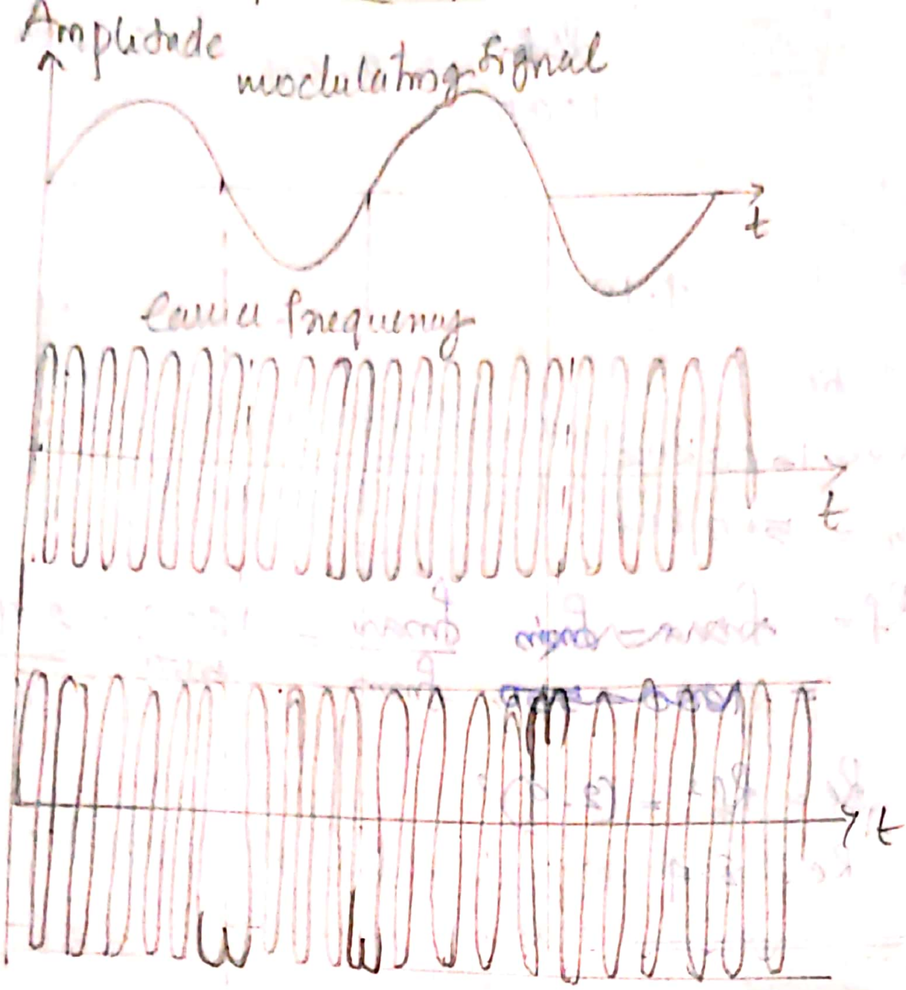
PHASE MODULATION : The signal (base band signal) can be passed to a phase modulator in which the instantaneous phase of the carrier is varied in accordance with the instantaneous value of the msg signal it will take general form as

$$V_{pm} = A_c \sin(\omega_c t + \theta_{pm}) \quad \text{—— (1)}$$

$$= V_c \sin(\omega_c t + m_p V_m \sin \omega_m t) \quad \text{—— (1a)}$$

where $M_p \rightarrow$ modulation index of phase modulation

$\theta_{pm} \rightarrow$ phase of modulated signal $= m_p V_m \sin \omega_m t$



Taking the angular part of phase modulated signal

$$\theta(t) = \omega_c t + \theta_{PM} \longrightarrow (2)$$

finding the angular frequency

$$\omega = \frac{d\theta}{dt}$$

$$2\pi f = \frac{d\theta}{dt}$$

$$f = \frac{1}{2\pi}\frac{d\theta}{dt}$$

$$= \frac{1}{2\pi}\frac{d}{dt}\left[\omega_c t + \theta_{PM}\right]$$

$$= \frac{1}{2\pi}\frac{d}{dt}\omega_c t + \frac{d}{dt}\theta_{PM}$$

$$= \frac{\omega_c}{2\pi} \times 1 + \frac{d}{2\pi dt}\theta_{PM}$$

~~$f = f_c + M_p \frac{d}{dt} V_m$~~

~~$\theta_{PM} = M_p V_m \sin\omega_m t$ (1a)~~

$\therefore \frac{d}{dt}$ ~~$m_p V_m \sin\omega_m t$~~

~~$f = \frac{\omega_c}{2\pi} + m_p$~~

$e_{pm} = m_p V_m \sin\omega_m t$. from eqn (1a)

