4. What are the Basic Types of Analogue Modulation Methods ?

Consider the carrier signal below:

$$\mathbf{s_c(t) = A_c(t)\cos(2\pi f_c t + \theta)}$$

1. Changing of the carrier amplitude $\mathbf{A_c(t)}$ produces

_____ ***Amplitude Modulation signal*** **(AM)**

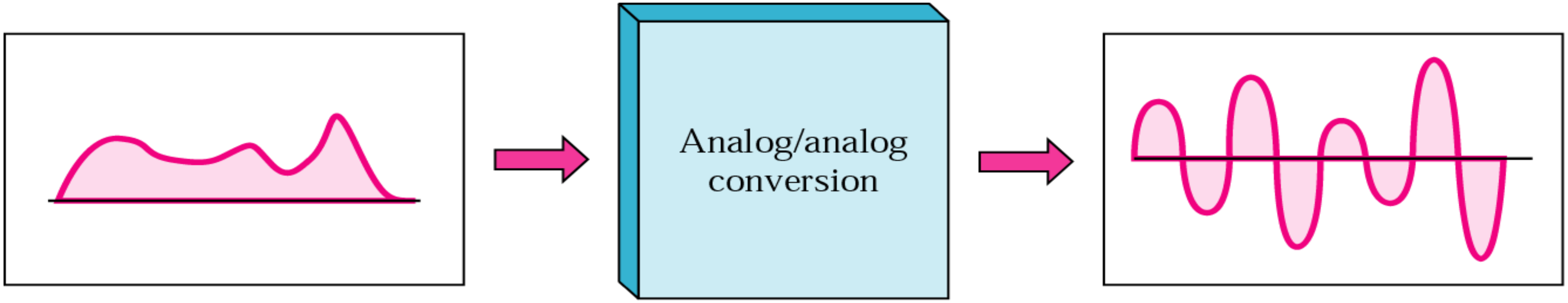
2. Changing of the carrier frequency $\mathbf{f_c}$ produces

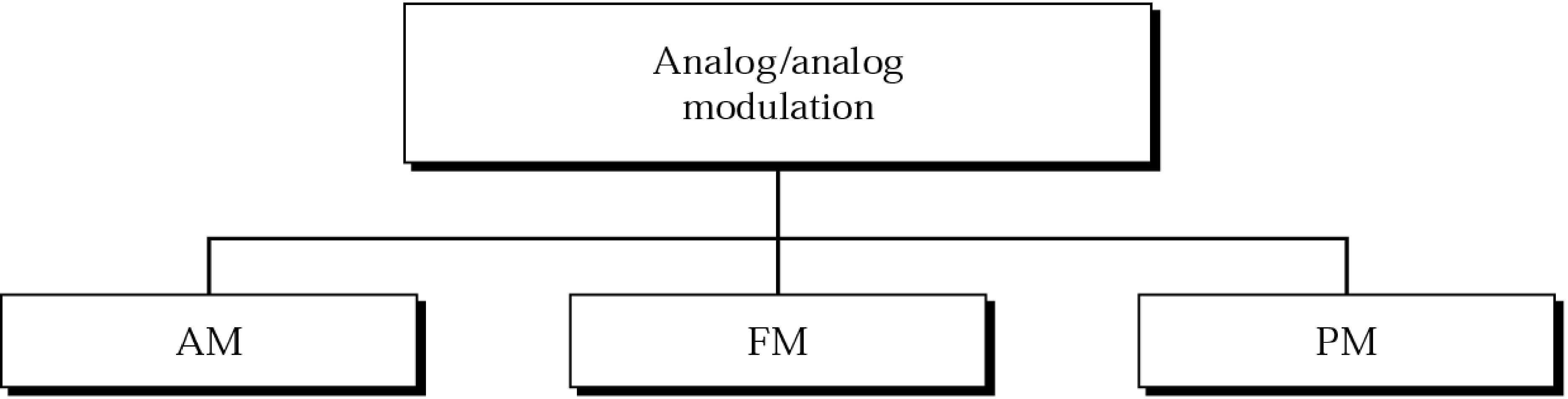
_____ ***Frequency Modulation signal*** **(FM)**

