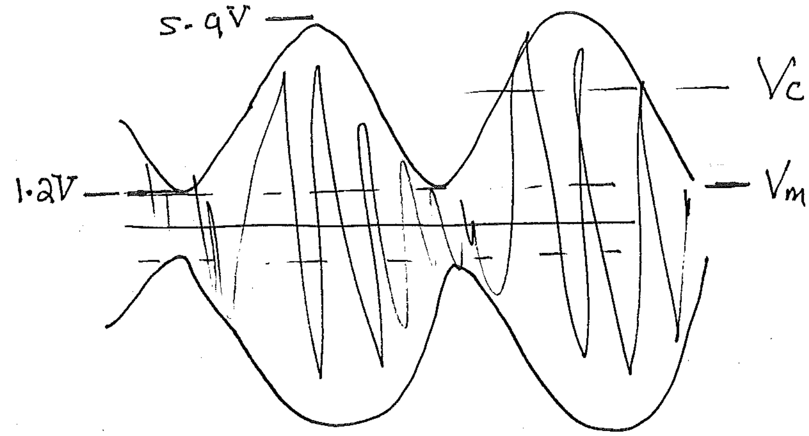
Example Assume this is what you see on the scope:



a) Find m

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{5.9 - 1.2}{5.9 + 1.2} = \underline{0.662}$$

b) Find Vc

$$\frac{V_{max} + V_{min}}{2} = \frac{5.9 + 1.2}{2} = \frac{7.1}{2} = \underline{3.55\,V}$$

c) Find Vm

$$V_m = \frac{V_{max} - V_{min}}{2} = \frac{5.9 - 1.2}{2} = \frac{4.7}{2} = \underline{2.35\,V}$$

note

$$m = \frac{V_m}{V_c} = \frac{2.35}{3.55} = \underline{0.662} \text{ The same as above}$$

= ratio of amp. of modulating signal & the amp. of the carrier signal

$$[V_c + V_m \cos(\omega_m t)] \cos \omega_c t = V_c \left[1 + \boxed{\frac{V_m}{V_c}} \cos \omega_m t\right] \cos(\omega_c t)$$

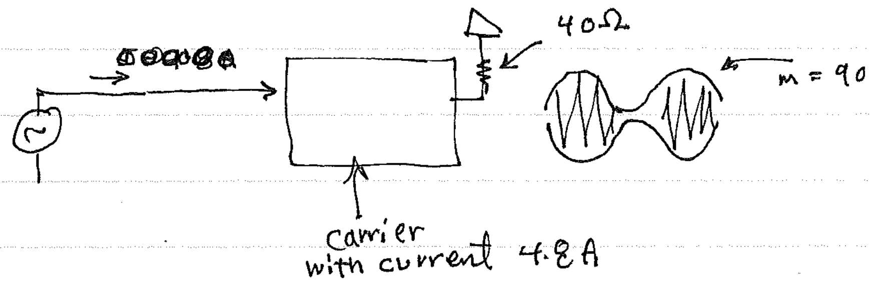
mod. Index

Example

An antenna has an impedance of 40Ω.
Unmodulated AM signal has a current of 4.8A (This carrier)
m = 90 percent

a) Calculate the carrier power
Total power
sideband power

b) If I changes from 4.8 to 5.1 A what happens to m ?



$$P_c = I^2 R = (4.8)^2(40) = 921.6\,W$$

see slides : $I_T = I_c \sqrt{1 + \frac{m^2}{2}} = 5.7\,A$ *

This indicates Antenna exp. current chnge from 4.8 to 5.7 A. ⇒ m = 90 Percent.

$$P_{Total} = I_{Total} \cdot R = (5.7)^2(40) = 1295$$

$$P_{SB} = P_{Total} - P_c = 373.4\,W$$

b) $m = \sqrt{2\left(\frac{I_T}{I_c}\right)^2 - 1} = \sqrt{2\left(\frac{5.1}{4.8}\right)^2 - 1} = 0.51$ (less)

* Remember

$$\frac{P_{Total}}{P_{carrier}} = \frac{I_T^2 R}{I_c^2 R} = 1 + \frac{m^2}{2} = \frac{I_T^2}{I_c^2}$$