$\therefore \frac{d}{dt} m_p V_m \sin\omega_m t$

$= m_p \frac{d}{dt} V_m \sin\omega_m t$

$$f = \frac{\omega_c}{2\pi} + \frac{m_p}{2\pi} \frac{d}{dt} \cdot V_m$$

$$\boxed{f = f_c + \frac{m_p}{2\pi} \frac{d}{dt} V_m} \longrightarrow (3)$$

where V_m is the instantaneous value of msg signal given by $V_m = V_m \sin\omega_m t$

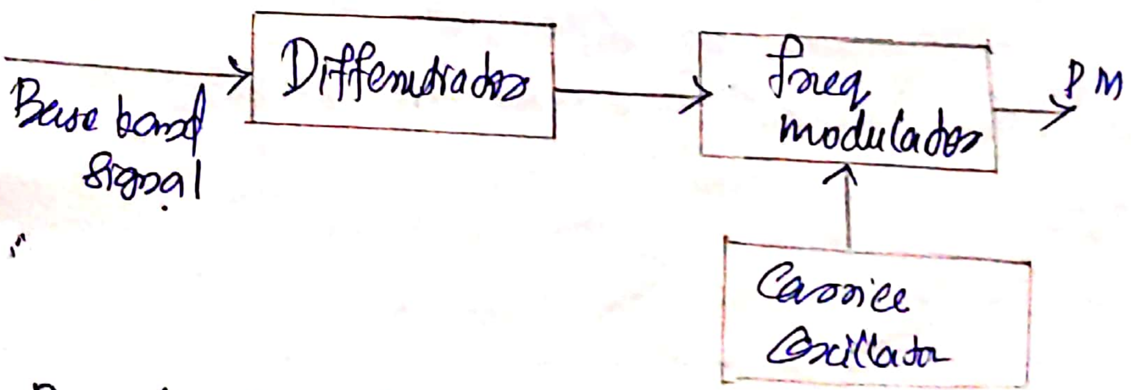
<u>Equivalence of PM of FM</u> : The modulation index of freq modulation is given by