3. Changing of the carrier phase $\boldsymbol{\theta}$ produces

Phase Modulation signal **(PM)**

Analogue Modulation Methods



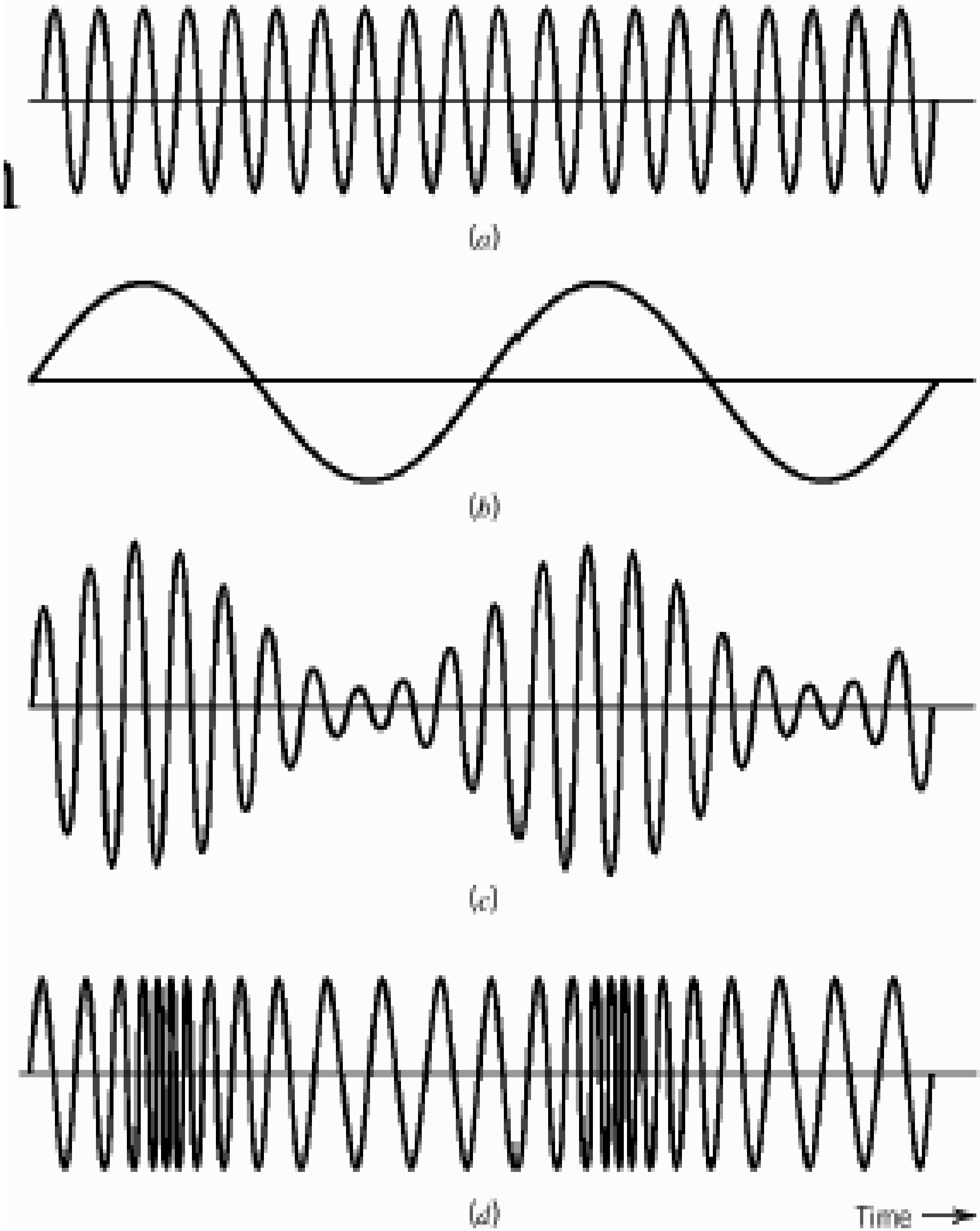


Sinusoidal carrier

Baseband signal

Amplitude Modulation

Frequency Modulation



