COMMUNICATION SYSTEMS:

Communication is defined as the process of transmitting information or signal from one point called the source to another point called the destination.

Information can either be continuos signal such as voice, Music, picture etc or discrete signals like data from computers or text etc.

BLOCK DIAGRAM OF A COMMUNICATION SYSTEM

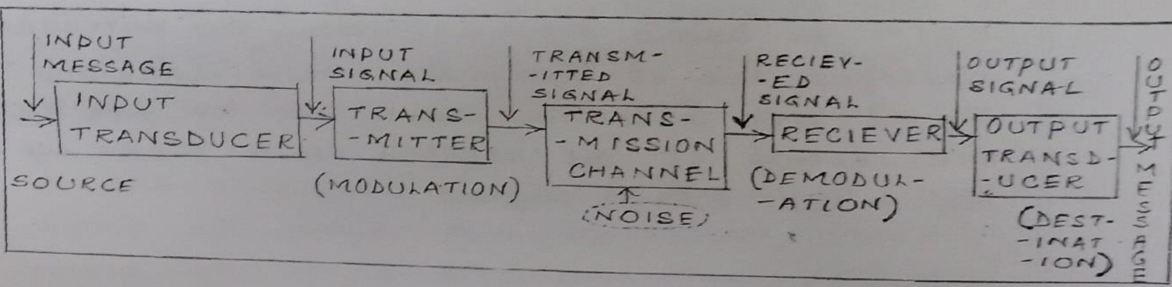


Fig shows block diagram of a basic commu-nication system. At the source the first block is input transducer. This is because information bearing signals (say continuos) are non electrical in nature. eg: voice. To convert this into electrical signal, at the input transducer is used to convert physical quantity into electrical signal eg: Microphone. At the destination this output signal, to physical quantity again a transducer is used such as loudspeaker. electrical in nature is converted — .

There are three essential blocks in a communicatio system.

1. TRANSMITTER: —

The o/p signal of the transducer is a complex signal. It is restricted to desired range of frequencies. Then on that signal Modulation is performed. Modulation is a process of altering the characterstics of high frequency signal called the carrier in accordance with the inform-ation carrying signal. There are 3 types of Modulation.
i) Amplitude Modulation ii) Frequency Modulation
iii) phase Modulation. This Modulated signal is then transmitted over transmission channel.

2.

TRANSMISSION CHANNEL: —

It is a medium by which the electronic signal is transmitted from one place to another. This can be either wire communication where pair of wires, cable are used to transmit information.

Eg:- Telephony where two physical wires are running between the transmitter and receiver. Now a days, the communication medium for telephony is optical fiber where light carries the information.

Second type is wireless communication where no physical wires exist between transmitter and receiver, instead signal is sent through free space or air.

Eg:— In radio communication, two antennas are employed, one at transmitter which transmits the signal, over a carrier wave, into the free space and second at the receiver which picks up the transmitted ~~carrier~~ signal.

3.

NOISE: —

Noise is random, undesirable electric energy that enters communication system via the medium and interferes with the transmitted signal. It can be either natural noise such as noise caused due to lightning during rainy season or radiation by the sun or man made noise or noise produced by electric ignition systems of cars etc. Noise is a serious problem in communication which cannot be eliminated completely but one can reduce its effect on signal.

4.

RECEIVER: —

It is a collection of electronic circuits designed to convert the modulated signal back to modulating signal. This process is known as demodulation.

5. Finally the output transducer is employed to convert electrical signal back to original information in physical form.

MODULATION:

Modulation is a process of Varying the characteristics of a high frequency carrier wave in accordance with the modulating signal whose frequency is low or less compared to carrier.

NEED FOR MODULATION:

1. The height of the antenna 'h' required for transmission and reception of radio waves in radio transmission is a function of wavelength of the frequency used i.e. $\lambda = c/f$. At low frequencies, λ is large and hence height of the antenna should be more to transmit the signal ($\because h \propto \lambda$). Therefore high frequencies are used to transmit information.

2. At low frequencies radiation is poor and signals gets highly attenuated. Therefore signals cannot be transmitted over longer distance. Modulation effectively increases the frequency of the signal to be radiated and thus increases the distance over which signals can be transmitted faithfully.