$$m_f = \frac{K V_m}{f_m}$$

while ~~equiv~~ the modulation index in phase modulation is given by

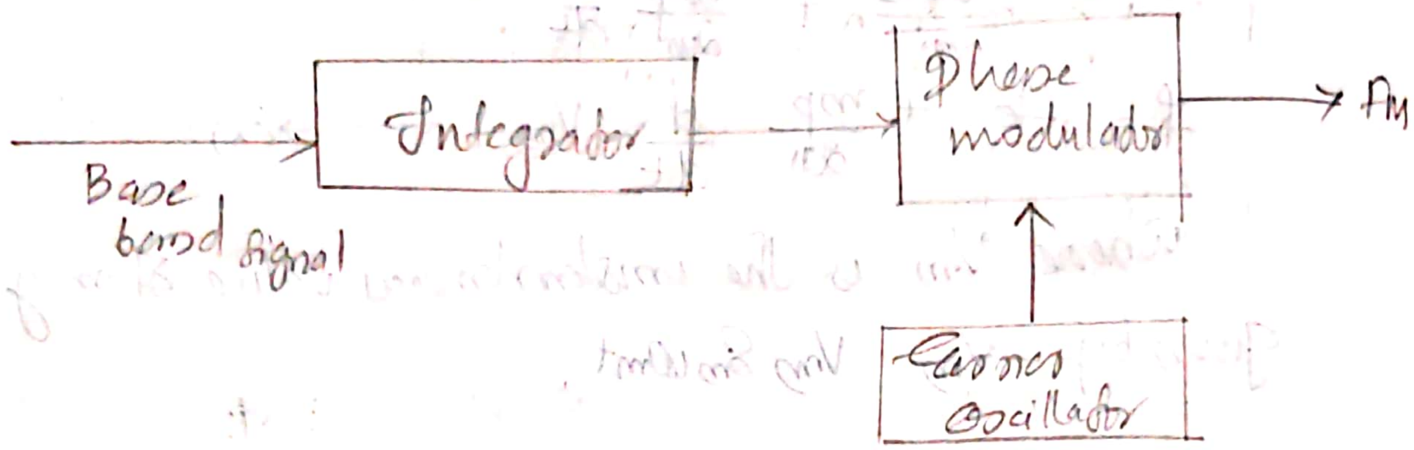
$$\text{Modulation index} = M_p V_m$$

From eqn (3) we can draw the ~~ck~~ block diagram of phase modulation

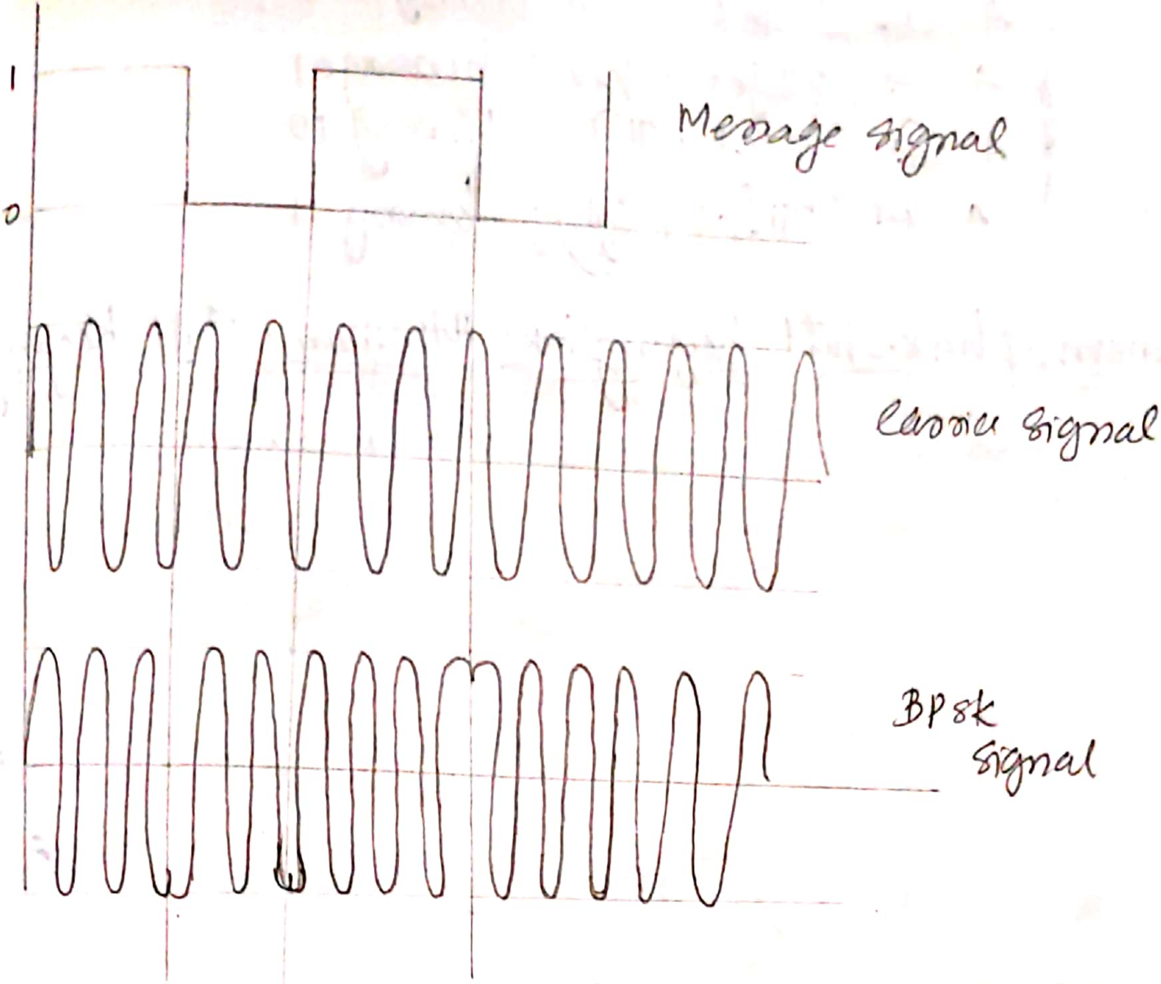


The Base band signal is passed through a differentiator ckt which is then applied to a freq. modulator where mixing up of the differentiated msg signal and high frequency generated signal to obtain a phase modulated signal.

Alternatively we can generate FM using case modulator and integrator as



Digital Phase Modulation : The modulation technique in which the information signal will be in digital form and the carrier signal in sinusoidal form. The phase of the carrier is varied in accordance with the digital values of information signal i.e binary 0 = a phase shift of 180° while binary 1 = a phase shift of 0°. Or in other words for binary 0 the carrier is multiplied by -1 and for binary 1 the carrier is multiplied by 1 which gives the wave form of Binary phase shift Keying.



