation

from these 3 figures, it is observed that the information is transmitted in the form of Variation of amplitude part of carrier signal.

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 \rightarrow from eqn ① $AM = x(t) \cos \omega_c t + A \cos \omega_c t$

$$\text{Let } x(t) = A_m \cos \omega_m t$$

$$\Rightarrow AM = A_m \cos \omega_m t \cos \omega_c t + A \cos \omega_c t$$

$$= A \cos \omega_c t \left[\frac{A_m}{A_c} \cos \omega_m t + 1 \right]$$

$$= A \cos \omega_c t \left[1 + \frac{A_m}{A_c} \cos \omega_m t \right]$$

$$AM = A \cos \omega_c t \left[1 + m \cos \omega_m t \right] - ④$$

$$\text{Here } m = \frac{A_m}{A_c}$$

↳ Modulation Index.

A_m = Amplitude part of baseband signal

A_c = Amplitude part of carrier signal.

Depending on Modulation Index (m) the types of Modulation \rightarrow

- i) Under Modulation ($m < 1$)
- ii) Critical Modulation ($m = 1$)
- iii) Over Modulation ($m > 1$)

The AM equation can be written as

$$AM = x(t)\cos\omega_ct + A\cos\omega_ct$$

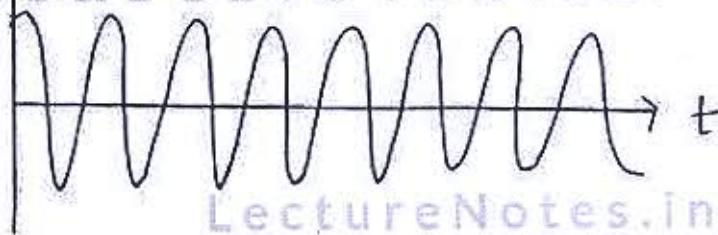
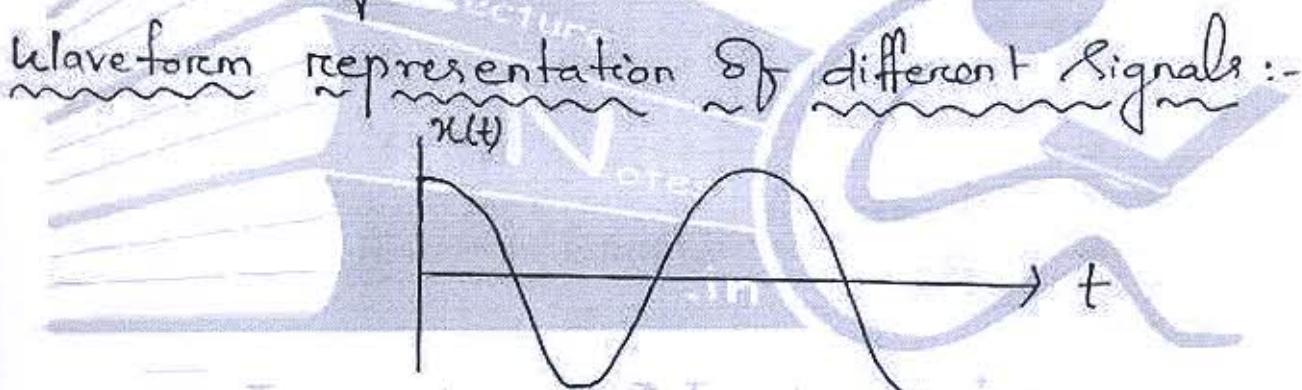
$$AM = \cos\omega_ct [x(t) + A] \quad | \underline{A + x(t) = E(t)}$$

$$AM = \cos\omega_ct E(t)$$

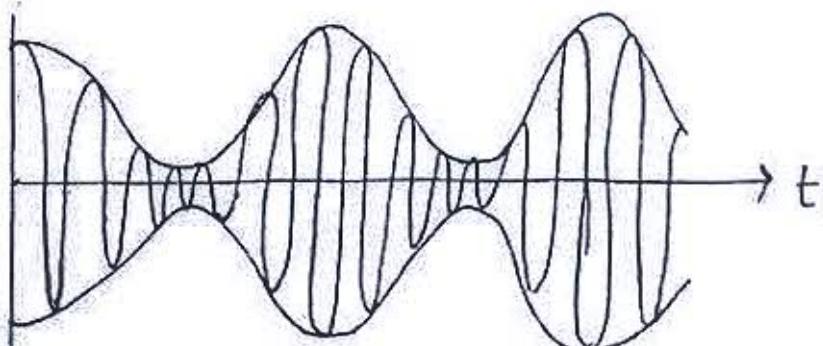
$$AM = E(t) \cos\omega_ct \quad \text{--- (3)}$$

$E(t)$ = Envelop part of modulated signal.