5. What are the different Forms of Amplitude Modulation ?

5. What are the different Forms of Amplitude Modulation ?

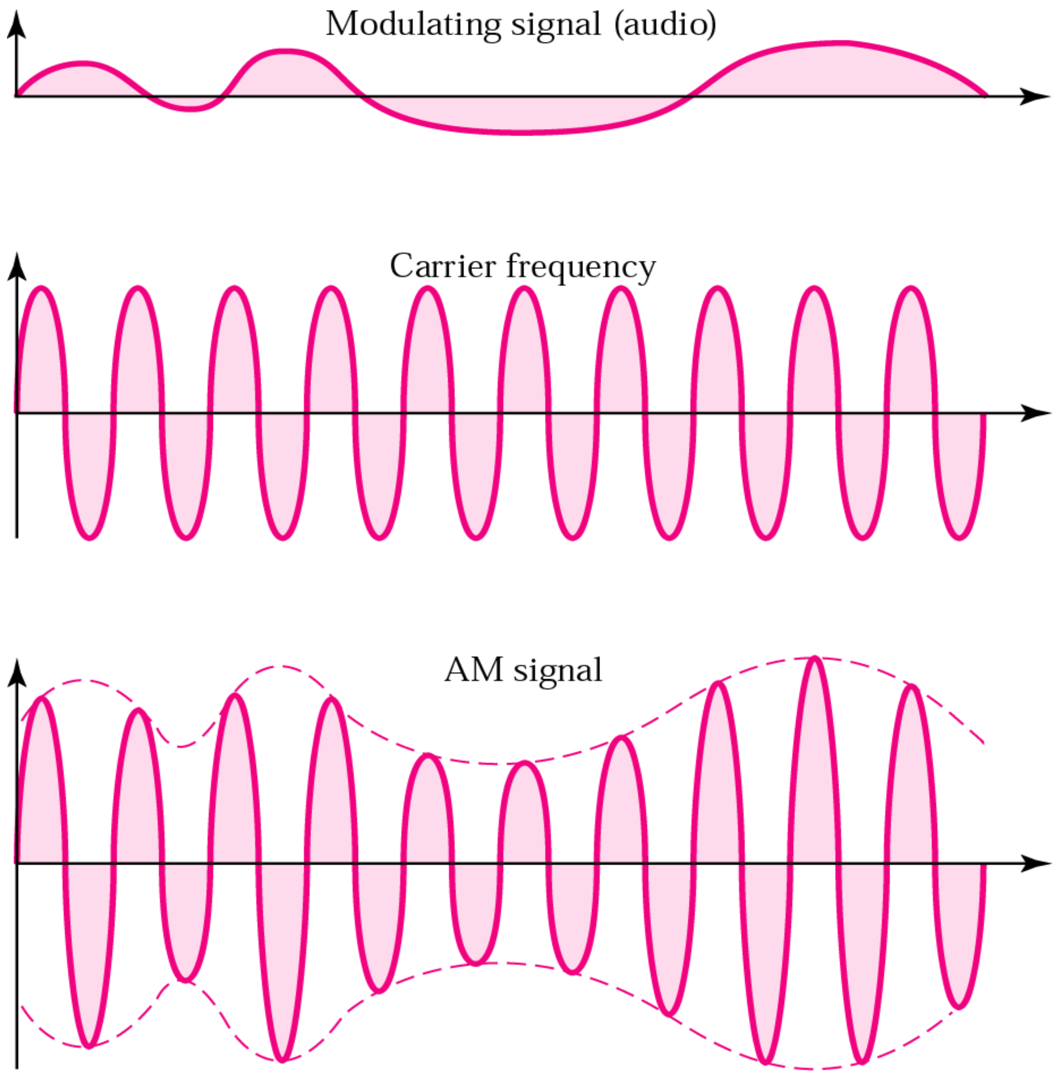
1. Conventional Amplitude Modulation **(DSB-LC)** *(Alternatively known as Full AM or Double Sideband with Large carrier (DSB-LC) modulation*

