$$v_{AM} = V_c \sin 2\pi f_c t + \frac{mV_c}{2} \cos 2\pi (f_c - f_m) t - \frac{mV_c}{2} \cos 2\pi (f_c + f_m) t$$

$$\boxed{P_{AM} = P_c + P_{lsb} + P_{usb}}$$

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

Carrier Power, $P_c = \dfrac{V_c^2}{2R}$

$$P_{usb} = P_{lsb} = \frac{m^2 V_c^2}{8R} = \frac{m^2}{4} \frac{V_c^2}{2R} = \frac{m^2}{4} P_c$$

Total Sideband Power

$$P_{sb} = P_{lsb} + P_{usb} = \frac{m^2}{4} P_c + \frac{m^2}{4} P_c = 2 \times \frac{m^2}{4} P_c$$

$$\boxed{P_{sb} = \frac{m^2}{2} P_c}$$

$$v_{AM} = V_c \sin 2\pi f_c t + \frac{mV_c}{2} \cos 2\pi (f_c - f_m)t - \frac{mV_c}{2} \cos 2\pi (f_c + f_m)t$$

$$P_T = \frac{V_C^2}{2R} + \frac{m^2 V_C^2}{4 \times 2R} + \frac{m^2 V_C^2}{4 \times 2R}$$

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

$$P_T = P_C + \frac{m^2}{4} P_C + \frac{m^2}{4} P_C$$

$$P_T = P_C \left(1 + \frac{m^2}{2} \right)$$

- If m=1

$$P_T = \frac{3}{2} P_C , P_C = \frac{2}{3} P_T$$

The total power content of an AM signal is 2500W. Determine the power being transmitted at the carrier frequency and at each of the sidebands when the percentage of modulation is 80%.

The total power content of an AM signal is 2500W. Determine the power being transmitted at the carrier frequency and at each of the sidebands when the percentage of modulation is 80%.

$P_C = 1893.9W$

$P_{LSB} = P_{USB} = 303.5W$

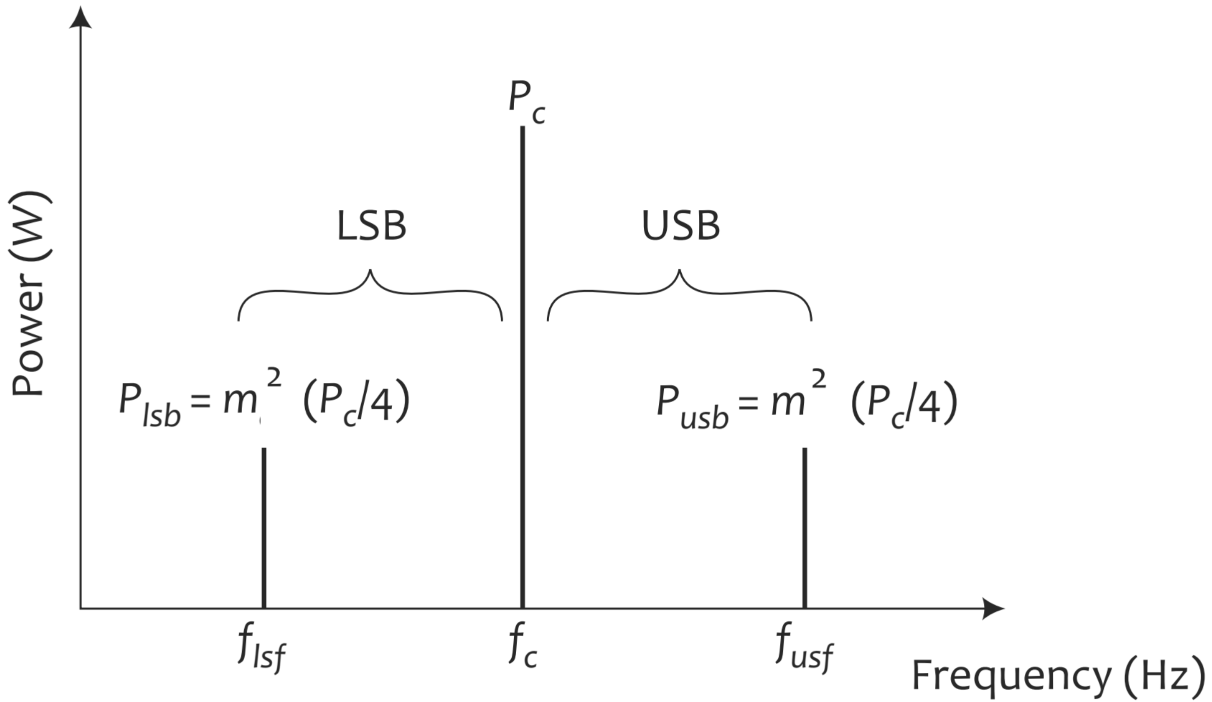
An AM broadcast station's peak carrier voltage of 2 kV has been amplitude modulated to an index of 75% with a 2 kHz test tone. The station broadcast frequency is 810 kHz. Compute the following:

