Angle Modulation

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Angle Modulation: Introduction

Angle Modulation is the process in which the frequency or the phase of the carrier signal varies according to the message signal.

Angle modulation are two types:

- Frequency Modulation (FM)
- Phase Modulation (PM)

It is used for:

- Commercial radio broadcasting
- Television sound transmission
- Two way mobile radio
- Cellular radio
- Microwave and satellite communication system

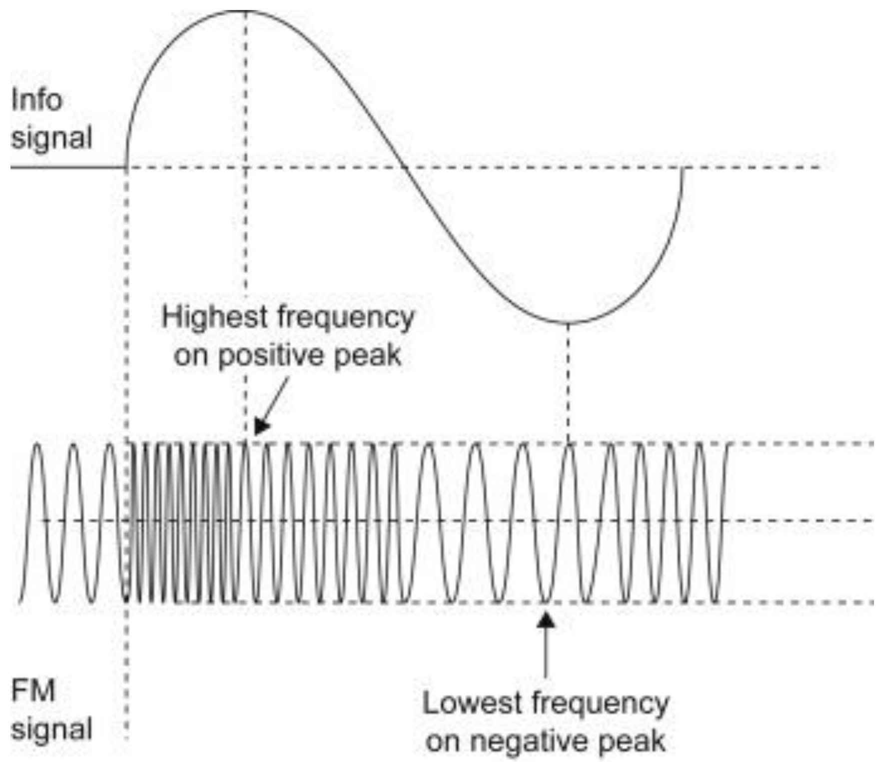
Angle Modulation: Introduction

Features of angle modulation:

- It can provide a better discrimination (robustness) against noise and interference than AM
- This improvement is achieved at the expense of increased transmission bandwidth
- In case of angle modulation, channel bandwidth may be exchanged for improved noise performance
- Such trade- off is not possible with AM

Frequency Modulation

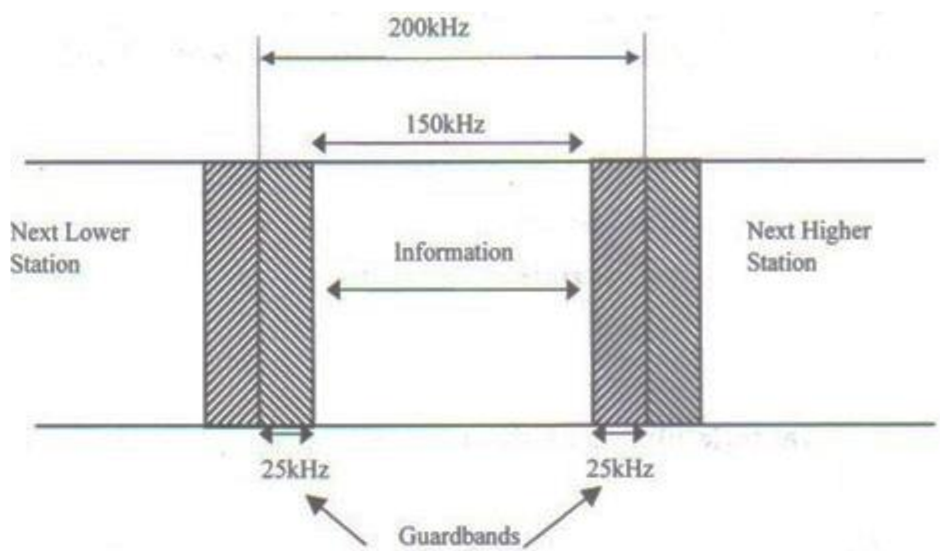
- In FM the carrier amplitude remains constant& the carrier frequency varies with the amplitude of modulating signal.
- The amount of change in carrier frequency produced by the modulating signal is known as **frequency deviation.**



Frequency Modulation

Important features of FM:

- The frequency varies.
- The rate of change of carrier frequency changes is the same as the frequency of the information signal
- The amount of carrier frequency changes is proportional to the amplitude of the information signal.
- The amplitude is constant.



