PRINCIPLES OF COMMUNICATIONS

UNIT-3

LECTURE-3

Angle Modulation

In this type of modulation, the frequency or phase of carrier is varied in proportion to the amplitude of the modulating signal.

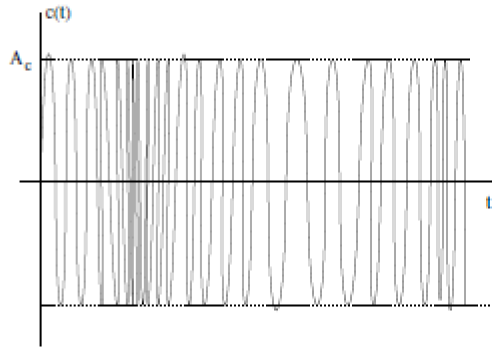

Figure 1: An angle modulated signal

If $s(t) = A_c \cos(\theta_i(t))$ is an angle modulated signal, then

1. Phase modulation:

$$\theta_i(t) = \omega_c t + k_p m(t)$$

where $\omega_c = 2\pi f_c$.

2. Frequency Modulation:

$$\omega_i(t) = \omega_c + k_f m(t)$$

$$\theta_i(t) = \int_0^t \omega_i(t)\, dt$$

$$= 2\pi \int_0^t f_i(t)\, dt + \int_0^t k_f\, m(t)\, dt$$

- Phase Modulation If $m(t) = A_m \cos(2\pi f_m t)$ is the message signal, then the phase modulated signal is given by

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

Here, k_p is phase sensitivity or phase modulation index.

- Frequency Modulation If $m(t) = A_m \cos(2\pi f_m t)$ is the message signal, then the Frequency modulated signal is given by

$$2\pi f_i(t) = \omega_c + k_f A_m \cos(2\pi f_m t)$$

$$\theta_i(t) = \omega_c t + \frac{k_f A_m}{2\pi f_m} \sin(2\pi f_m t)$$

here, $\frac{k_f A_m}{2\pi}$ is called frequency deviation (Δf) and $\frac{\Delta f}{f_m}$ is called modulation index (β). The Frequency modulated signal is given by

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

Depending on how small β is FM is either *Narrowband FM*($\beta << 1$) or *Wideband FM*($\beta \approx 1$).

- Narrow-Band FM (NBFM)

  In NBFM $\beta << 1$, therefor $s(t)$ reduces as follows:

$$\begin{aligned} s(t) &= A_c \cos(2\pi f_c t + \beta \sin(2\pi f_m t)) \\ &= A_c \cos(2\pi f_c t) \cos(\beta \sin(2\pi f_m t)) - \\ & \quad A_c \sin(2\pi f_c t) \sin(\beta \sin(2\pi f_m t)) \end{aligned}$$

  Since, β is very small, the above equation reduces to

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

The above equation is similar to AM. Hence, for NBFM the bandwidth is same as that of AM i.e.,
$2 \times message\ bandwidth (2 \times B)$.
A NBFM signal is generated as shown in Figure ??.

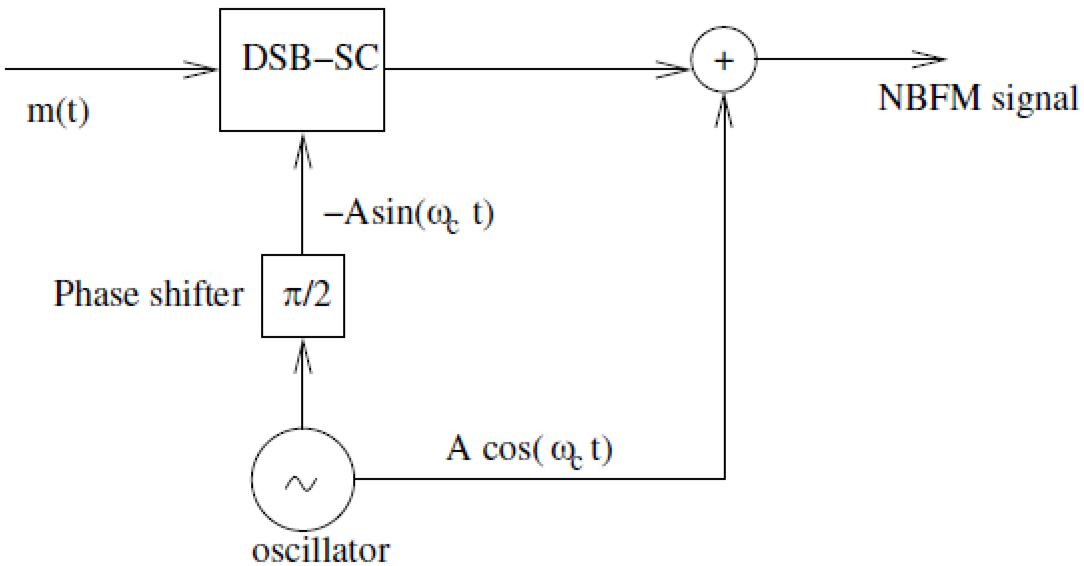

Figure 2: Generation of NBFM signal