Govt. Mahila Engineering College, Ajmer

Ist Mid Term Examination-2017-18 (Even Sem.)

Principles of Communication (4IT5A)

Max. Marks: 10 Max Time: 01 Hour

Note: - All Questions are Compulsory and carry equal marks.

1. What are modulation & its needs? Explain the working principle of envelope detector for demodulation of AM wave using suitable diagrams.
2. Derive the expression of transmission efficiency for single tone sinusoidal AM wave.
   A 400 W carrier is modulated to a depth of 75%. Find the total power in the amplitude modulated wave. Assume the modulating signal to be a sinusoidal one.
3. Show the relation between FM & PM using suitable diagrams and equations.
   A carrier of frequency 10^6 Hz and amplitude 3 V is frequency modulated by a sinusoidal signal with frequency 500 Hz and peak amplitude 1 V. The frequency deviation is 1 KHz. The level of the modulating waveform is changed to 5 V peak and the modulating frequency is changed to 2 KHz. Write the expression for the new modulated wave form.
4. Explain the functionality of frequency division multiplexer (FDM) using block diagrams.

"MODULATION"

Modulation is a scheme which alters some characteristics of high frequency carrier signal in accordance with the low frequency message signal called the modulating signal (message signal, baseband signal).

The term baseband is used to designate the band of frequency representing the original signal as defined by the source of information.

The fundamental goal of modulation is to produce an information bearing modulated wave whose properties are best suited for efficiant utilisation of the communication channel. Because the message signal is a low frequency signal and cannot be transmitted efficiently over the channel directly.

Types of Modulation-

1. Continuous Wave modulation : It is a continuous process and is best suited for signal which vary continuously with time in CW modulation the carrier signal is usually sinusoidal in nature.
2. Pulse modulation : PM is a discrete or a discontinuous process. This is best suited for messages which are discrete in nature. The carrier signal in this case is simply a train of pulses.

Need for Modulation :

1. Efficient radiation : In radio communication, electromagnetic wave from the transmitting antenna, for efficient radiation from a

a radiative element it is necessary that the size of the element should be of the order of $\frac{\lambda}{10}$, λ = signal wavelength.

2. Frequency Translation: Modulation enables one to translate the signal occupying similar frequency ranges to different region in the freq. spectrum.

3. Multiplexing: Send a number of signals simultaneously between two point modulation scheme enables one to multiplex a no. of signals at the same time in a single channel without any interference among themselves.

4. Reduction of Noise

Continuous wave modulation are of two type:

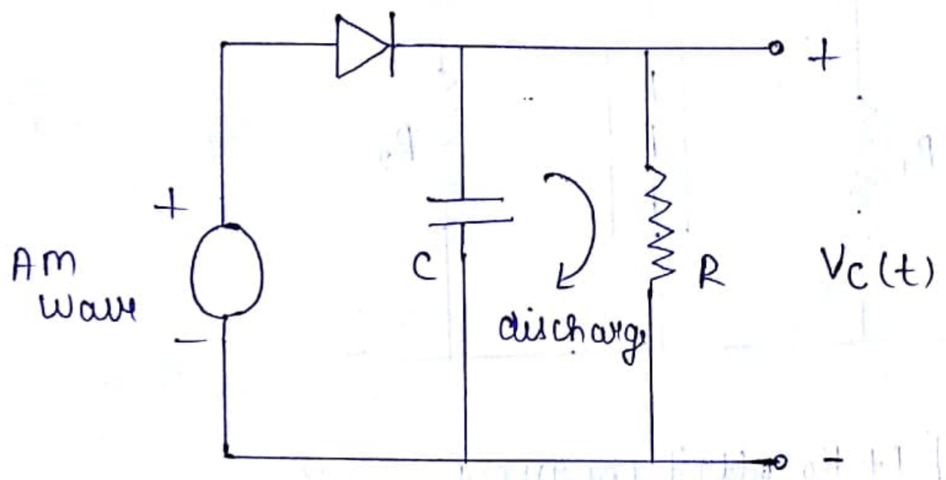
1. Linear
2. Non-linear (exponential)

A linear modulation scheme is one in which superposition theorum holds other modulation (non-linear) where superposition theorum does not hold good.