3. The modulation permits multiplexing to be used. Multiplexing mean transmission of two or more message signals simultaneously over the same channel. In this each message signal are modulated using different carrier frequency signal and then are transmitted over a single channel. At the receiver the message signals are extracted individually by tuning to their respective carrier frequencies.

AMPLITUDE MODULATION:

In amplitude Modulation the amplitude of the carrier wave is varied in accordance with the Modulating signal or Message signal.

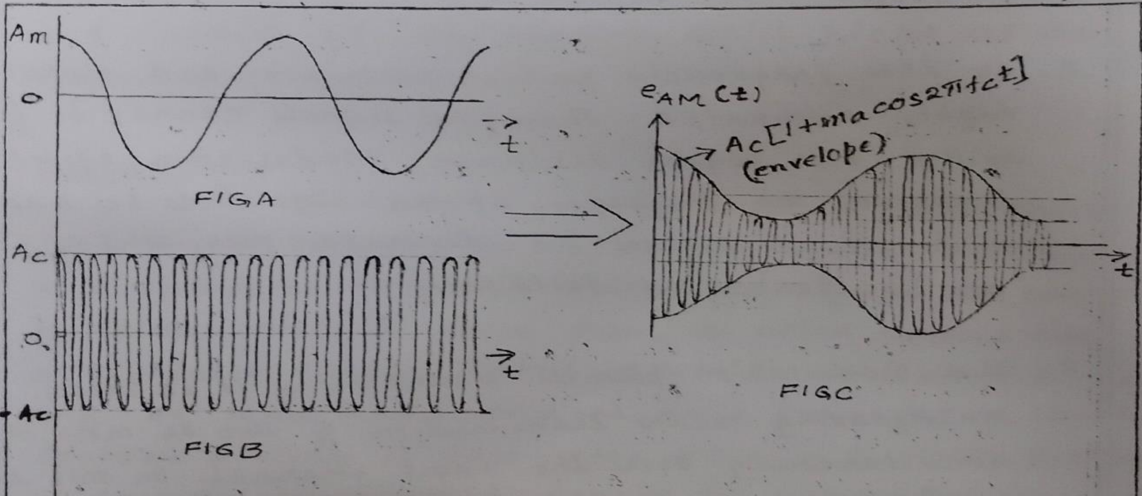
CARRIER SIGNAL:

The carrier signal or wave is a high frequency signal.

MODULATING SIGNAL:

The Modulating signal or wave is a low frequency signal which is nothing but message signal eg: voice signal.

> Thus Amplitude Modulation is defined as a system of Modulation in which the amplitude of carrier wave is made proportional to the instantaneous amplitude of the modulating signal.



FIGA: MODULATING SIGNAL

FIGB: CARRIER SIGNAL

FIGC: AMPLITUDE MODULATED SIGNAL.

EQUATION FOR AMPLITUDE MODULATED SIGNAL.

Let the equation of the carrier signal is given by $e_c(t) = A_c \cos(W_c t + \phi)$

where $A_c \rightarrow$ Amplitude of the carrier signal

$W_c = 2\pi f_c \rightarrow$ Angular frequency of carrier signal.

$\phi \rightarrow$ phase of the carrier.

Assuming $\phi = 0$; $e_c(t) = A_c \cos W_c t. = A_c \cos 2\pi f_c t$

Let the equation of Modulating signal is given by

$e_m(t) = A_m \cos W_m t$

where $A_m \rightarrow$ Amplitude of the Modulating signal

$W_m \rightarrow$ Angular frequency of Modulating signal.

$= 2\pi f_m t$.

$\therefore$ The equation of AM wave is given by

$e_{AM}(t) = A_c \cdot \cos 2\pi f_c t + m(t) \cos 2\pi f_c t$.

substituting $m(t) = A_m \cos 2\pi f_m t$

$= A_c [1 + \frac{A_m}{A_c} \cos 2\pi f_m t] \cos 2\pi f_c t$

$\therefore$ Instantaneous voltage of Amplitude Modulated signal,

$$\boxed{e_{AM}(t) = A_c [1 + m_a \cos 2\pi f_m t] \cos 2\pi f_c t}$$

where $m_a = \frac{A_m}{A_c}$ is called modulation index. the modulation index gives depth of modulation & is defined as

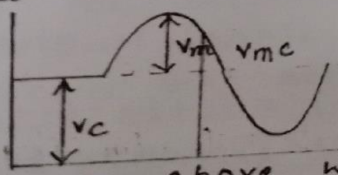
$$\boxed{m_a = \frac{A_m}{A_c} = \text{Ratio of Modulating signal Amplitude to the ratio of carrier signal Amplitude.}}$$

m_a value lies between 0 and 1. If $m_a < 1$, Amplitude Modulated signal is said to be under Modulated. If $m_a > 1$, Amplitude Modulated signal is said to be over Modulated, If $m_a = 1$ it is perfect modulation.

