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Amplitude Modulation (AM)

$$e(t) = [E_{c_{max}} + e_m(t)] \cos(2\pi f_c t + \phi)$$

envelope of wave

$E_c \rightarrow$ Amplitude Of Carrier

$e_m(t) \rightarrow e_m(t) = E_m \cos(2\pi f_m t + \phi)$

$$A_{max} = A_c + A_m$$

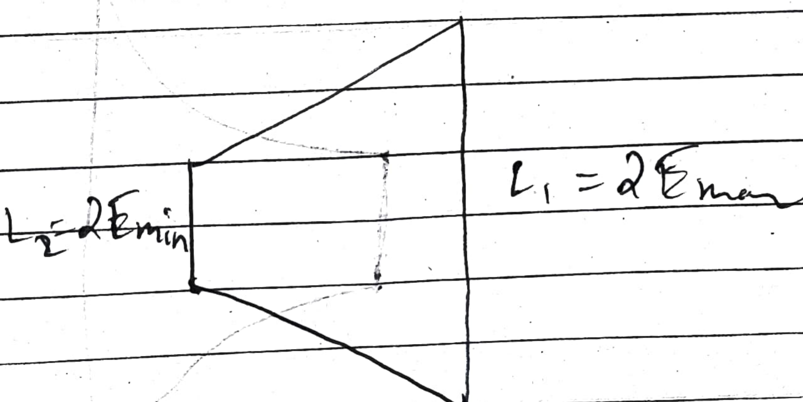
$$A_{min} = A_c - A_m$$

$$\mu = \frac{A_m}{A_c}$$

modulation index

$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{L_1 - L_2}{L_1 + L_2}$$

(a) $L_2 = 2E_{min}$, $L_1 = 2E_{max}$



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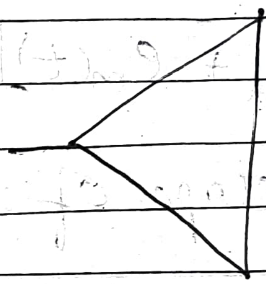
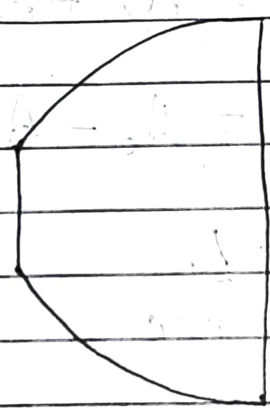
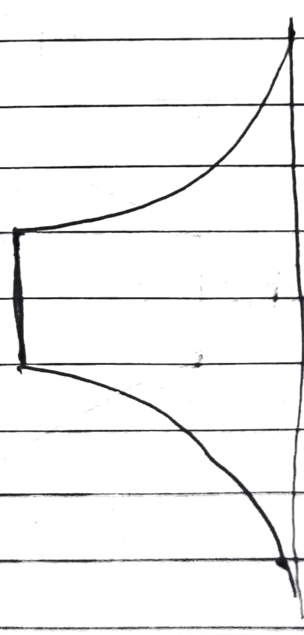
(b) For m > 1



(c) Envelope distortion insufficient RF drive modulator.



(d) Envelope distortion resulting from non-linearities in the modulator.



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$$e(t) = E_{cmax}(1 + m\cos 2\pi f_m t)\cos 2\pi f_c t$$

$$= E_{cmax}\cos 2\pi f_c t + \frac{m E_{cmax}}{2}\cos 2\pi(f_c - f_m)t$$

$$+ \frac{m}{2}E_{cmax}\cos 2\pi(f_c + f_m)t$$

Band width $= f_{USB} - f_{LSB}$

$f_{USB} = f_c + f_m$

$f_{LSB} = f_c - f_m$

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

P_{total} ↑ Power

↑ Carrier

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

$$- \frac{V_m}{2}\cos 2\pi t(f_c + f_m)$$

Finally, ∴

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

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$$P_T = \frac{E^2}{R}$$

$$\frac{E_c^2}{R} = P_c$$

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

$$\therefore E = E_c\sqrt{1+\frac{m^2}{2}}$$

$$I = I_c\sqrt{1+\frac{m^2}{2}}$$

$$\therefore m = \sqrt{\left(2\left(\frac{I}{I_c}\right)^2-1\right)}$$

$$P_{USB} = \frac{A_m^2 A_c^2}{8R}$$

$$P_t = \frac{A_m^2 A_c^2}{4R}$$

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* Single side band suppressed signal
SSBSC