Linear modulation is essentialy direct frequency translation of message spectral.

Linear → AM
DSB
SSB
VSB

The output of envelope detector follows the envelope of the modulated signal.



Working of Envelope Detector -:

1. In the positive cycle of AM wave, diode conducts and capacitor charges up to peak voltage of input signal.
2. When i/p falls below this peak, diode comes in cut off state because the capacitor have greater voltage than i/p signal voltage.
3. The capacitor now discharge through the resistor R at slow rate determined by time constant RC.
4. When the input voltage becomes greater than the capacitor voltage the diode conducts again. The capacitor agains charges to the peak value of this new cycle.
   The output Vc(t) closely follows the envelope of the input.
5. The capacitor discharge between positive peaks causes a ripple signal of frequency f_c in the output. The ripple can be reduced by increasing the time constant RC so that the capacitor discharge thru

Power in AM System (Sideband and Carrier power in AM):

$$s(t) = A_c \cos 2\pi f_c t + k A_c m(t) \cos 2\pi f_c t$$

$$P_c = \frac{A_c^2}{2} \quad \text{and} \quad P_s = \frac{k^2 A_c^2}{2} \overline{m^2(t)}$$

Where, $\overline{m^2(t)}$ = mean square value of $m(t)$

Total power, $P_t = P_c + P_s = \frac{A_c^2}{2} + \frac{K^2 A_c^2}{2} \overline{m^2(t)}$

Fraction of total power is utilized in the transmission of the information.

$$\eta = \text{transmission efficiency} = \frac{P_s}{P_t} \times 100\%$$

$$\eta = \frac{\frac{k^2 A_c^2}{2} \overline{m^2(t)}}{\frac{A_c^2}{2} + \frac{k^2 A_c^2}{2} \overline{m^2(t)}} \times 100\% = \frac{k^2 \overline{m^2(t)}}{1 + k^2 \overline{m^2(t)}} \times 100$$

The total power in the modulated wave will be:

$$P_t = \frac{V^2_{carr}}{R} + \frac{V^2_{LSB}}{R} + \frac{V^2_{USB}}{R}$$

$$\text{Carrier power} = \frac{V^2_{carr}}{R} = \frac{(A_c/\sqrt{2})^2}{R} = \frac{1}{2}\frac{A_c^2}{R}$$

$$P_{LSB} = P_{USB} = \frac{V^2_{SB}}{R} = \frac{(\mu A_c/2\sqrt{2})^2}{R} = \frac{\mu^2 A_c^2}{8R}$$

$$P_t = \frac{A_c^2}{2R} + \frac{\mu^2 A_c^2}{8R} + \frac{\mu^2 A_c^2}{8R}$$

$$= P_c + \frac{\mu^2}{4} P_c + \frac{\mu^2}{4} P_c$$

$$P_t = P_c + \frac{\mu^2}{2} P_c = P_c\left(1 + \frac{\mu^2}{2}\right)$$

$$\boxed{\frac{P_t}{P_c} = \left(1 + \frac{\mu^2}{2}\right)}$$

Single tone -

$$m(t) = A_m \cos 2\pi f_m t.$$

$$\therefore \overline{m^2(t)} = \frac{A_m^2}{2}. \quad \text{Efficiency } (\eta) = \frac{k^2 \frac{A_m^2}{2}}{1 + k^2 \frac{A_m^2}{2}} \times 100$$

$$\eta = \frac{k^2 A_m^2}{2 + k^2 A_m^2} \times 100\%$$

$$= \frac{\mu^2}{2 + \mu^2} \times 100\% \quad [\because \text{ Where } \mu = K A_m]$$

For $\mu = 1$ $\quad \eta_{max} = \frac{1}{3} \times 100\% = 33.33\%$

This means that for the highest modulation index ($\mu = 1$), the efficiency is 33.33% and 67% of the total power is carried by carrier and is wasted.