Also in the equation $A_c[1 + m_a \cos 2\pi f_c t]$ is known as envelope of AM wave.

OR

You can derive it in following manner.



Let the carrier signal be given by $e_c(t) = A_c \cos W_c t$ and modulating signal given by $e_m(t) = A_m \cos W_m t$

From the above waveform

Amplitude $A = A_c + A_m \cos W_m t$

$= A_c + m_a A_c \cos W_m t$

$= A_c[1 + m_a \cos W_m t]$

$\therefore$ Instantaneous voltage of Amplitude Modulated signal is

$e_{AM}(t) = A \cos W_c t = A_c [1 + m_a \cos W_m t] \cos W_c t$

$$\therefore \boxed{e_{AM}(t) = A_c [1 + m_a \cos 2\pi f_m t] \cos 2\pi f_c t}$$

$= A_c \cos W_c t + m_a A_c \cos 2\pi f_m t \cos 2\pi f_c t$

$= A_c \cos W_c t + \frac{m_a A_c}{2} \cos 2\pi (f_c - f_m) t + \frac{m_a A_c}{2} \cos 2\pi (f_c + f_m) t$

FREQUENCY SPECTRUM

The equation of AM signal is given by

$e_{AM}(t) = A_c[1 + m_a \cos W_m t] \cos W_c t$

$= A_c \cos W_c t + m_a A_c \cos W_m t \cos W_c t$

$$\boxed{e_{AM}(t) = A_c \cos W_c t + \frac{m_a A_c}{2} \left\{ \cos(\underbrace{W_c + W_m}_{2\pi(f_c+f_m)})t + \cos(\underbrace{W_c - W_m}_{2\pi(f_c-f_m)})t \right\}}$$

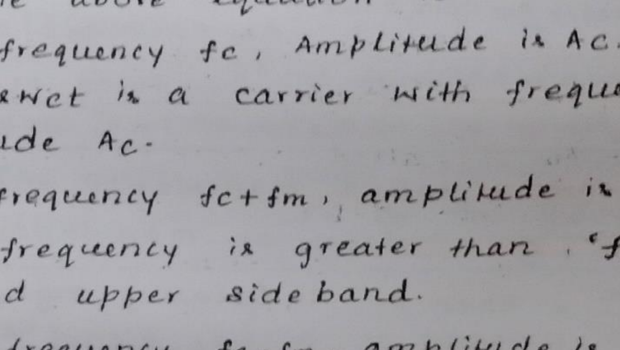
From the above equation we can infere that

i) At frequency f_c, Amplitude is A_c. Therefore $A_c \cos W_c t$ is a carrier with frequency f_c and Amplitude A_c.

ii) At frequency $f_c + f_m$, amplitude is $\frac{m_a A_c}{2}$. Since this frequency is greater than 'f_c' it is called upper side band.

iii) At frequency $f_c - f_m$, amplitude is $\frac{m_a A_c}{2}$. Since this frequency is less than 'f_c' it is called lower side band.

This is illustrated in figure below.



Therefore, Bandwidth of AM signal is given by

$(BW)_{AM} = f_c + f_m - (f_c - f_m) = \cancel{f_c} + f_m - \cancel{f_c} + f_m$

$\boxed{(BW)_{AM} = 2 f_m}$ i.e. the seperation between adjacent carrier is twice the modulating signal frequency.

POWER RELATION IN AM WAVE:

As shown above the AM signal consists of carrier and two side bands. Hence the power in modulated signal is high compared to unmodulated carrier. Therefore total power of AM signal is equal to carrier power plus side band power.

$\therefore \; P_T = P_c + P_{SB}$

But sideband consists of lower side band (LSB) & upper side band (USB) i.e SB = LSB + USB

$\therefore \; P_T = P_c + P_{LSB} + P_{USB}$.