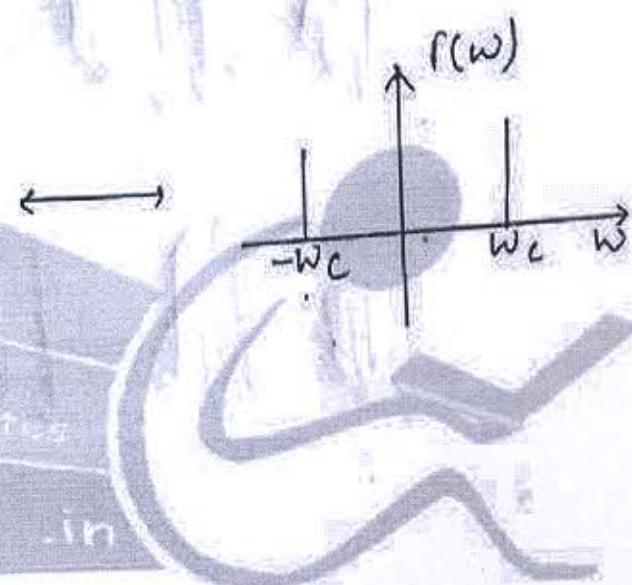
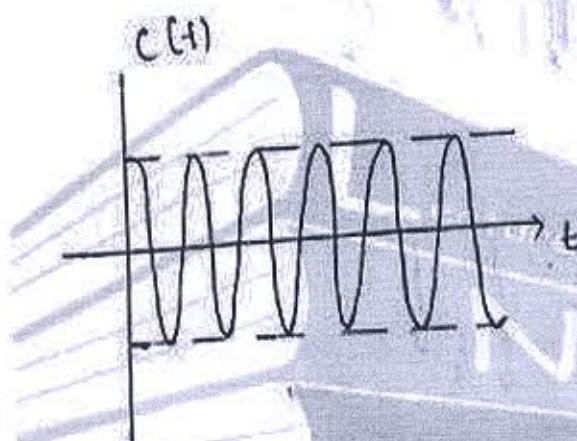
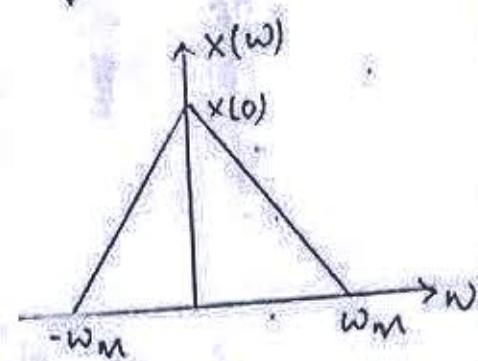
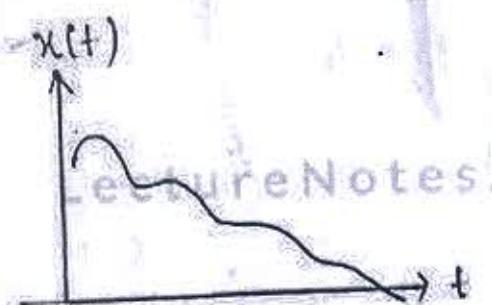
The envelop part of modulated signal contains baseband signal.