$$m(t) = A_m \cos(2\pi f_m t)$$
$$c(t) = A_c \cos(2\pi f_c t)$$

$$s(t) = \frac{A_m A_c}{2} \left[2\pi(f_c + f_m)t\right] \quad \text{USB}$$

$$s(t) = \frac{A_m A_c}{2} \left[2\pi(f_c - f_m)t\right] \quad \text{LSB}$$

Bandwidth = f_m

$$P_{USB} = \frac{A_m^2 A_c^2}{8R}$$

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

$$P_{LSB} = \frac{A_m^2 A_c^2}{8R}$$

Eq^n of FM Wave

$$s(t) = A_c \cos\left(2\pi f_c t + 2\pi K_f \int m(t)\,dt\right)$$

$$s(t) = A_c \cos\left(2\pi f_c t + \beta \sin(2\pi f_m t)\right)$$

$$\beta = \text{modulation Index} = \frac{\Delta f}{f_m} = \frac{K_f A_m}{f_m}$$

Phase Modulation (PM)

$$\phi_i = K_p m(t)$$

Instantaneous phase

Phase Sensitivity

message signal

Eqn of PM wave -

$$s(t) = A_c \cos(2\pi f_c t + K_p m(t))$$

$$s(t) = A_c \cos(2\pi f_c t + \beta \cos(2\pi f_m t))$$

β = modulation Index $= \Delta\phi = K_p A_m$

phase deviation

* Digital phase Modulation

$$e(t) = A\,p(t)\,E_{cmax} \cos w_c t$$

$p(t) = +V \quad e(t) = AVE_{cmax} \cos w_c t$

$p(t) = -V \quad e(t) = AVE_{cmax} \cos(w_c t + 180^\circ)$

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* ASK (Amplitude Shift Keying Modulation

$v_m = V_m$ when symbol is 1

$v_m = 0$ when symbol is 0.

Let $v_c = V_c \cos w_c t$

$v_{ASK} = V_m V_c \cos w_c t$ when 1

$= 0$ when 0

Demodulation of ASK signal

1. Coherent ASK Detector

Carrier at the receiver:

$v_c' = V_c' \cos w_c t$

Output of multiplier:

$s_1 = v_{ASK} v_c' = \frac{V_m V_c V_c'}{2}(1 + \cos 2w_c t)$

when 1

$= 0$ when 0

∴ filter output is

$s_2 \propto V_m$

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$$BW = \frac{R_b}{\eta}$$

$\eta \rightarrow$ bit/sample

$R_b \rightarrow$ bits/sec

* FSK (Frequency Shift Keying Modulation)

Let two carriers:

$$v_{c_1} = V_c \cos w_{c_1} t$$

$$v_{c_2} = V_c \cos w_{c_2} t$$

FSK Signal

$$v_{FSK} = V_m V_c \cos w_{c_1} t \quad \text{when } 1$$

$$= V_m V_c \cos w_{c_2} t \quad \text{when } 0$$

Demodulation

Output of multiplier upper channel freq ω_{c1} $\rightarrow$ $S_{1u} = V_{FSK} V'_{c_1} = \frac{V_m V_c V'_c}{2} (1 + \cos 2w_{c_1} t)$

Freq c_2 $\rightarrow$ $S_{1u} = \frac{V_m V_c V'_c}{2} [\cos(w_{c_1} - w_{c_2})t + \cos(w_{c_1} + w_{c_2})t]$

$$S_{2u} = \frac{V_m V_c V'_c}{2}.$$

low pass filter in upper channel having freq. c_1

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$S_{2u} = 0$ freq c_2

$\therefore$ filter output in upper channel
$S_{2u} \propto V_m$

during the interval having freq. ω_{c_1}
~~S_{2u}~~

ω_{c_2} $S_{2u} \propto 0$

* PSK (Phase Shift Keying Modulation)

$v_{c_1} = V_c \cos \omega_c t$

$v_{c_2} = -V_c \cos \omega_c t$

$\therefore$ $V_{psk} = V_m V_c \cos \omega_c t$ when 1
$= -V_m V_c \cos \omega_c t$ when 0

Demodulation

$S_{14} = V_{psk} V'_{c_1} = \frac{V_m V_c V'_c}{2} (1 + \cos 2\omega_c t$

$v'_{c_1} = V'_c \cos \omega_c t$
$v'_{c_2} = -V'_c \cos \omega_c t$

multiplier 0°

$S_{14} = V_{psk} V'_{c_1} = \frac{V_m V_c V'_c}{2} (1 + \cos 2\omega_c t)$

multiplier 180° $S_{14} = \frac{V_m V_c V'_c}{2} (1 + \cos 2\omega_c t)$

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$$S_{24} = \frac{V_m V_c V_c'}{2}$$ 0° phase shift low pass filter

$$S_{24} = \frac{-V_m V_c V_c'}{2}$$ 180° phase shift low pass filter