Carrier power $P_c = \frac{(\text{voltage (RMS) of carrier})^2}{R} = \frac{(A_c/\sqrt{2})^2}{R} = \frac{A_c^2}{2R}$.

upper side band & lower side band } power : $P_{USB} = P_{LSB} = \frac{(\text{Amplitude or voltage (RMS) of sideband})^2}{R}$

$$\Rightarrow P_{SB} = \frac{\left(\frac{m_a A_c}{2\sqrt{2}}\right)^2}{R} \Rightarrow \boxed{\frac{m_a^2 A_c^2}{8R} = P_{USB} = P_{LSB}}$$

$$\therefore \; P_T = \left\{ \frac{A_c^2}{2R} + \underbrace{\frac{m_a^2 A_c^2}{8R}}_{(USB)} + \underbrace{\frac{m_a^2 A_c^2}{8R}}_{(LSB)} \right\} = \frac{A_c^2}{2R}\left[1 + \frac{m_a^2}{2}\right]$$

$$\therefore \; P_T = \frac{A_c^2}{2R}\left\{1 + \frac{m_a^2}{2}\right\}$$

Assuming $R = 1\Omega$; $\boxed{P_T = \frac{A_c^2}{2}\left\{1 + \frac{m_a^2}{2}\right\}} = \boxed{P_c\left[1 + \frac{m_a^2}{2}\right]}$

If $m_a = 1$; $P_T = \frac{A_c^2}{2}\{1 + 1/2\} = 1.5 P_c$; $\boxed{P_T = 1.5 P_c}$

i.e. while transmitting AM signal, most of the power is carried by the carrier and only few by the sidebands. But the information is present in the sidebands. Therefore most of the power is wasted in carrier. This indicates that AM is not effecient.

CURRENT CALCULATION :

$$P_T = P_c\left[1 + \frac{m_a^2}{2}\right]$$

$$I_t^2 \cancel{R} = I_c^2 \cancel{R}\left[1 + \frac{m_a^2}{2}\right]$$

where $I_t \rightarrow$ current with modulation

$I_c \rightarrow$ current without modulation

$R \rightarrow$ Resistance of the antenna

$$\frac{P_T}{P_c} = \frac{I_t^2 \cancel{R}}{I_c^2 \cancel{R}} = 1 + \frac{m_a^2}{2}$$

or $\frac{m_a^2}{2} = \frac{I_t^2}{I_c^2} - 1$ OR $\boxed{m_a = \sqrt{2\left[\frac{I_t^2}{I_c^2} - 1\right]}}$

MODULATION BY SEVERAL SINE WAVES:

Modulation by several sine waves means the modulating signal consists of several sine waves i.e. $m(t) = A_1 \sin w_1 t + A_2 \sin w_2 t + A_3 \sin w_3 t + \ldots\ldots$

∴ Effective value of Modulating signal.

$$A_t = \sqrt{A_1^2 + A_2^2 + A_3^2 + A_4^2 + \ldots\ldots}$$

∴ Therefore overall modulation index

$$m_t = \frac{A_t}{A_c} = \sqrt{\frac{A_1^2 + A_2^2 + A_3^2 + \ldots\ldots}{A_c^2}}$$

$$= \sqrt{\frac{A_1^2}{A_c^2} + \frac{A_2^2}{A_c^2} + \frac{A_3^2}{A_c^2} + \ldots\ldots}$$

$$\boxed{m_{at} = \sqrt{m_{a1}^2 + m_{a2}^2 + m_{a3}^2 + \ldots}}$$

For this total power: $\boxed{P_t = P_c\left[1 + \frac{m_{at}^2}{2}\right]}$

PROBLEMS: [Remember the formula WRITTEN IN rectangular blocks)

① For an AM signal $e_{AM}(t) = 10[1 + 0.5 \cos 2\pi 4 \times 10^3 t] \cdot \cos 2\pi 500 t \times 10^3$

i) calculate carrier Amplitude & carrier frequency
ii) Modulation index iii) Modulating signal frequency - and Amplitude
iv) USB & LSB v) Bandwidth of AM.