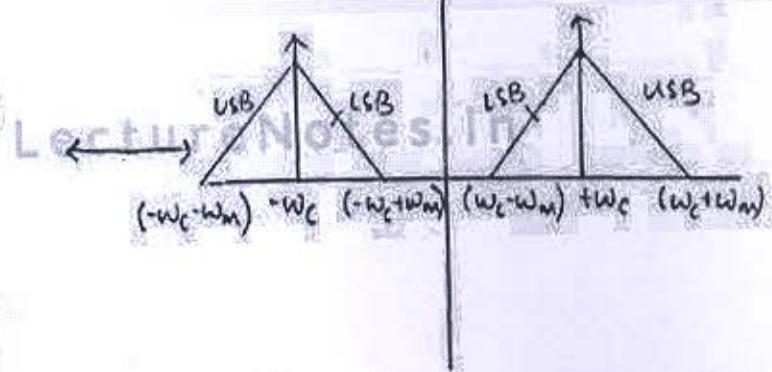
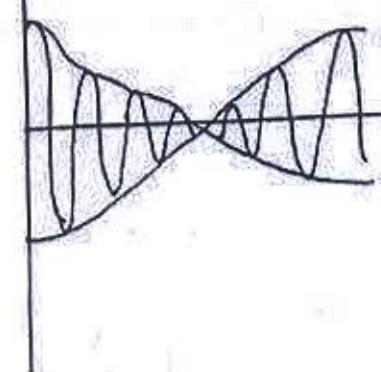
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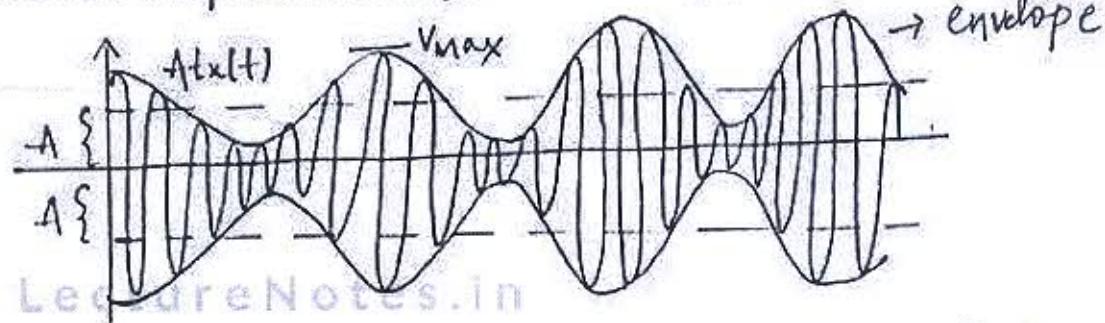
Waveform representation of all signals and their frequency Domain Analysis :-



AM signal

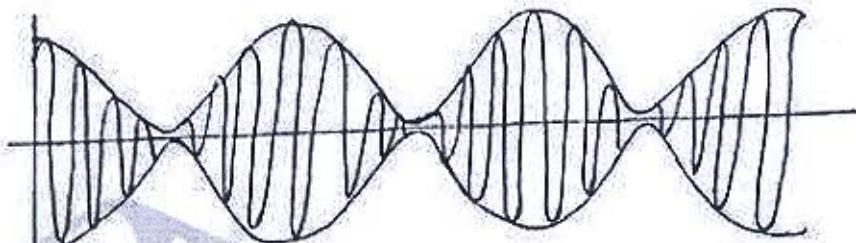


Waveform representation :-

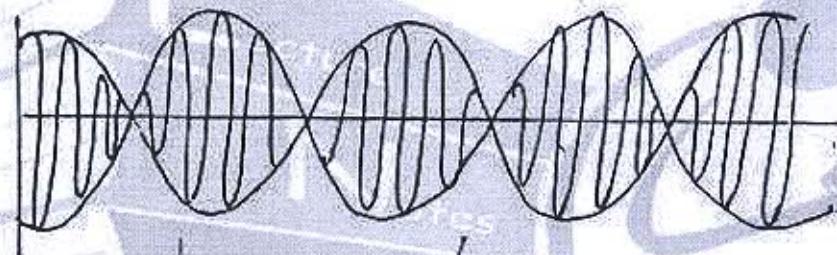


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$\mu = 1$



$\mu > 1$



SPECTRUM OF AM / FREQUENCY DOMAIN

REPRESENTATION

Lets consider baseband signal $\leftrightarrow x(t)$ whose frequency ranging from $-\omega_m$ to ω_m .