1. The lower and upper sidebands frequencies, f_{LSB} and f_{USB}
2. The peak modulation voltage, V_m
3. The peak lower and upper sideband voltages, V_{LSB} and V_{USB}
4. The maximum signal amplitude, V_{max}
5. The minimum signal amplitude, V_{min}
6. Sketch the freq spectrum

A spectrum analyzer with an input impedance of 50 Ω is used to measure the power spectrum of an AM signal at the output of a preamplifier circuit. The AM signal has been modulated with a sine wave. The effective power P_C is 745 mW, and each sideband, P_{USB} and P_{LSB} is 125 mW. Compute the following:

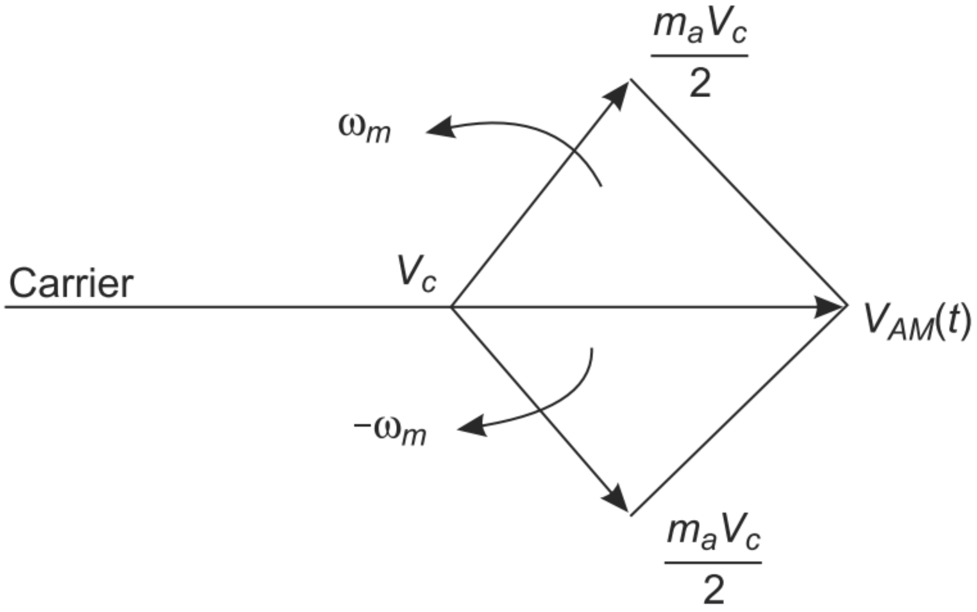
- The total effective power, P_T
- The peak carrier voltage, V_C
- The modulation index, m, and the percentage of modulation index M
- The modulation voltage V_m
- The lower and upper sideband voltages, V_{LSB} and V_{USB}
- Sketch the power spectrum

Power Spectrum of an AM Signal



Phasor Representation of AM with Carrier

$$v_{AM} = V_c \sin 2\pi f_c t + \frac{mV_c}{2}\cos 2\pi (f_c - f_m)t - \frac{mV_c}{2}\cos 2\pi (f_c + f_m)t$$



An AM signal has a peak unmodulated carrier voltage, Vc = 100 V, a load resistance, RL = 50 W, and a modulation index, ma = 1. Determine the following:

(a) The carrier power

(b) The lower-sideband and upper-sideband power

(c) Total sideband power

(d) Total power of the modulated AM signal

(e) Sketch the AM power spectrum

(a) We know that the carrier power, $P_c = \frac{V_c^2}{2\,R_L}$

For given values of $V_c = 100$ V, and $R_L = 50\ \Omega$, we have

$$P_c = \frac{100^2}{2 \times 50} = 100\ \mathbf{W}$$

(b) We know that lower or upper-sideband power, $P_{lsb} = P_{usb} = \frac{m_a^2}{4} P_c$