ANS: i) carrier Amplitude: $A_c = \underline{10V}$

carrier frequency: $f_c = 500 \times 10^3 = \underline{500 kHz}$

ii) $m_a = \frac{A_m}{A_c} = \underline{0.5}$ (from the equation)

∵ $e_{AM}(t) = A_c [1 + m_a \cos 2\pi f_m t] \cos 2\pi f_c t$

iii) Modulating signal frequency $f_m = 4 KHz$

iv) $USB = f_c + f_m = 500 + 4 = 504 kHz$

$LSB = f_c - f_m = 500 - 4 = 496 kHz$

v) $Bandwidth = 2f_m = 2 \times 4 KHz = 8 KHz$

(2) An audio signal $10 \sin 2\pi \times 1000t$ amplitude modulates a carrier of $40 \sin 2\pi \times 2000t$. Find

i) Modulation index ii) sideband frequencies

iii) Bandwidth iv) Total power delivered if $R_L = 1K\Omega$

v) Amplitude of each sideband component.

ANS: Given $e_m(t) = 10 \sin 2\pi \times 1000t$; $A_m = 10V$, $f_m = 1000 Hz$

$e_c(t) = 40 \sin 2\pi \times 2000t$; $A_c = 40$, $f_c = 2000 Hz$

i) Modulation index, $m_a = \frac{A_m}{A_C} = \frac{10}{40} = 0.25$

ii) sideband frequencies, USB $f_c + f_m = 3000 Hz$
LSB $f_c - f_m = 1000 Hz$

iii) Bandwidth $= 2f_m = 2 \times 1000 = 2000 Hz$

iv) Total power delivered if $R_L = 1k\Omega$

$$= P_c\left[1 + \frac{m_a}{2}\right] = \frac{A_c^2}{2}\left[1 + \frac{0.25}{2}\right]$$

$$= \frac{1600}{2}\left[1 + \frac{0.25}{2}\right] =$$

AMPLITUDE OF USB = AMPLITUDE OF LSB

$$A_r = \frac{m_a A_C}{2} = \frac{0.25 \times 40}{2} = \underline{5V}$$

(3) A 1000W, 100KHz carrie modulated to a depth of 50% by Modulating signal of frequency of 2KHz. calculate total power transmitted. What are the sideband components of AM wave?

ANS Given $P_c = 1000 W$, $f_c = 100 \times 10^3 Hz$, $m_a = 0.5$, $f_m = 2 \times 10^3 Hz$

Total power transmitted

$$P_T = P_c\left[1 + \frac{m_a^2}{2}\right]$$

$$P_T = \left[1 + \frac{0.5^2}{2}\right] \times 1000 = 1125W$$
$$= 1.125 KW$$

side band components ; USB = $f_c + f_m = 100 + 2 = 102 KHz$
LSB = $f_c - f_m = 100 - 2 = 98 KHz$

(4) A broad cast radio transmitter radiates 10kW when the modulation percentage is 60. How much of this is carrier?

ANS: $P_T = 10\times10^3$; $m_a = 60/100 = 0.6$

$\therefore P_c = \dfrac{P_t}{1+m_a^2/2} = \dfrac{10\times10^3}{1+0.6^2/2} = 8.47\times10^3 = \underline{\underline{8.5\text{kW}}}$

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(5) The antenna current of an AM transmitter is 8A when only carrier is sent, but it increases to 8.93A when carrier is modulated by a single sine wave. Find the percentage Modulation. Determine the antenna current when depth of modulation changes to 0.8. (IMP)

ANS Given $I_c = 8A$ (current when only carrier is sent)

$I_t = 8.93A$ (current of modulated carrier)

i)

$\therefore I_t = I_c\sqrt{1+\dfrac{m_a^2}{2}}$; $m_a = \sqrt{\left(\dfrac{I_t^2}{I_c^2}-1\right)\times2} = \sqrt{\left[\left(\dfrac{8.93}{8}\right)^2-1\right]\times2}$

$\therefore m_a = 0.701$; or $\underline{\underline{m_a = 70.1\%}}$.

ii)

$I_t = ?$ when $m_a = 0.8$

$\therefore I_t = I_c\sqrt{1+\dfrac{m_a^2}{2}} = 8\sqrt{1+\dfrac{0.8^2}{2}} = \underline{\underline{9.19A}}$

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(6) A certain transmitter radiates 9kW with carrier unmodulated and 10.125kW when carrier is sinusoidally modulated. calculate modulation index. If another sine wave corresponding to 40% modulation is transmitted simultaneously, determine total power radiated. (IMP).