2. Double Side Band Suppressed Carrier **(DSB-SC)** modulation

3. Single Sideband **(SSB)** modulation

4. Vestigial Sideband **(VSB)** modulation

Conventional Amplitude Modulation (Full AM)



6. Derive the Frequency Spectrum for Full-AM Modulation (DSB-LC)

6. Derive the Frequency Spectrum for Full-AM Modulation (DSB-LC)

1 The carrier signal is

$$s_c(t) = A_c \cos(\omega_c t) \quad \text{where } \omega_c = 2\pi f_c$$

2 In the same way, a modulating signal (information signal) can also be expressed as

$$s_m(t) = A_m \cos \omega_m t$$

3 The amplitude-modulated wave can be expressed as

$$s(t) = \left[A_c + s_m(t)\right]\cos(\omega_c t)$$

4 By substitution

$$s(t) = \left[A_c + A_m \cos(\omega_m t)\right]\cos(\omega_c t)$$

5 The modulation index.

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

6 Therefore The full AM signal may be written as

$$s(t) = A_c(1 + m\cos(\omega_m t))\cos(\omega_c t)$$

$$\cos A \cos B = 1/2[\cos(A+B) + \cos(A-B)]$$

$$s(t) = A_c(\cos\omega_c t) + \frac{mA_c}{2}\cos(\omega_c + \omega_m)t + \frac{mA_c}{2}\cos(\omega_c - \omega_m)t$$

7. Draw the Frequency Spectrum of the above AM signal and calculate the Bandwidth

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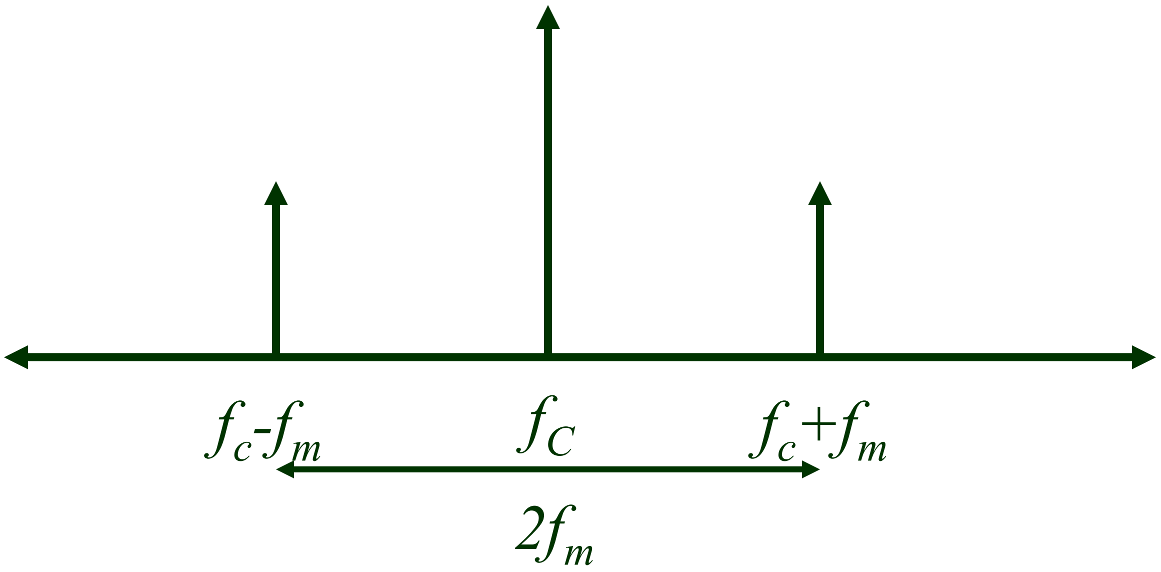
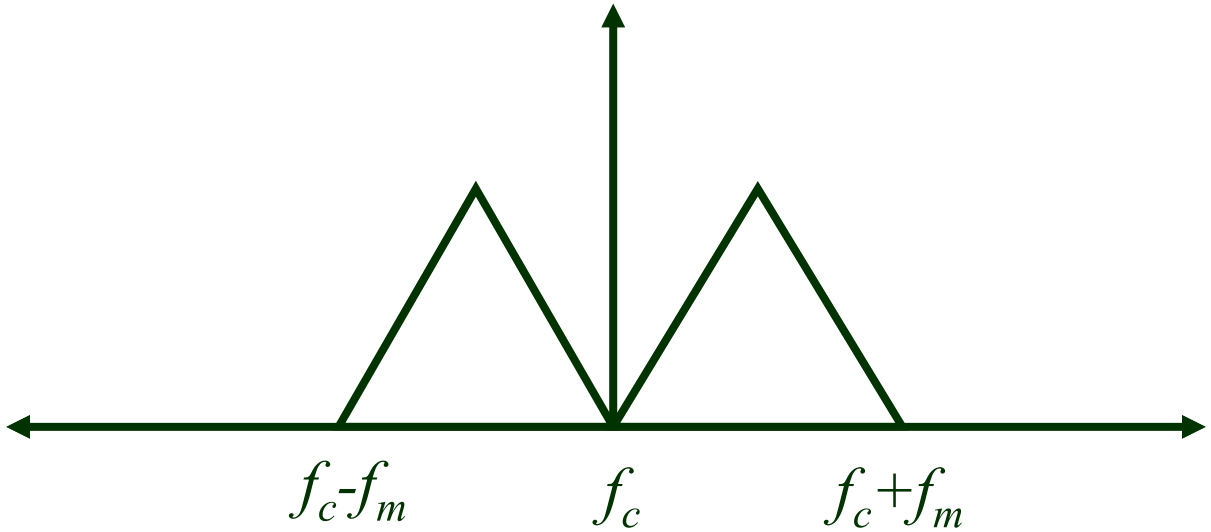