For $m_a = 1$, and $P_c = 100$ W, we have

$$P_{lsb} = P_{usb} = \frac{1^2}{4} \times 100 = 25\ \mathbf{W}$$

(c) We know that total sideband power, $P_{sb} = \frac{m_a^2}{2} P_c$

For $m_a = 1$, and $P_c = 100$ W, we have

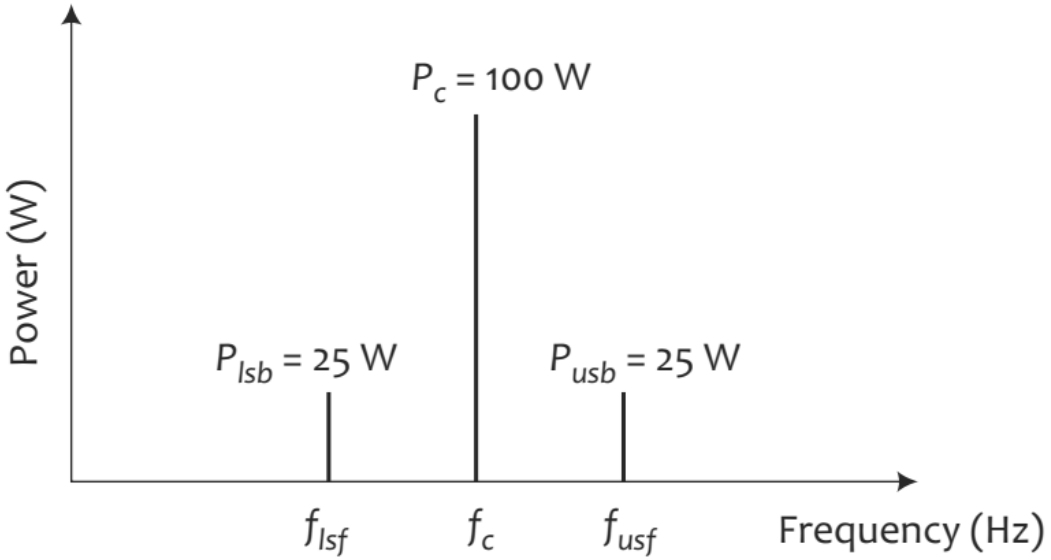
$$P_{sb} = \frac{1^2}{2} \times 100 = 50 \textbf{ W}$$

(d) We know that total AM power, $P_{AM} = P_c \left(1 + \frac{m_a^2}{2}\right)$

For $m_a = 1$, and $P_c = 100$ W, we have

$$P_{AM} = (100 \text{ W}) \left(1 + \frac{1^2}{2}\right) = 150 \textbf{ W}$$

The AM power spectrum is shown in Fig. 4.16.



Total Sideband Power

Total current and carrier current in AM wave

$$P_T = P_C\left(1+\frac{m^2}{2}\right)$$

$$I_T{}^2 R = I_C{}^2 R\left(1+\frac{m^2}{2}\right)$$

$$\frac{I_T}{I_C} = \sqrt{\left(1+\frac{m^2}{2}\right)}$$

Modulation Efficiency

The ratio of amount of useful message power to the total power

$$\% \, \eta = \frac{\text{Total power in side bands}}{\text{Total power}} \times 100$$

$$= \frac{P_{\text{LSB}} + P_{\text{USB}}}{P_{\text{T}}} \times 100$$

Modulation Efficiency

$$= \frac{\dfrac{m_a^2 V_C^2}{8R} + \dfrac{m_a^2 V_C^2}{8R}}{\dfrac{V_C^2}{2R}\left[1 + \dfrac{m_a^2}{2}\right]} \times 100$$

$$= \frac{\dfrac{m_a^2 V_C^2}{4R}}{\dfrac{V_C^2}{2R}\left[1 + \dfrac{m_a^2}{2}\right]} \times 100$$

Modulation Efficiency

$$= \frac{\dfrac{m_a^2}{2}}{1 + \dfrac{m_a^2}{2}} \times 100$$

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

Modulation Efficiency

$$= \frac{\frac{m_a^2}{2}}{1 + \frac{m_a^2}{2}} \times 100$$

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

Modulation Efficiency

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

$$m_a = 1,$$

$$\% \, \eta = \frac{1}{3} \times 100 = 33.3\%$$

33.3% of energy is used and the remaining power is wasted

The unmodulated carrier current to the aerial of a transmitter is 100 A. Determine increase in the currents which will result from the application of 80% modulation.

$$I_T = I_C\sqrt{1+\frac{m^2}{2}}$$

$$I_T = 100\sqrt{1+\frac{(0.8)^2}{2}} = 114.9\ \text{A}$$

due to modulation

= 114.9 - 100 = 14.9 Amp. **Ans.**

An AM transmitter has a carrier power of 30 W. The percentage of modulation is 85 percent. Calculate (a) the total power and (b) the power in one sideband.

a. $P_T = P_c\left(1 + \frac{m^2}{2}\right) = 30\left[1 + \frac{(0.85)^2}{2}\right] = 30\left(1 + \frac{0.7225}{2}\right)$

$P_T = 30(1.36125) = 40.8 \text{ W}$

b. $P_{\text{SB}} \text{ (both)} = P_T - P_c = 40.8 - 30 = 10.8 \text{ W}$

$P_{\text{SB}} \text{ (one)} = \frac{P_{\text{SB}}}{2} = \frac{10.8}{2} = 5.4 \text{ W}$