~~st~~ SSB

Example P.1

$$x_{AM}(t) = \left[15 + 2\cos 80\pi t + 5\sin(120\pi t)\right]\cos(4000\pi t) \quad \text{(Volt)}$$

a) what kind of AM is this ? conventional AM signal

b) plot the spectrum of $X_{AM}(t)$ that is fft of $x_{AM}(t)$

c) Determine the power in Carrier & sideband spectral components

d) Calcolate the modulation index & the power officiency

e) what is the message signal ? $2\cos 80\pi t + 5\sin(120\pi t)$

f) what is the carrier freq ? 2000 Hz

g) Find the normalized message

Example (Ans.) P.2

$$x_{AM}(t) = 15\cos(4000\pi t) + 2\cos(80\pi t)\cos(4000\pi t) + 5\sin(120\pi t)\cos(4000\pi t)$$

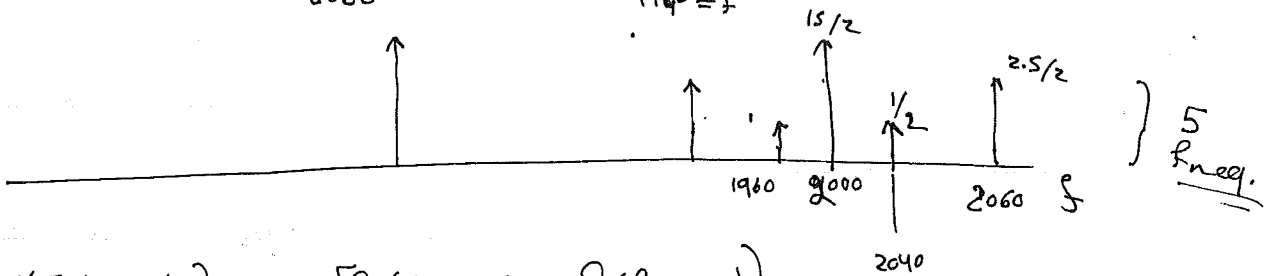
$$= 15\cos(4000\pi t) +$$

$$\cos(4080\pi t) + \cos(3920\pi t) + \quad (1960 = f)$$

$$2.5\sin(4120\pi t) - 2.5\sin(3880\pi t) \quad (2060,\ 1940 = f)$$

(A)

b)



$$\mathcal{F}\{x_{AM}(t)\} = \frac{15}{2}\left[\delta(f-2000) + \delta(f+2000)\right] +$$

$$\frac{1}{2}\left[\delta(f-2040) + \delta(f+2040) + \delta(f-1960) + \delta(f+1960)\right]$$

$$\frac{2.5}{2j}\left[\delta(f-2060) - \delta(f+2060)\right] - \frac{2.5}{2j}\left[\delta(f-1940) - \delta(f+1940)\right]$$

c)

Power in carrier:

$$P_{carrier} = \frac{(15)^2}{T}\int_{-T/2}^{T/2}\cos^2(4000\pi t) = \frac{(15)^2}{2} = \boxed{112.5\ W}$$

Power in sideband (see (A) above)

$$= \frac{(1)^2}{2} + \frac{(1)^2}{2} + \frac{(2.5)^2}{2} + \frac{(-2.5)^2}{2} = 0.5 + 0.5 + 6.25 =$$

$$= \boxed{7.25\ W} \quad \Rightarrow \text{Total power} = 2P_{sideband} + P_{carrier}$$

→

Example P.3

modulation index: $A_c \equiv$ Amp. of carrier

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

To find A_{max} we can plot the modulated signal X_{AM}
In that case we can find $A_{max} - A_c$
If we plot the message signal, we can find A_{max}

$$\Rightarrow \quad |A_{max} - A_c| = 6.1178 \rightarrow \quad m = \frac{6.1178}{15} = 0.408$$

g) message signal is $\quad 2\cos(80\pi t) + 5\sin(120\pi t)$

normalized message signal is

$$m\Big[\underbrace{x \cos(80\pi t) + y \sin(120\pi t)}_{\text{normalized message}}\Big]$$

we know $\quad m \cdot x = \frac{2}{15} \rightarrow x = (2/15)/m = \underline{0.327}$

$m \cdot y = 5/15 \rightarrow y \ (5/15)/m = \underline{0.817}$

Power in the normalized message

$$\frac{(0.327)^2}{2} + \frac{(0.817)^2}{2} = 0.387 \text{ W}$$

Power Efficiency

$$\eta = \frac{\text{signal power}}{\text{Total power}} = \frac{m^2 \cdot P_{ns}}{1 + m^2 P_{ns}}$$ (P_{ns} = normalized power of signal)

$$= \frac{(0.408)^2 \ 0.387}{1 + (0.408)^2 0.387} = \underline{6.65\%}$$