Amplitude Modulation - 3

- AM Spectrum
- Power and Bandwidth of AM Signal
- Multiple Tone AM

$x_m(t)$, $x_c(t)$, $x_{AM}(t)$

$A_m \cos W_m t$ $A_c \cos W_c t$ $A_c [1 + m \cos W_m t] \cos W_c t$

$x_m(t) \longleftrightarrow X_m(f)$, $x_c(t) \overset{F}{\longleftrightarrow} X_c(f)$, $x_{Am}(t) \longrightarrow X_{AM}(f)$

$$x_{Am}(t) = \underbrace{A_c \cos W_c t}_{x_1(t)} + \underbrace{x_m(t) \cos w_c t}_{x_2(t)}$$

$$X_{Am}(f) = X_1(f) + X_2(f)$$

$\rightarrow$ $x_m(t) e^{jw_c t} \longleftrightarrow X(w_c - w_m)$

$\rightarrow$ $x_m(t) e^{-jw_c t} \longleftrightarrow X(w_c + w_m)$

Euler Equation: $\cos wt = \frac{1}{2}\left[e^{jwt} + e^{-jwt}\right]$

$$x_{Am}(t) = A_c \cos w_c t + x_m(t) \cos w_c t$$

$= A \ldots \qquad x \ldots (e^{jw_c t} \quad e^{-jw_c t})$

$x_{AM}(t) = A_c \cos \ldots + x_m(t) \cos \ldots$

$$= \frac{A_c}{2}\left(e^{j\omega_c t} + e^{-j\omega_c t}\right) + \frac{x_m(t)}{2}\left(e^{j\omega_c t} + e^{-j\omega_c t}\right)$$

x_1 $\qquad$ x_2

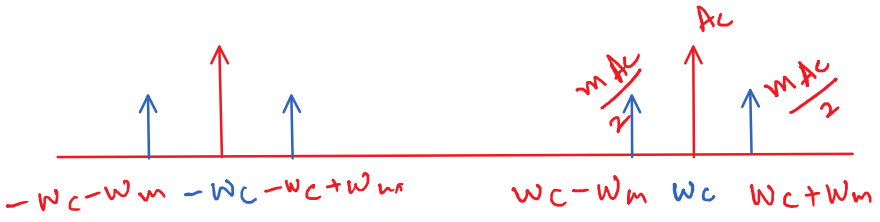
$$= \frac{1}{2} x_m(t)\, e^{j\omega_c t} + \frac{1}{2} x_m(t)\, e^{-j\omega_c t}$$

$$X_2(f) = \frac{1}{2} X(\omega_c - \omega_m) + \frac{1}{2} X(\omega_c + \omega_m)$$

$$X_1(f) = \pi A \left(\delta(\omega - \omega_c) + \delta(\omega + \omega_c)\right)$$

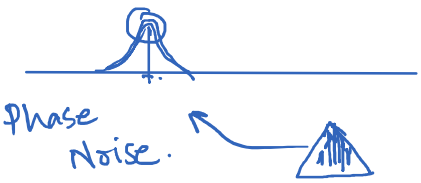
$$X_{AM}(f) = \pi A\left[\left(\delta(\omega - \omega_c) + \delta(\omega + \omega_c)\right) + \frac{1}{2}\left(X(\omega_c - \omega_m) + X(\omega_c + \omega_m)\right)\right]$$

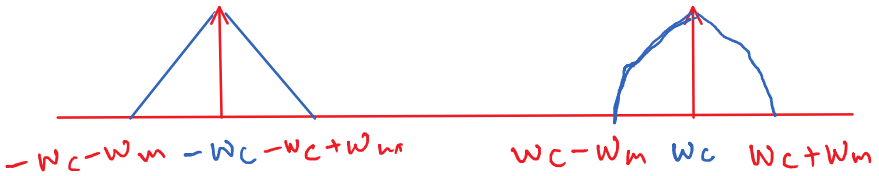
ω_c , $\omega_c + \omega_m$, $\omega_c - \omega_m$

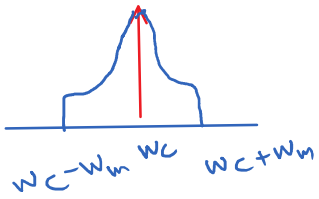


$\delta(t) \longrightarrow \delta(t)$

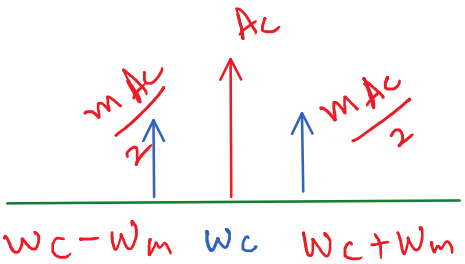
$\delta(f)$







Power and Bandwidth of AM Signal



$$x_{AM}(t) = A_c \cos w_c t + \frac{mA_c}{2}\left[\cos(w_c - w_m) + \cos(w_c + w_m)\right]$$

$$X_{AM}(f) = \pi A\left(\delta(w-w_c)+\delta(w+w_c)\right) + \frac{1}{2}\left[X(w_c-w_m) + X(w_c+w_m)\right]$$

w_c , w_c+w_m , w_c-w_m .