ANS Given $P_c = 9\text{kW}$, $P_t = 10.125\text{kW}$.

i) $P_t = P_c\left[1+\dfrac{m_a^2}{2}\right]$; $m_a = \sqrt{2\left[\dfrac{P_t}{P_c}-1\right]} = \sqrt{2\left[\dfrac{10.125}{9}-1\right]}$

$\therefore \underline{\underline{m_a = 0.5}}$

ii) $m_{a1} = 0.5$ $m_{a2} = 0.4$; $\therefore m_t = \sqrt{m_{a1}^2+m_{a2}^2}$

$= \sqrt{0.5^2+0.4^2}$

$= \underline{\underline{0.64}}$

$\therefore P_t = P_c\left[1+\dfrac{m_t^2}{2}\right]$

$= 9\left[1+\dfrac{0.64^2}{2}\right] = \underline{\underline{10.84\text{kW}}}$

(7) P.T Modulation index of AM wave is $\frac{A_{max} - A_{min}}{A_{max} + A_{min}}$. If the positive RF peaks of AM wave rise to a maximum of 15V & minimum drops to 5V. Determine Modulation index and unmodulated carrier Amplitude. (V.V.IMP).

ANS:

From the waveform.

$$A_m = \frac{A_{max} - A_{min}}{2}$$

$$A_c = A_{MAX} - A_m = A_{MAX} - \frac{(A_{MAX} - A_{MIN})}{2}$$

$$= \frac{A_{max} + A_{min}}{2}$$

Modulation index: $m_a = \frac{A_m}{A_c}$

Substituting A_m & A_c : $\boxed{m_a = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}}$.

Given $A_{max} = 15V$; $A_{min} = 5V$

i) $m_a = \frac{15-5}{15+5} = \frac{10}{20} = 0.5$

ii) From the waveform

$$A_m = \frac{A_{max} - A_{min}}{2} = \frac{15-5}{2} = 5V.$$

We know that $m_a = \frac{A_m}{A_c}$; $A_c = \frac{A_m}{m_a}$

$$\therefore A_c = \frac{5}{0.5} = 10V$$

(8) A 360W carrier is simultaneously modulated by two audio waves with percentage modulation of 55 and 65 respectively. Find modulation index and total power radiated and power in sidebands. Take $R_L = 1\Omega$

ANS. $m_{at} = \sqrt{m_{a_1}^2 + m_{a_2}^2} = \sqrt{(0.55)^2 + (0.65)^2} = 0.85$

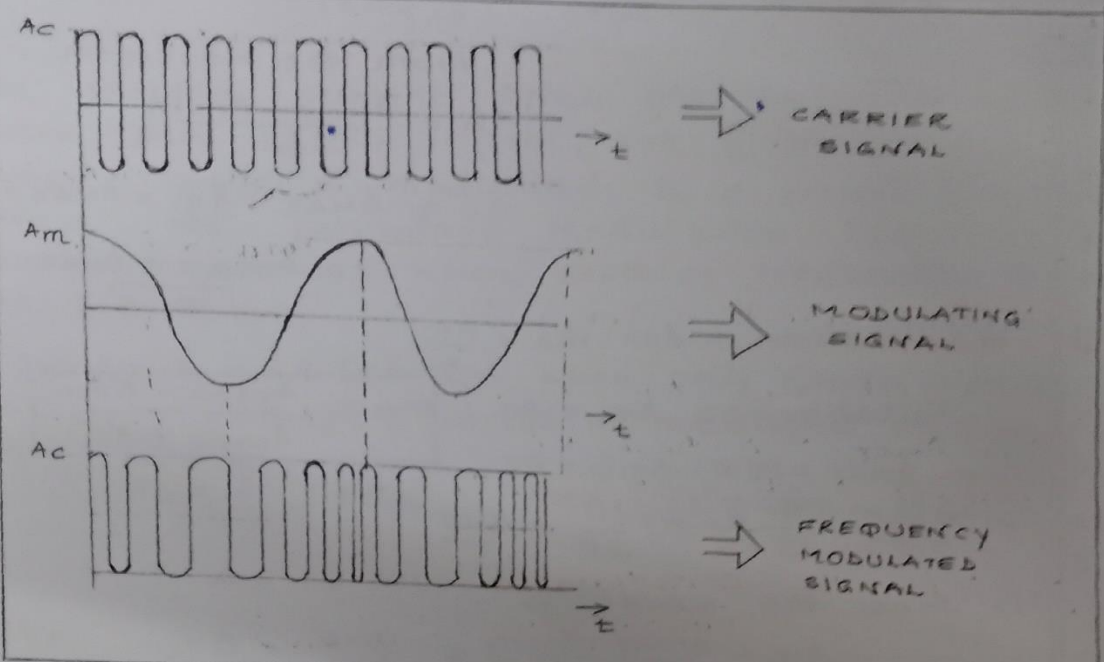
$$\therefore P_t = P_c\left[1 + m_{at}^2/2\right] = 360\left[1 + 0.85^2/2\right] = 490.5W$$