Q) A 400W carrier is modulated to a depth of 75%. Calculate the total power in the modulated wave. Assume the message signal is to be sinusoidal.

$$\frac{P_S}{P_t} = \frac{\mu^2}{2 + \mu^2} \quad \text{Where, } P_t = P_S + P_c$$

$$P_S = P_t - P_c.$$

$$\frac{P_t - P_c}{P_t} = \frac{\mu^2}{2 + \mu^2} \Rightarrow 1 - \frac{P_c}{P_t} = \frac{\mu^2}{2 + \mu^2}$$

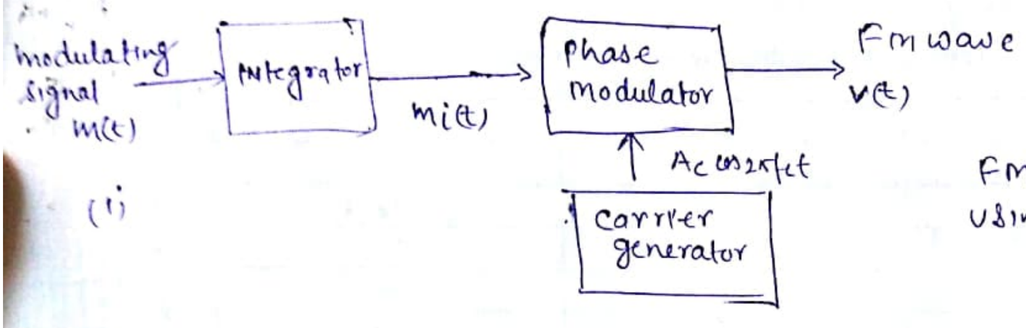
$$1 - \frac{\mu^2}{2 + \mu^2} = \frac{P_c}{P_t} \Rightarrow \frac{2}{2 + \mu^2} = \frac{P_c}{P_t}$$

$$\frac{P_t}{P_c} = \frac{\mu^2 + 2}{2} \Rightarrow 1 + \frac{\mu^2}{2}$$

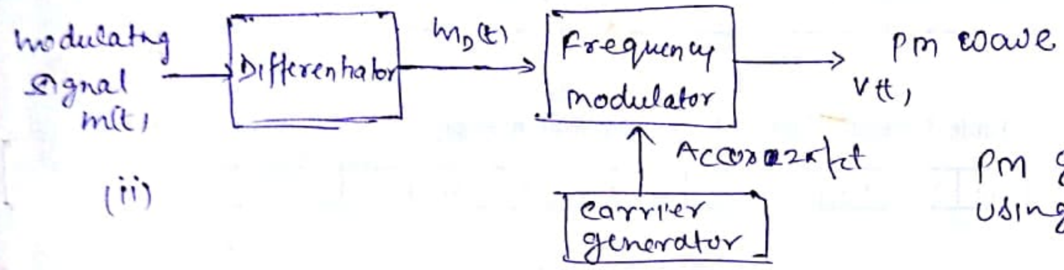
$$P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$$

$\mu = 75\%$ $\quad \therefore P_t = 400\left(1 + \frac{(.75)^2}{2}\right) = 512.5\text{W}$ Ans

Relationship Between PM & FM :- FM & PM are closely related in the sense that the net effect of both is variation in total phase angles.



FM generation using phase modulator.



PM generation using frequency modulator

(i) $v(t) = A_c \cos[2\pi f_c t + k' m_i(t)]$ where $m_i(t) = k'' \int_0^t m(t)\,dt$

So $v(t) = A_c \cos[2\pi f_c t + k'k'' \int_0^t m(t)\,dt]$

$= A_c \cos[2\pi f_c t + k_f \int_0^t m(t)\,dt]$

(ii) $v(t) = A_c \cos[2\pi f_c t + k' \int_0^t m_D(t)\,dt]$ where $m_D(t) = k'' \frac{d\,m(t)}{dt}$

$= A_c \cos[2\pi f_c t + k'k'' \int_0^t \frac{d\,m(t)}{dt}\,dt]$

$= A_c \cos[2\pi f_c t + k_p m(t)]$

Q A carrier wave of freq. 1 MHz and amplitude 3 V. is frequency modulated by a sinusoidal modulating signal freq. of 500 Hz and of peak amplitude 1 volt. The frequency deviation Δf is 1 kHz. The level of the modulating waveform is changed to 5 volt peak and the modulating freq. is changed to 2 kHz. Obtain the expression for the new FM wave.