FM frequency allocation by FCC

Analysis of FM

Mathematical analysis:

Let message signal $v_m(t) = V_m cos\omega_m t$

And carrier signal, $v_c(t) = V_c cos[\omega_c t + \theta]$

In FM, frequency changes with the change of the amplitude of the information signal. So the instantaneous frequency of the FM wave is

$$\omega_i = \omega_c + K v_m(t)$$

$$\omega_i = \omega_c + K V_m cos\omega_m t$$

Where, k is the constant of proportionality.

Thus, we get the FM wave as; $v_{FM}(t) = V_c cos[\omega_c t + \theta]$

As, we know $\theta(t) = \int_{-\infty}^{t} \omega_i(t) dt$, $v_{FM}(t) = V_c cos[\omega_c t + \frac{KV_m}{\omega_m} sin\omega_m t]$

$$v_{FM}(t) = V_c cos[\omega_c t + m_f sin\omega_m t]$$

Where, modulation index for FM is given by, $m_f = \frac{KV_m}{\omega_m}$

Analysis of FM

Frequency deviation: ∆f is the relative placement of carrier frequency (Hz) with respect to is unmodulated value. Given as:

$$\omega_{max} = \omega_c + KV_m$$

$$\omega_{max} = \omega_c - KV_m$$

$$\omega_d = \omega_{max} - \omega_c = \omega_c - \omega_{min} = KV_m$$

$$\Delta f = \frac{\omega_d}{2\pi} = \frac{KV_m}{2\pi}$$

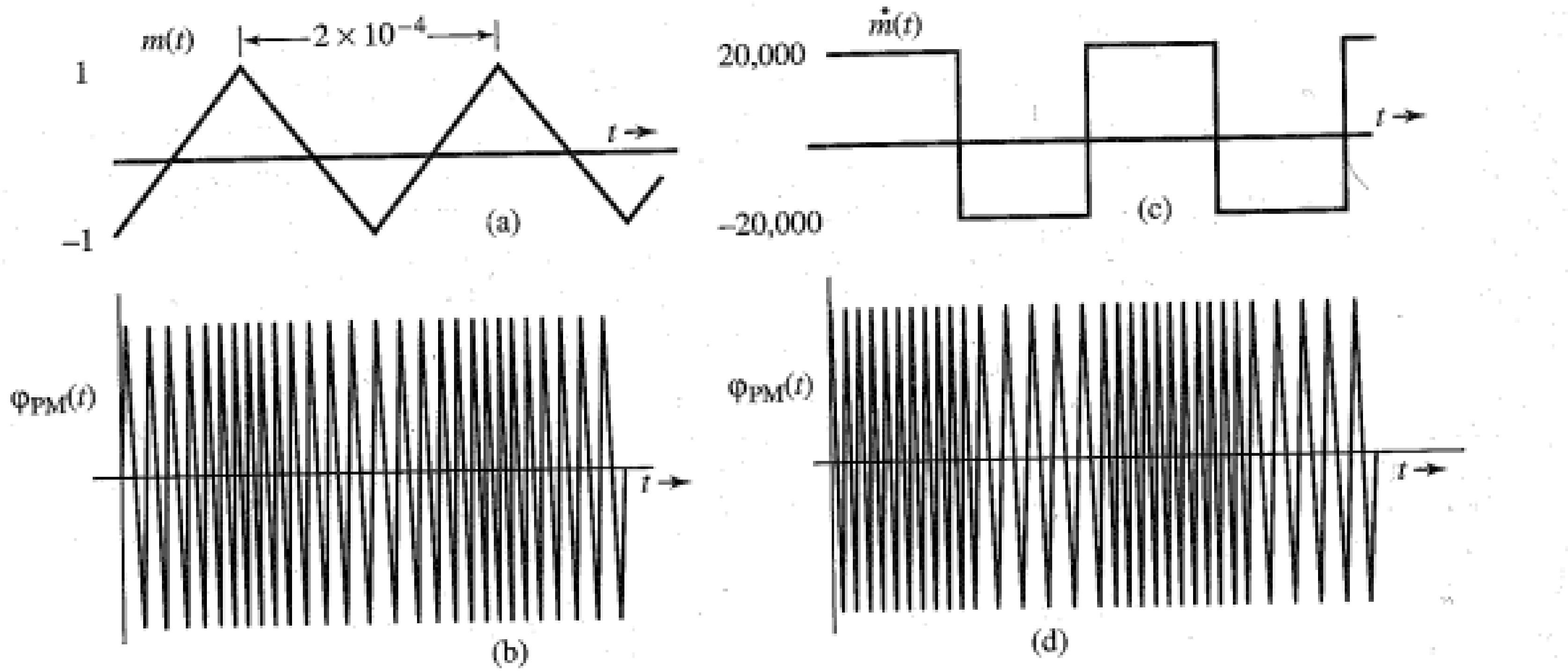
$$\Delta f \propto V_m$$

$$m_f = \frac{\Delta f}{f_m}$$

Example of FM

Determine the peak frequency deviation(Δf) and modulation index (m_f) for an FM modulator with a deviation sensitivity K=5KHz and modulating signal, $v_m(t) = 2\cos(2\pi 2000t)$

EXAMPLE 5.1 Sketch FM and PM waves for the modulating signal $m(t)$ shown in Fig. 5.4a. The constants k_f and k_p are $2\pi \times 10^5$ and 10π, respectively, and the carrier frequency f_c is 100 MHz.