8. Draw Frequency Spectrum for a complex input signal with AM

8. Draw Frequency Spectrum for a complex input signal with AM



Frequency Spectrum of an AM signal

The frequency spectrum of AM waveform contains three parts:

1. A component at the carrier frequency f_c
2. An upper side band (USB), whose highest frequency component is at f_c+f_m
3. A lower side band (LSB), whose highest frequency component is at f_c-f_m

The bandwidth of the modulated waveform is twice *the information signal bandwidth.*

- Because of the two side bands in the frequency spectrum its often called Double Sideband with Large Carrier.(DSB-LC)

- The information in the base band (information) signal is duplicated in the **LSB** and **USB** and the **carrier** conveys **no** information.

Example

We have an audio signal with a bandwidth of 5 KHz. What is the bandwidth needed if we modulate the signal using AM?

Example

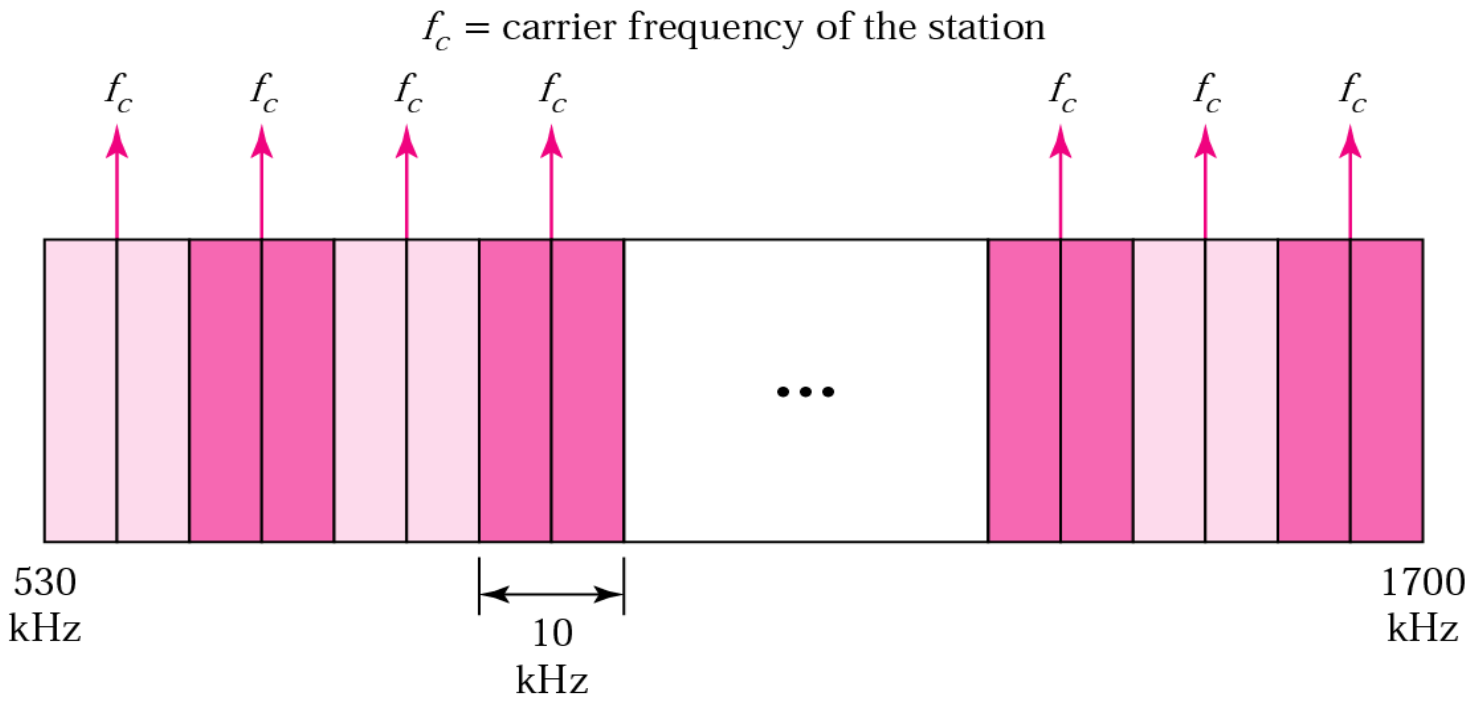
We have an audio signal with a bandwidth of 5 KHz. What is the bandwidth needed if we modulate the signal using AM?

Solution

An AM signal requires twice the bandwidth of the original signal:

$$BW = 2 \times 5 \text{ KHz} = 10 \text{ KHz}$$

AM Radio Band



9. What is the significance of modulation index ?

- **m** is merely defined as a parameter, which determines the amount of modulation.

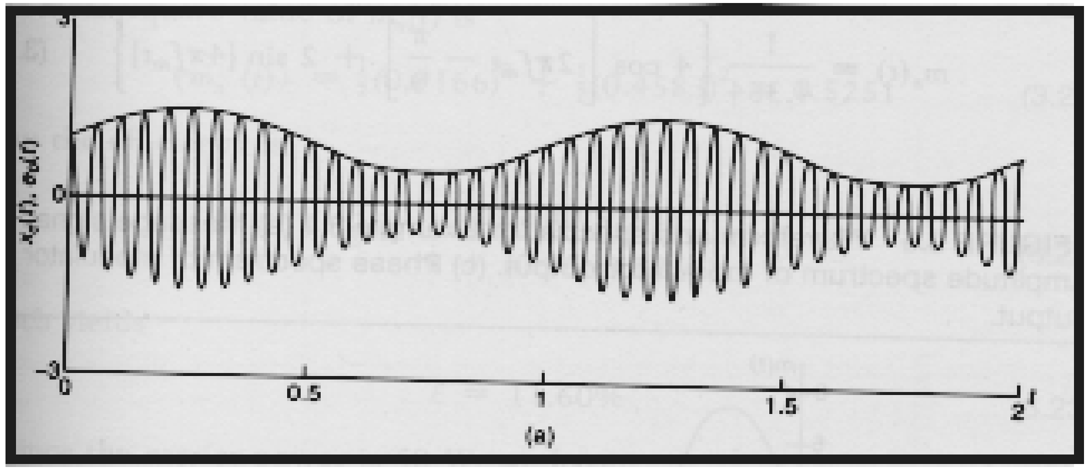
- What is the degree of modulation required to establish a desirable AM communication link?