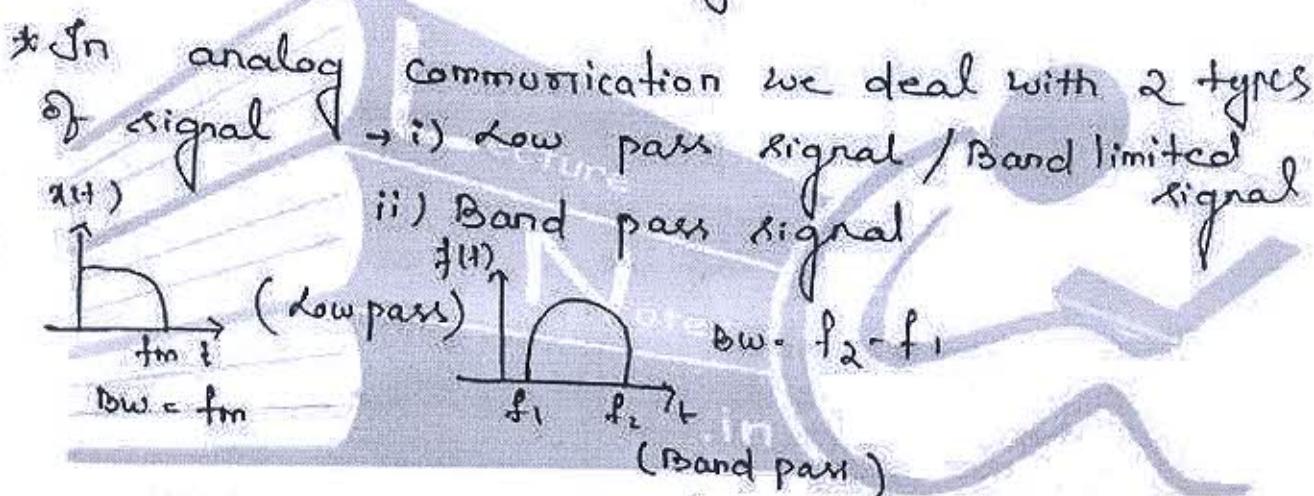
Lets consider a Carrier signal $\leftrightarrow c(t) = A \cos \omega_c t$
Then the Amplitude modulated Signal represented as $z(t)$

$$z(t) = x(t) \cos \omega_c t + A \cos \omega_c t$$

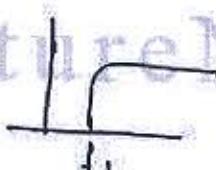
Remember :-

* Modulation is a fundamental requirement of a communication system.

* Carrier frequency is greater than the modulating frequencies and the signal which results from the process of modulation is known as modulated signal.

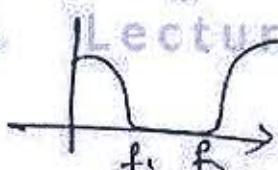


High pass signal



$$Bw = (\omega - f_1)$$

Band rejected signal



$$Bw = (\omega - f_2) - (f_1 - \omega)$$

In these 2 case Bw is not finite
So high level signal and band rejected signals are not used in analog communication.

Mathematical Analysis :-

$$c(t) = A \cos \omega_c t$$

$$F[c(t)] = \pi A [\delta(\omega + \omega_c) + \delta(\omega - \omega_c)]$$

↓

fourier transform Notes.in

$$\mathcal{F}[c(t)]$$

$$z(t) = x(t) \cos \omega_c t + A \cos \omega_c t$$

$$F[z(t)] = Z(\omega)$$

$$Z(\omega) = F[x(t) \cos \omega_c t] + F[A \cos \omega_c t]$$

$$= \frac{1}{2} [X(\omega - \omega_c) + X(\omega + \omega_c)] + F[c(t)]$$

$$Z(\omega) = \frac{1}{2} [X(\omega - \omega_c) + X(\omega + \omega_c)] + \pi A [\delta(\omega + \omega_c) + \delta(\omega - \omega_c)]$$

*Note :- The AM equation i.e. eqn ② contains DSB-FC signal.

DSB - Double Sideband means two sides and they are USB and LSB.

USB - Upper Sideband

LSB - Lower Sideband.

* Note :- When a function is multiplied with $\cos \omega_c t$ then two things are done to find fourier transform.

- ① Amplitude becomes half
- ② Frequency translation occurs.