$$P_{SB} = P_{USB} = P_{LSB} = \frac{m_{at}^2 A_c^2}{8} = \frac{m_{at}^2 A_c^2}{4 \; 2} = P_c \frac{m_{at}^2}{4}$$

$$= \frac{360 \times 0.85^2}{4} = 65.25W$$

FREQUENCY MODULATION:

In frequency modulation the frequency of the carrier wave is varied in accordance with the amplitude of the modulating signal. The amplitude of the carrier signal is held constant.



As shown in fig above the frequency of carrier wave is made proportional to the instantaneous amplitude of modulating signal.

EXPRESSION FOR FM signal:

Since the frequency of carrier signal in frequency modulated signal is governed by the amplitude of the modulating signal, instantaneous frequency of FM is given by

$$f_{FM} = f_c + k e_m(t)$$

$$= f_c + K A_m \cos 2\pi f_m t.$$

$$f_{FM} = f_c + \Delta f \cos 2\pi f_m t \rightarrow (1)$$

where $\Delta f = KA_m$ is called frequency deviation and $K \rightarrow$ frequency deviation constant.

Multiplying by 2π on both sides in equ (1) we have

$$2\pi f_{FM} = 2\pi f_c + 2\pi \Delta f \cos 2\pi f_m t$$

$$W_{FM} = W_c + \Delta W \cos 2\pi f_m t$$

since $W_{FM} = \frac{d\theta(t)}{dt}$

Integrating both the sides; $W_{FM}t = \theta(t)$

$$W_{FM}t = W_ct + \frac{\Delta W}{2\pi f_m}\int \cos 2\pi f_m t\, dt$$

$$W_{FM}t = W_ct + \frac{\Delta W}{W_m}\sin 2\pi f_m t = \theta(t).$$

since we are varying frequency of carrier signal in frequency modulated signal, we can write equation for FM signal

$$e_{FM}(t) = A_c \cos(W_ct + \phi)$$

$$= A_c \cos(W_{FM}t) = A_c\cos(\theta(t)).$$

$$= A_c \cos\left(W_ct + \frac{\Delta W}{W_m}\sin 2\pi f_m t\right)$$

$$= A_c \cos\left(W_ct + \frac{2\pi\Delta f}{2\pi f_m}\sin 2\pi f_m t\right)$$

$$= A_c \cos\left(W_ct + \frac{\Delta f}{f_m}\sin 2\pi f_m t\right)$$

$$\boxed{e_{FM}(t) = A_c \cos(W_ct + \beta \sin 2\pi f_m t)}$$

Where $\boxed{\beta = \frac{\Delta f}{f_m}}$ is the modulation index of FM signal and is defined as the ratio of frequency deviation to that of frequency of modulating signal. Unlike AM signal, in FM modulation index is not restricted. It can be more than unity.

Unlike AM, the sidebands in FM are infinite and hence ideally Bandwidth of FM is infinite. But for calculation purpose it can be determined by using CARSON'S RULE according to which Bandwidth of FM; $\boxed{BW_{FM} = 2(\Delta f + f_m)}$

where $\Delta f \rightarrow$ frequency deviation

$f_m \rightarrow$ Modulating frequency.