Answer is to maintain $m<1.0$ ($m<100\%$).

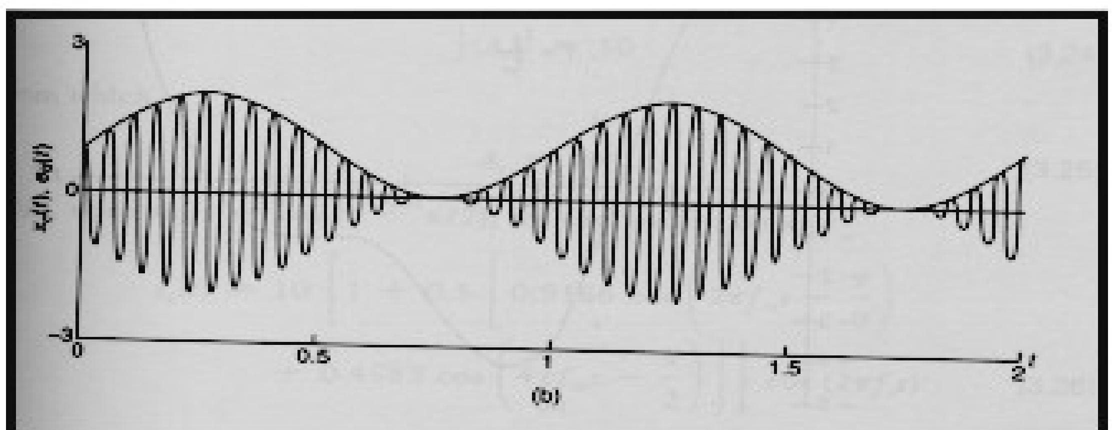
- This is important for successful retrieval of the original transmitted information at the receiver end.

9. What is the significance of modulation index ?

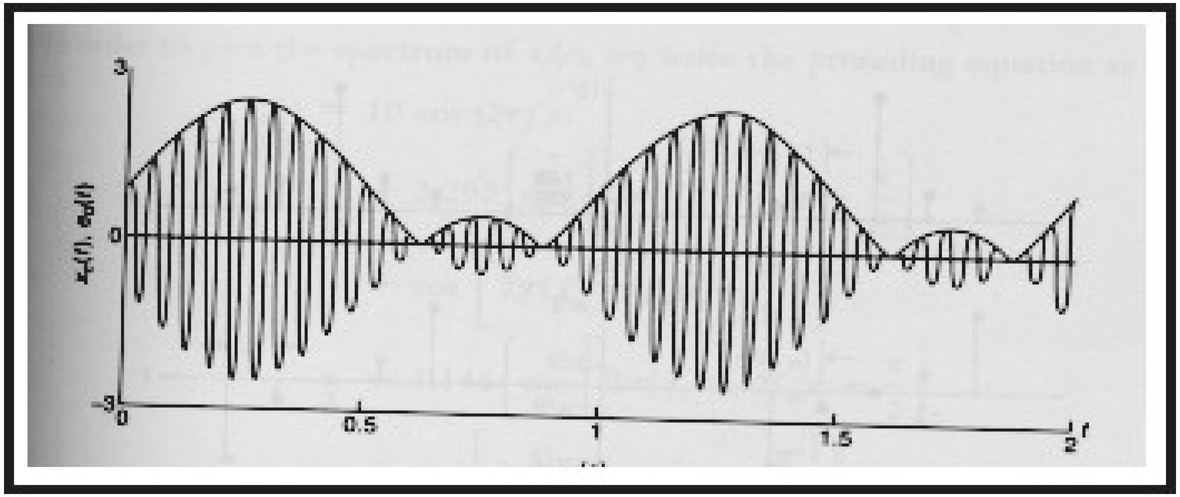
Modulation carrier and envelope detector outputs for various values of the modulation index



$\mu = 0.5$



$\mu = 1.0$



$\mu = 1.5$

- If the amplitude of the modulating signal is higher than the carrier amplitude, which in turn implies the modulation index $m \geq 1.0(100\%)$ This will cause severe distortion to the modulated signal.

10. Calculate the power efficiency of AM signals