Communication Systems

Lecture - 11

Dr. Tarun Kumar Dey,

Associate professor. Department of Physics

L.S College; BRA Bihar University, Muzzaffarpur.

Youtube channel – Tarun Kumar Dey

Online Course Link -

https://findmementor.com/mentee/view_details/tkdeyphy

Frequency modulation : When a modulating AF wave is superimposed on a high frequency carrier wave in such a way that the amplitude of modulated wave is same as that of the carrier wave , but its frequency is varied in accordance with the instantaneous value of the modulating voltage , the procee is called frequency modulation (FM).

Let the instantaneous carrier voltage (e_c) and modulating voltage (e_m) be represented by

$$e_c = E_c \cos \omega_c t \qquad (1)$$

$$e_m = E_m \cos \omega_m t \qquad (2)$$

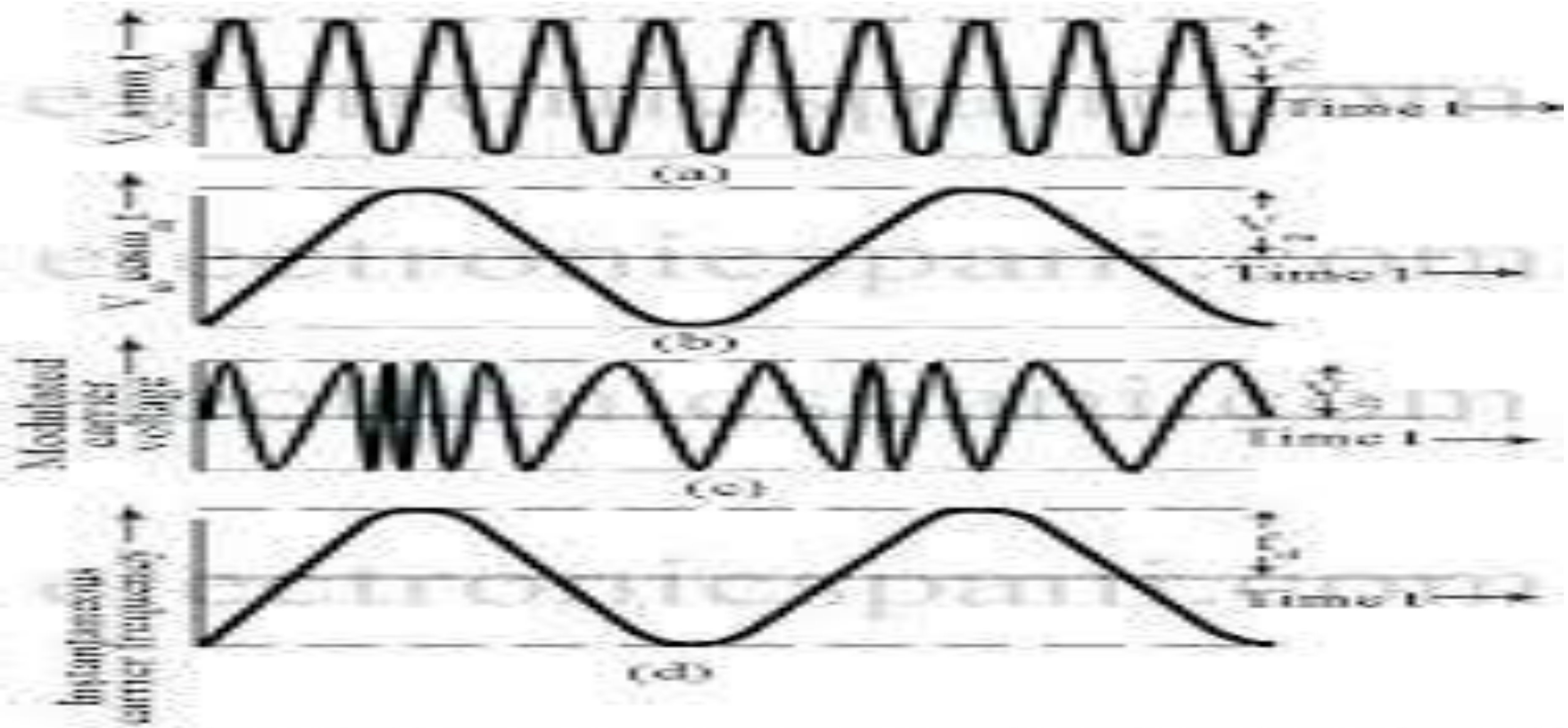

Figure 1: Waveform of Frequency Modulated Carrier Voltage

In frequency modulation , the amount by which carrier frequency is varied from its unmodulated value ($f_c = \omega_c / 2\pi$) is called the deviation .This deviation is proportional to the instantaneous value of the modulating voltage . the rate at which the frequency variation takes place is equal to the modulating frequency .

If f is frequency of FM wave at any instant t and f_c is constant frequency of the carrier wave , then

Deviation (in frequency) , $\delta = f - f_c$ (3)

From the definition of frequency modulation ,

$$\delta \propto e_m$$

$\delta \propto E_m \cos \omega_m t$

$$\delta = k E_m \cos \omega_m t \qquad (4)$$

Where k is a proportionality constant ,Using (3) , we get

$\delta = f - f_c = k E_m \cos \omega_m t$

or $f = f_c + k E_m \cos \omega_m t \qquad (5)$

The deviation wii be maximum , when

$\cos \omega_m t = 1$

$f = f_c + k E_m$

$\delta_{max} = f_{max} - f_c = \pm k E_m$

Modulation Index (m_f) : It is defined as the ratio of maximum frequency deviation to the modulating frequency i.e.,

$$m_f = \delta_{max} / f_m$$

The instantaneous amplitude of frequency modulated wave is given by

$$A = A_0 \cos\phi,$$

Where ϕ is the function of carrier angular frequency (ω_c) and modulating angular frequency (ω_m) . In fact ,

$$\phi = (\omega_c t + \delta / f_m \text{ Cos } \omega_m t) \quad (6)$$

Frequency Spectrum of FM wave

The **out put** of an **FM** consists of carrier frequency and almost infinite number of side bands , whose frequencies are $(f_c \pm f_m)$, $(f_c \pm 2f_m)$, $(f_c \pm 3f_m)$ … and so on . The side bands are separated from the carrier by f_m , $2f_m$, $3f_m$ … etc .

The number of side bands depends on the modulation index .

Band width = 2nx (f_m)

Where n is the number of particular sideband pair .