PROBLEMS:

① Given a FM equation $e_{FM}(t) = 10\cos[2\pi \times 10^8 t + 5\sin 2\pi \times 15\times 10^3 t]$ calculate i> carrier frequency ii> Modulating frequency iii> frequency deviation iv> Bandwidth using carson's rule. (IMP)

ANS: i) $f_c = 10^8$ Hz or carrier frequency f_c = MHz

ii) $f_m = 15\times10^3$ Hz or Modulating frequency = 15 KHz

iii) Modulation index, $\frac{\Delta f}{f_m} = 5$

From equation $e_{FM}(t) = A_c \cdot \cos[W_ct + \beta \sin 2\pi f_m t]$ [COMPARING GIVEN EQU]

iv) $B.W_{FM} = 2(\Delta f + f_m)$ $[\Delta f = \beta f_m$

$= 2(\beta f_m + f_m)$

$= 2f_m(\beta+1) = 2\times15\times10^3[5+1] = \underline{180\text{ KHz}}$

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(2) A carrier of amplitude 5V and frequency 90MHz is FM by a sinusoidal voltage of amplitude 5V and frequency 15KHz. The frequency deviation is 1 KHz/V. Calculate frequency deviation and Modulation index.

ANS Frequency deviation = kA_m

Give $k = 1$ KHz/V, $A_m = 5$V $\}$ $\Delta f = 1\times5 = 5$ KHz.

Modulation index; $\beta = \frac{\Delta f}{f_m} = \frac{5\times10^3}{15\times10^3} = \underline{0.333}$

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(3) In an FM system when the audio frequency is 50Hz and modulating voltage 2.5V, the deviation produced is 5KHz. If modulating voltage is now increased to 7.5V, calculate new value of frequency deviation. If the AF voltage is raised to 10V while modulating frequency dropped to 250Hz. What is the frequency deviation? Calculate Modulation index in each case. (V.IMP)

ANS Given $f_m = 50$ Hz, $A_m = 2.5$V, $\Delta f = 5\times10^3$ Hz;

i) Modulation index $= \frac{\Delta f}{f_m} = \frac{5\times10^3}{50} = \underline{100} = \beta_1$

Given if $A_m = 7.5$V, $\Delta f = ?$ $\therefore \Delta f = KA_m$

K = deviation constant $= \frac{\Delta f}{A_m} = \frac{5\times10^3}{2.5} = 2$ KHz/V.

ii) New value of $\Delta f = K\cdot A_m = 2\times7.5 = \underline{15\text{ KHz}}$

Modulation index $\beta_2 = \frac{\Delta f}{f_m} = \frac{15\times10^3}{50} = \underline{300}$

iii) Given if $A_m = 10$V; $f_m = 250$ Hz, $\Delta f = ?$

$\therefore \Delta f = K A_m = (2\,kHz/V)\cdot(10V) = 20\,kHz$

Modulation index $\beta_3 = \frac{\Delta f}{f_m} = \frac{20\times10^3}{25Q} = \underline{800}$

NOTE: Total power in FM system is given by

$P_{TOTAL} = \frac{A_c^2}{2R}$ (since carrier Amplitude remains same, total power depends only on that amplitude)

Q. Define the following (IMP)

i) Deviation ratio:

It is defined as ratio of maximum frequency deviation to that of maximum modulating frequency.

ii) Frequency Deviation:

As the modulating signal amplitude varies carrier frequency varies above and below its centre carrier frequency. The amount of change in carrier frequency produced by the modulating signal is known as frequency deviation or frequency shift.

Q. Write the differences b/w AM & FM OR compare merits and demerits of AM & FM. (V.V.IMP)

AMPLITUDE MODULATION	FREQUENCY MODULATION
① In AM amplitude is varied, frequency is kept constant	In FM frequency is varied, Amplitude is kept constant
② Modulation index can have or has values from 0 to 1.	Modulation index is much greater than unity.
③ There are only two side bands	There are large number of side bands
④ Bandwidth is twice the modulating frequency = $2f_m$	Band width is much greater than AM; $2(\Delta f + f_m)$
⑤ It is more susceptible to noise because effects Amplitude of the signal not the frequency	More immune to noise.
⑥ covers very long distances power required is very high	covers smaller distances power required is low
⑦ carrier frequency is in the lower RF range 300, 03MHz	carrier frequency is in VHF & UHF range i.e 88-108 MHz VHF → very high frequency UHF → upper high frequency
⑧ propagation is by ground wave in MW band and sky wave in SW band. MW → Medium wave ; SW → short wave	ropagation is by space wave / line of sight.