Problem - 2

Q. Find the percent modulation of AM wave whose total power content is 2500 W and Sideband power contains 400W.

Sol: Given data

$$P_t = 2500 \text{ W}, P_{SB} = 400 \text{ W}$$

$$P_{SSB} = P_{USB} = P_{LSB}$$

$$\text{we know } P_t = P_c + P_{SSB} \Rightarrow P_c + P_{USB} + P_{LSB}$$

$$P_t = P_c + 400 + 400$$

$$2500 = P_c + 800$$

$$\boxed{P_c = 1700 \text{ W}}$$

$$P_{USB} = P_{LSB} = \frac{\mu^2 P_c}{2}$$

$$400 = \frac{\mu^2 \times 1700}{4}$$

$$\mu^2 = \frac{400 \times 4}{1700} = \frac{16}{17} = 0.941$$

in % = 94 %

* Remember

$$P_{USB} = P_{LSB} = \frac{\mu^2 P_c}{4}$$

$$P_t = P_c + \frac{\mu^2 P_c}{2}$$

$$\text{Mod} = \frac{\mu^2}{2 + \mu^2} \text{ or } \frac{P_s}{P_t}$$

Problem - 3

Q. The antenna current of an AM transmitter is 8 Amp if only the carrier is sent but it increases to 8.93 A. if the carrier is modulated. Then determine % of modulation and also determine the antenna current if the % of modulation changes to 80 %.

$$\text{Given : } I_T = 8.93 \quad M = 80\%$$

$$I_c = 8$$

then to find M we can apply the

$$\text{formula : } I_T = I_c \sqrt{1 + \frac{M^2}{2}}$$

$$\Rightarrow \frac{I_T}{I_c} = \sqrt{1 + \frac{M^2}{2}} = \frac{8.93}{8} = \sqrt{1 + \frac{M^2}{2}}$$

$$\Rightarrow M = 0.7 \text{ in}$$

$$\text{in } \% = 70\%$$

$$I_{T_1} = I_{c_1} \sqrt{1 + \frac{M_1^2}{2}}$$

$$I_{T_1} = 8 \sqrt{1 + (0.8)^2}$$

$$I_{T_1} = 9.19 \text{ A}$$

ANGLE MODULATION

Angle Modulation :-

Definition :- The process in which the total phase angle of unmodulated carrier signal is varied according to the instantaneous value of modulating signal is known as Angle Modulation.

$$\text{Equation is } c(t) = A_c \cos [\omega_c t + \phi_0] \quad (1)$$

ϕ_0 = phase angle of unmodulated carrier signal at time $t = 0$.

$\omega_c t$ = phase angle of unmodulated carrier signal which varies with time.

Let substitute $\phi_0 + \omega_c t$ as $\phi(t)$

$$\Rightarrow \phi(t) = \omega_c t + \phi_0 \quad (2)$$

$$c(t) = A_c \cos \phi(t) \quad (3)$$

so now eqⁿ (3) can be written as real part of rotating phasor as $A_c e^{j\phi(t)}$

$$\text{Re [rotating phasor} = A_c e^{j\phi(t)}]$$

$$c(t) = \text{Re} [A_c \cos \phi(t) + j \sin \phi(t)] \quad (4)$$

$$\text{Now } \phi(t) = \omega_c t + \phi_0$$

differentiating $\phi(t)$ wrt t we get

$$\frac{d\phi(t)}{dt} = \omega_c \quad (5)$$

From eqn ⑤ we can observe that ω_c is varied with time period t and this time dependent angular frequency is known as instantaneous frequency and corresponding phase angle is known as instantaneous phase angle.

$$\frac{d\phi_i(t)}{dt} = \omega_i \quad \text{--- ⑥}$$

$$\text{and } \phi_i(t) = \int \omega_i dt \quad \text{--- ⑦}$$

~~Angle Modulation is of 2 types~~

- i) Phase modulation
- ii) Frequency modulation.

Phase Modulation :- In this modulation scheme the total instantaneous phase angle is varied linearly with respect to the instantaneous value of baseband signal yet about the unmodulated carrier phase angle ($\omega_c t$).
 (in other words)

* The instantaneous phase angle is equal to the phase angle of unmodulated carrier signal in addition with time varying component which is directly proportional to the baseband signal $f(t)$.