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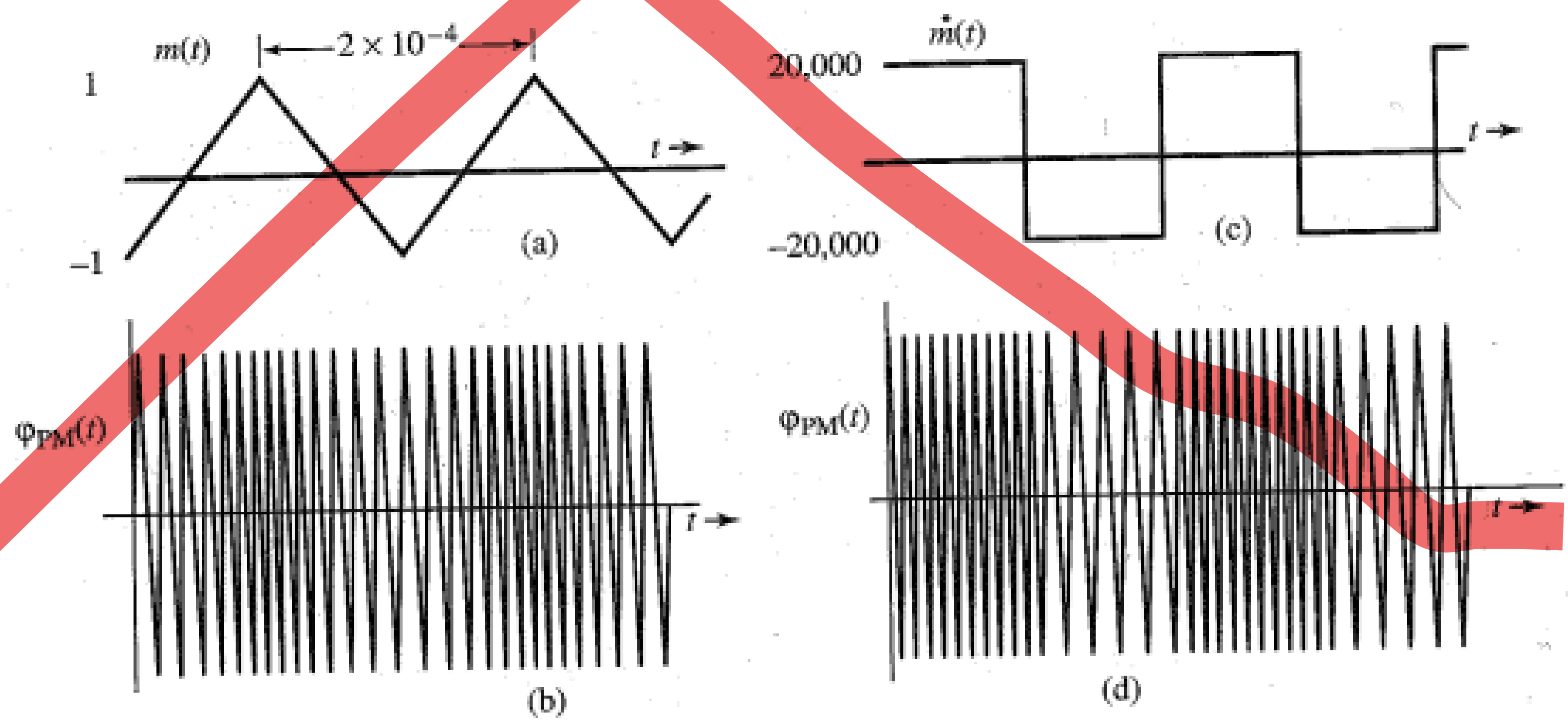

FM Bandwidth

- Theoretically, the generation and transmission of FM requires infinite bandwidth. Practically, FM system have finite bandwidth and they perform well.
- The value of modulation index determine the number of sidebands that have the significant relative amplitudes
- If n is the number of sideband pairs, and line of frequency spectrum are spaced by f_m, thus, the bandwidth is

$$B_{fm} = 2nf_m \text{ for n} \geq 1$$

Assume, m_f is large and n is approximate m_f+2, thus

$$B_{fm} = 2(m_f + 2)f_m$$

$$B_{fm} = 2\left(\frac{\Delta f}{f_m} + 2\right)f_m = 2(\Delta f + f_m)$$

It is called Carson's rule