Ans

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

$f_c = 1\ \text{MHz}$ $\quad A_c = 3V$ $\quad A_m = 1\ V$ $\quad \Delta f = 1\ \text{kHz}$

$\Delta f = k_f A_m$ $\quad k_f = \frac{\Delta f}{A_m} = \frac{1\ \text{kHz}}{1V} = 10^3\ \text{Hz/volt}$

Second case $\quad A_m = 5\ V$ $\quad f_m = 2\ \text{kHz}$

$$\beta = \frac{\Delta f}{f_m} = \frac{k_f A_m}{f_m} = \frac{10^3 \times 5}{2 \times 10^3} = 2.5$$

$$s(t) = 3 \cos[2\pi(1 \times 10^6)t + 2.5 \sin 2\pi(2 \times 10^3)t]$$

Frequency-Division Multiplexing

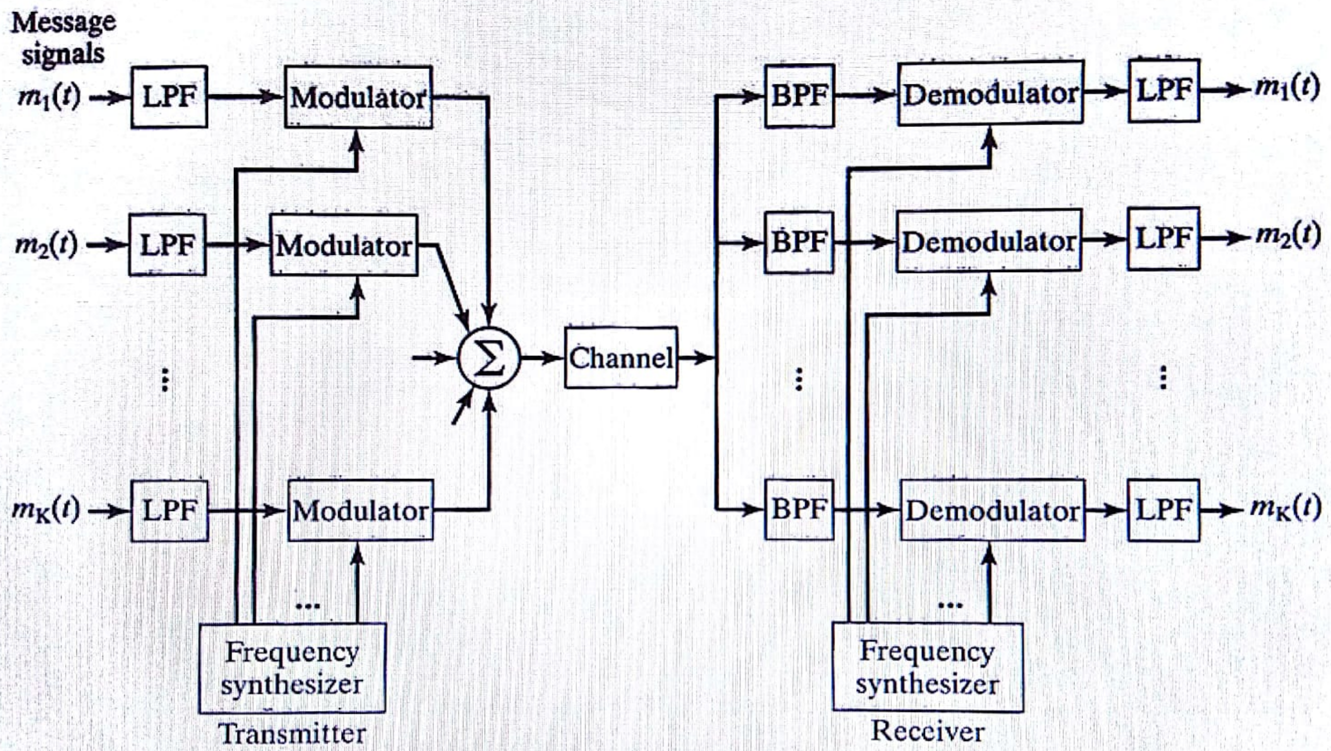


Figure 3.31 Frequency-division multiplexing of multiple signals.