Department of Communications Engineering

Communication Systems

Third Year Class

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Lecture 5

Angle Modulation, PM, and FM

Angle Modulation

$$x(t) = A_c \cos(2\pi f_c t + \theta_0) \quad \text{——— (1)}$$

or $$x(t) = A_c \cos(\omega_c t + \theta_0) \quad \text{——— (1)}$$

Let $$\phi = \omega_c t + \theta_0 \quad \text{——— (2)}$$

$$\frac{d\phi}{dt} = \frac{d\omega_c t}{dt} + \frac{d\theta_0}{dt}$$

$$\boxed{\omega_c = \frac{d\phi}{dt}}$$ lets say ω_c = instantinuous angular frequency

$\therefore$ $\omega_c = \omega_i$

$\therefore$ $$\phi = \int \omega_i \, dt \quad \text{——— (3)}$$

Now ϕ is time-dependent, thus if ϕ varies with the message, the carrier signal is then angle modulated

$$x(t) = A_c \cos(\phi) \quad \text{——— (4)}.$$

Angle Modulation

Frequency Modulation (FM)
- frequency of the carrier is varied ~~with~~ according to the message signal

Phase Modulation (PM)
- Phase angle of the carrier is varied according to the message signal

* FM & PM are better than amplitude modulation such as noise reduction, and efficient use of power.

* Disadvantages of FM & PM are increased bandwidth and use of complex circuits.

Applications
1. Radio broadcasting,
2. Two way mobile Radio,
3. Microwave communication,
4. TV sound transmission,
5. Cellular radio, and
6. Satellite Communication.

Phase Modulation

we know $x(t) = A_c \cos(\omega_c t + \theta_0)$

or $x(t) = A_c \cos\phi$

where $\phi = \omega_c t + \theta_0$

* neglecting θ_0, we get total phase angle of unmodulated carrier is

$$\phi = \omega_c t$$

* In PM, ϕ changed linearly with the message.

→ Denoting ϕ_i as the instantinuous phase angle,

$$\phi_i = \omega_c t + K_p m(t) \quad \text{——} (10)$$

K_p is the constant of phase sensitivity.

$$\therefore \boxed{x_{PM}(t) = A_c \cos\left[\omega_c t + K_p m(t)\right]} \quad \text{——} (12)$$

Frequency Modulation :

* The carrier frequency will changed according to the message signal,

* The carrier frequency will deviate linearly according to the message signal.

→ The instantinuous frequency is

$$\boxed{\omega_i = \omega_c + k_f\, m(t)} \quad (13)$$

k_f is constant of the frequency sensitivity.

Hence, $\phi_i = \int \left[\omega_c + k_f\, m(t)\right] dt$

$$= \omega_c t + k_f \int m(t)\, dt$$

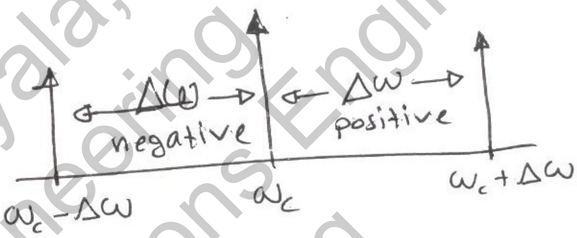
Thus:

$$\boxed{x_{FM}(t) = A_c \cos\left[\omega_c t + k_f \int_0^t m(t)\, dt\right]} \quad (14)$$

* The maximum change in ω_i (instantinuous angular freq.) from the carrier frequency ω_c is called the **frequency deviation** $(\Delta\omega)$

* The deviation is due to the message, thus, the deviation maybe +ve or -ve.

$$\therefore \quad \Delta\omega = \left| k_f \, m(t) \right|_{max}$$



Relationship between FM & PM :-

- Angle modulation is $S(t) = A_c \cos \phi_i$
- For PM $\quad S_{PM}(t) = A_c \cos\left[\omega_c t + k_p x(t)\right]$
- For FM $\quad S_{FM}(t) = A_c \cos\left[\omega_c t + k_f \int_0^t m(t)\, dt\right]$

related to each other, because in both cases there is a variation in total phase angle.

Hence, FM can be obtained using PM or PM can be obtained using FM.