An antenna has an impedance of 40 Ohm. An unmodulated AM signal produces a current of 4.8 A. The modulation is 90 percent. Calculate

(a) the carrier power,

(b) the total power, and

(c) the sideband power.

a. $P_c = I^2R = (4.8)^2(40) = (23.04)(40) = 921.6 \text{ W}$

b. $I_T = I_c\sqrt{1 + \dfrac{m^2}{2}} = 4.8\sqrt{1 + \dfrac{(0.9)^2}{2}} = 4.8\sqrt{1 + \dfrac{0.81}{2}}$

$I_T = 4.8\sqrt{1.405} = 5.7 \text{ A}$

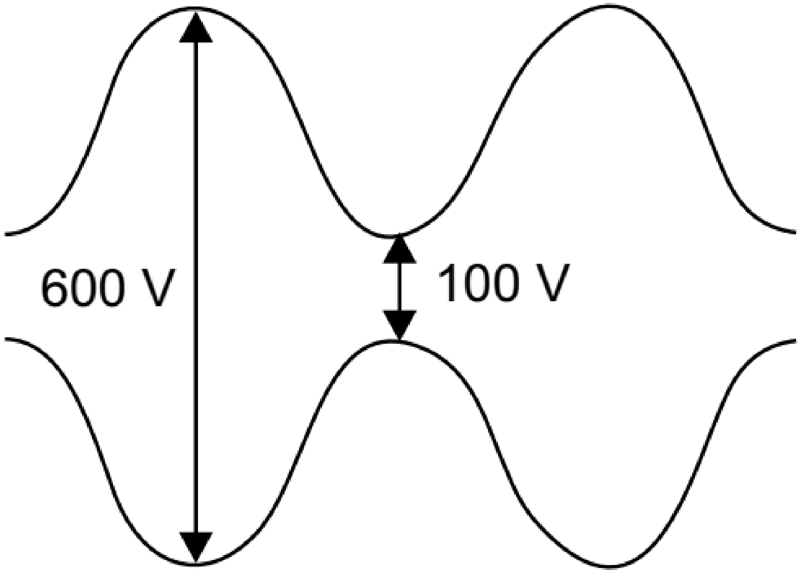
$P_T = I_T{}^2\text{R} = (5.7)^2(40) = 32.49(40) = 1295 \text{ W}$

c. $P_{\text{SB}} = P_T - P_c = 1295 - 921.6 = 373.4 \text{ W (186.7 W each sideband)}$

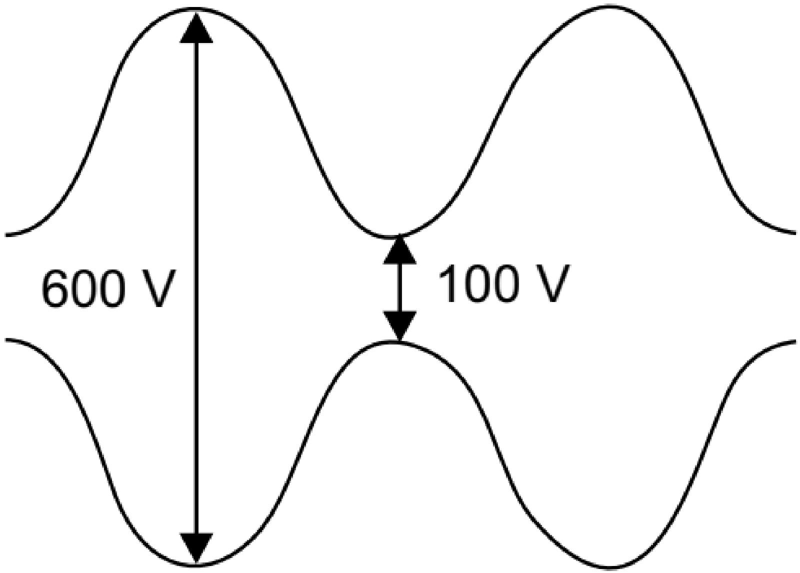
The transmitter experiences an antenna current change from 4.8 A unmodulated to 5.1 A. What is the percentage of modulation?

$$
\begin{aligned}
m &= \sqrt{2\left[\left(\frac{I_T}{I_c}\right)^2 - 1\right]} \\
&= \sqrt{2\left[\left(\frac{5.1}{4.8}\right)^2 - 1\right]} \\
&= \sqrt{2[(1.0625)^2 - 1]} \\
&= \sqrt{2(1.13 - 1)} \\
&= \sqrt{2(0.13)} \\
&= \sqrt{0.26} \\
m &= 0.51
\end{aligned}
$$

Find the depth of modulation



Find the depth of modulation



70%