$$P_t = P_{LSB} + P_{USB} + P_c$$

$x_c = A_c \cos w_c t$ → V_c

$x_m = A_m \cos w_m t$ → V_m .

$V_{c,RMS} = V_c/\sqrt{2}$: $P_c = V^2/R \Rightarrow V_c^2/\sqrt{2}^2 \cdot R = V_c^2/2R$

$V_{m,RMS} = V_m/\sqrt{2}$: $P_m = V_m^2/2R$. $= P_{LSB} = P_{USB}$

$= \left(\frac{mV_c}{2}\right)^2 / 2R = \frac{m^2 V_c^2}{4 \cdot 2R}$

$= m^2 \cdot P_c$

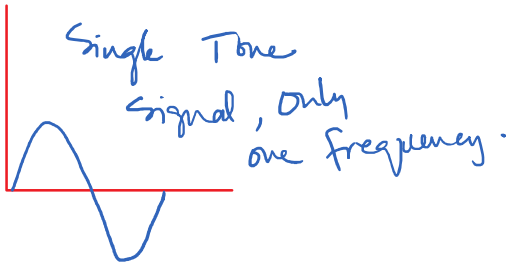
$$P_t = P_c\left(1 + \frac{m^2}{2}\right) \quad \overline{4}$$

Bandwidth = $f_{high} - f_{low}$

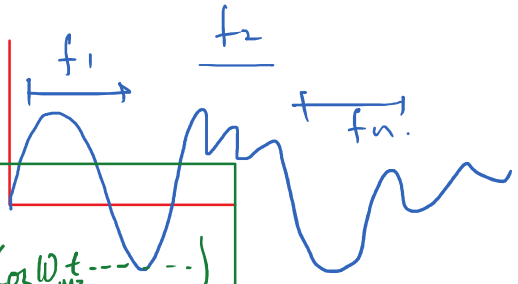
$$B = (\omega_c + \omega_m) - (\omega_c - \omega_m)$$
$$B = 2\omega_m$$

Multi - tone AM Signal

$x_m(t) = A_m \cos \omega_m t$ →

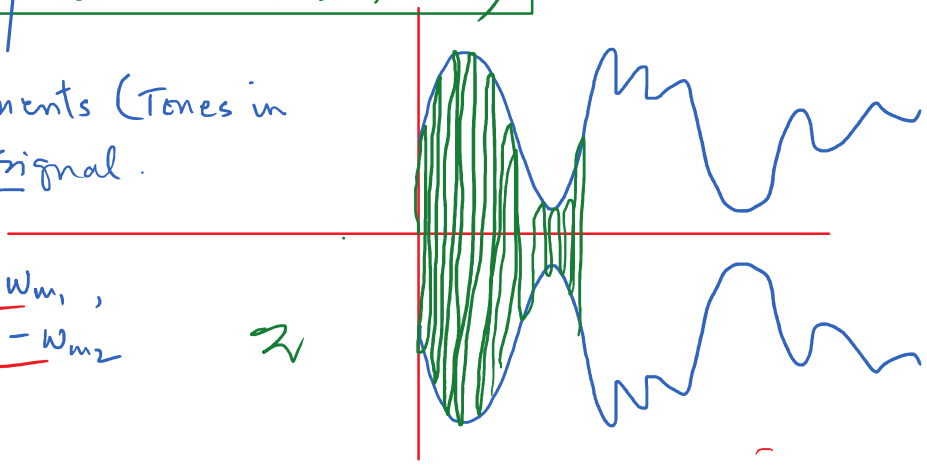


$x_m(t) = A_{m_1} \cos \omega_{m_1} t + A_{m_2} \cos \omega_{m_2} t + \cdots$



$$x_{AM}(t) = A_c \cos \omega_c t \left(1 + m_1 \cos \omega_{m_1} t + m_2 \cos \omega_{m_2} t + m_3 \cos \omega_{m_3} t \cdots\right)$$

Frequency Components (Tones in Multitone AM signal.



ω_c, $\omega_c + \omega_{m_1}$, $\omega_c - \omega_{m_1}$,
$\omega_c + \omega_{m_2}$, $\omega_c - \omega_{m_2}$ 2