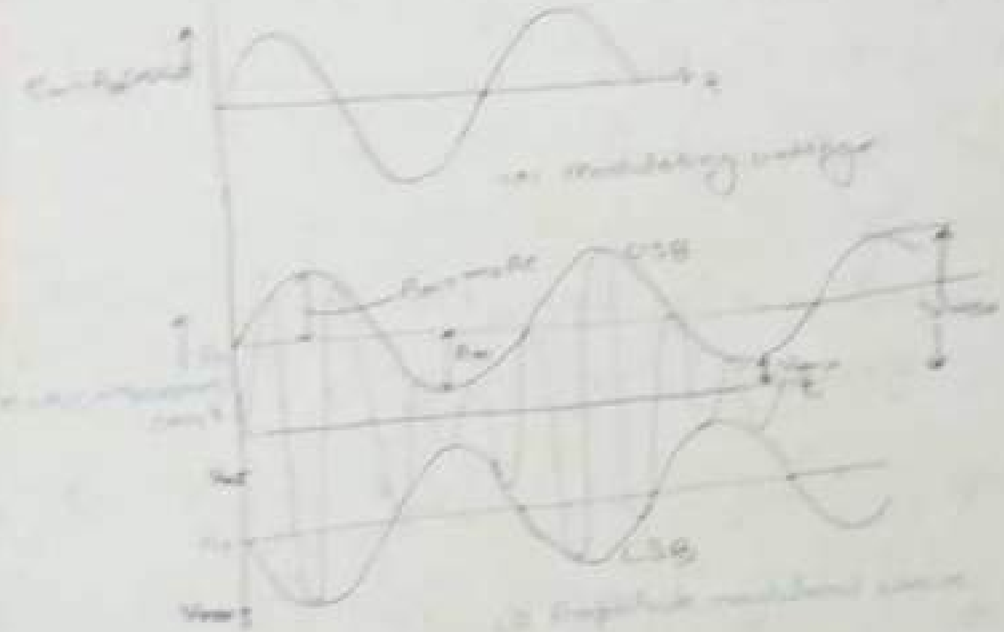
Representation of AM —

Given below fig shows the waveform of the modulating signal and that of modulated wave called the modulation envelope.



modulation index $m_a = k_a \frac{A_m}{A_c}$ when $k_a = 1$ $\boxed{m_a = \frac{A_m}{A_c}}$

hence $m_a = \frac{\text{Amplitude of modulating signal}}{\text{Amplitude of carrier wave}}$

from AM wave fig.

$$A_m = \frac{V_{max} - V_{min}}{2} \quad \text{—} ①$$

also

$$A_c = V_{max} - A_m$$

$$= V_{max} - \frac{V_{max} - V_{min}}{2}$$

$$= \frac{2V_{max} - V_{max} + V_{min}}{2}$$

$$= \frac{V_{max} + V_{min}}{2} \quad \text{—} ②$$

hence from eq^n ① and ②

$$\boxed{m_a = \frac{A_m}{A_c} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}}$$

... where μ is percentage of modulation ...

[illegible]:— ... modulated wave ... frequency ... component ... carrier wave. Amplitude of side bands ... depends upon m_a. So total power in modulated signal depends upon the modulation index.

So total power of the wave

$$P_t\,(\text{or } P_m) = P_c + P_{LSB} + P_{USB} = \frac{V_{carr}^2}{R} + \frac{V_{LSB}^2}{R} + \frac{V_{USB}^2}{R}$$

$$P_c = \frac{V_{carr}^2}{R}$$ where all voltages ... rms values

R is the resistance (e.g. antenna) in which power is dissipated

$$P_c = \frac{1}{R}\left(\frac{A_c}{\sqrt{2}}\right)^2 = \frac{A_c^2}{2R}$$

Similarly

$$P_{LSB} = P_{USB} = \frac{V_{SB}^2}{R} = \frac{1}{R}\left(\frac{m_a A_c}{2\sqrt{2}}\right)^2 = \frac{m_a^2 A_c^2}{8R}$$

So

$$P_t = \frac{A_c^2}{2R} + \frac{m_a^2 A_c^2}{8R} + \frac{m_a^2 A_c^2}{8R}$$

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

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

So $$\boxed{P_t = P_c\left(1 + \frac{m_a^2}{2}\right)}$$ This eq^n ... P_t ...

Power contained in side bands

$$P_{SB} = P_{LSB} + P_{USB}$$

$$= \frac{m_a^2 A_c^2}{8R} + \frac{m_a^2 A_c^2}{8R}$$

$$= \frac{A_c^2}{2R}\,\frac{m_a^2}{2}$$

$$\boxed{P_{SB} = P_c\,\frac{m_a^2}{2}}$$

When $m_a = 1$ then $P_{SB}/P_t = \frac{m_a^2/2}{1 + m_a^2/2} = \frac{1}{3}$ ... only $\frac{1}{3}$ of total ... contained in the ... side bands ...

(a) at $m_a = 1$ then $P_t = P_c(1+\frac{1}{2}) = 1.5P_c$. So the max. power in AM wave is 1.5 time carrier power. It is max power that relevant amplifier must be capable of handling without distortion.

Current calculation — Let I_c be unmodulated current and I_t the total (or modulated current) of an AM transmitter. If R is the resistance in which both currents flow, then

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

$$\text{So} \quad \boxed{I_t = I_c\sqrt{1+\frac{m_a^2}{2}}}$$

Note — modulation index = depth of modulation

Modulation by several sine wave —

(i) Let V_1, V_2, V_3 etc be the simultaneous modulation voltage. Then the total modulating voltage V_t is —

$$V_t = \sqrt{V_1^2 + V_2^2 + V_3^2 + \cdots}$$

Dividing both sides by V_c we get

$$\frac{V_t}{V_c} = \sqrt{V_1^2+V_2^2+\cdots}\,/V_c$$

$$= \sqrt{\left(\frac{V_1}{V_c}\right)^2 + \left(\frac{V_2}{V_c}\right)^2 + \cdots}$$

i.e.

$$m_t = \sqrt{m_1^2 + m_2^2 + m_3^2 + \cdots}$$

where m_t is the over all modulation index. So over all AM wave is

$$e = A_c(1 + m_1\cos\omega_1 t + m_2\cos\omega_2 t + m_3\cos\omega_3 t \cdots)\cos\omega_c t$$

(ii) from eqn —

$$P_t = P_c\left(1+\frac{m_a^2}{2}\right) = P_c + \frac{P_c m_a^2}{2} = P_c + P_{SB}$$

where P_{SB} is the total side band power and is given by

$$P_{SB} = P_c\frac{m_a^2}{2}$$ where m_a = total modulation index ~~(or m_t for general)~~

If several sine wave ~~simultaneously~~ ~~sine wave modulate the carrier~~ simultaneously modulate the carrier. So carrier power is unaffected and P_{SB} is sum of the individual P_{SB}'s. Hence we have