In Binary phase shift keying no. of bits included is 2 ie either zero or 1 and the BPSK signal can be represented as

$$s(t) = \begin{cases} A\cos 2\pi f_c t \ ; & \text{binary } 1 \\ A\cos(2\pi f_c t + \pi) \ ; & \text{binary } 0 \end{cases}$$

$$= \begin{cases} A\cos 2\pi f_c t \ ; & \text{binary } 1 \\ -A\cos 2\pi f_c t \ ; & \text{binary } 0 \end{cases}$$

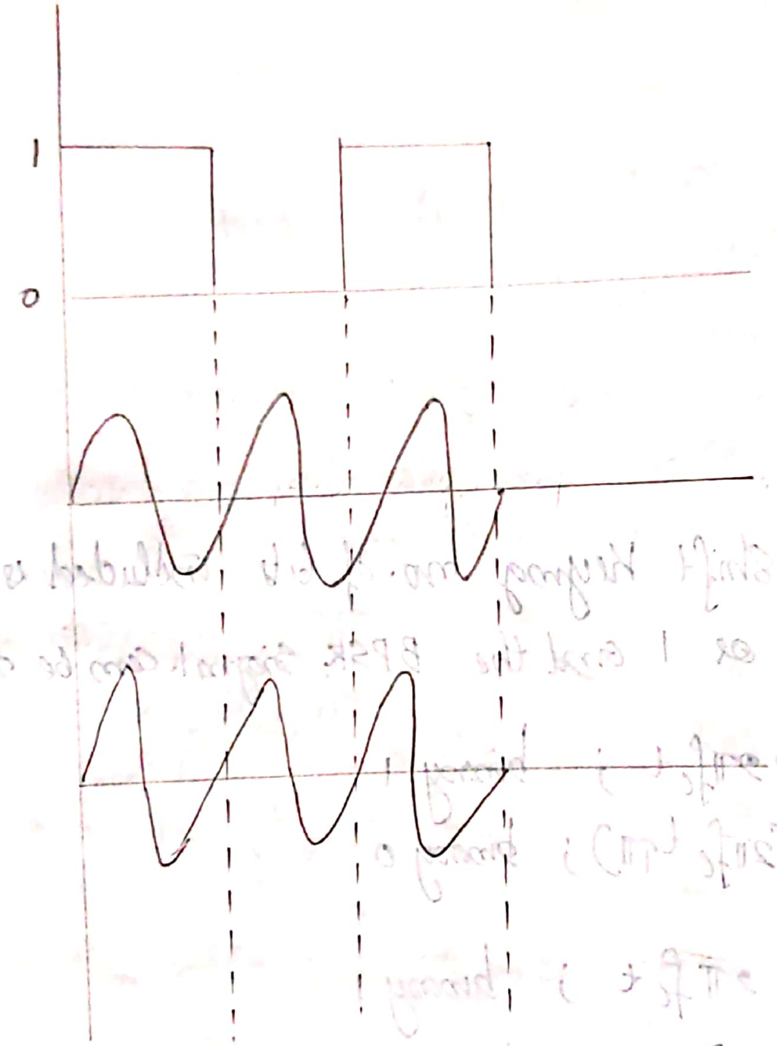
The technique is also known as Biphase modulation technique.

Quadrature phase shift keying : Here the modulated in phase at angles 0°, 90°, 180° and 270°. At once all the four phase shifts are done for the same carrier signal with respect to the message signal. The QPSK signal can be written as

~~$s(t) = \{A\cos 2\pi f_c t$~~

$$S(t) = \begin{cases} A \cos 2\pi f_c t & ; \text{binary } 00 \\ A \cos(2\pi f_c t + \pi/2) & ; \text{binary } 01 \\ A \cos(2\pi f_c t + \pi) & ; \text{binary } 10 \\ A \cos(2\pi f_c t + \frac{3\pi}{2}) & ; \text{binary } 11 \end{cases}$$

Minimum phase Shift keying (OR) Minimum Shift Keying



This is a special type of continuous phase FSK. Here no phase discontinuity occurs but the frequency changes at zero crossing point. The modulation index of MSK is given by

$$M_{max} = 0.5$$

$$M_{max} = \frac{2\Delta F}{R}$$

where $\Delta F \rightarrow$ frequency deviation.

Advantages :→ good spectral efficiency

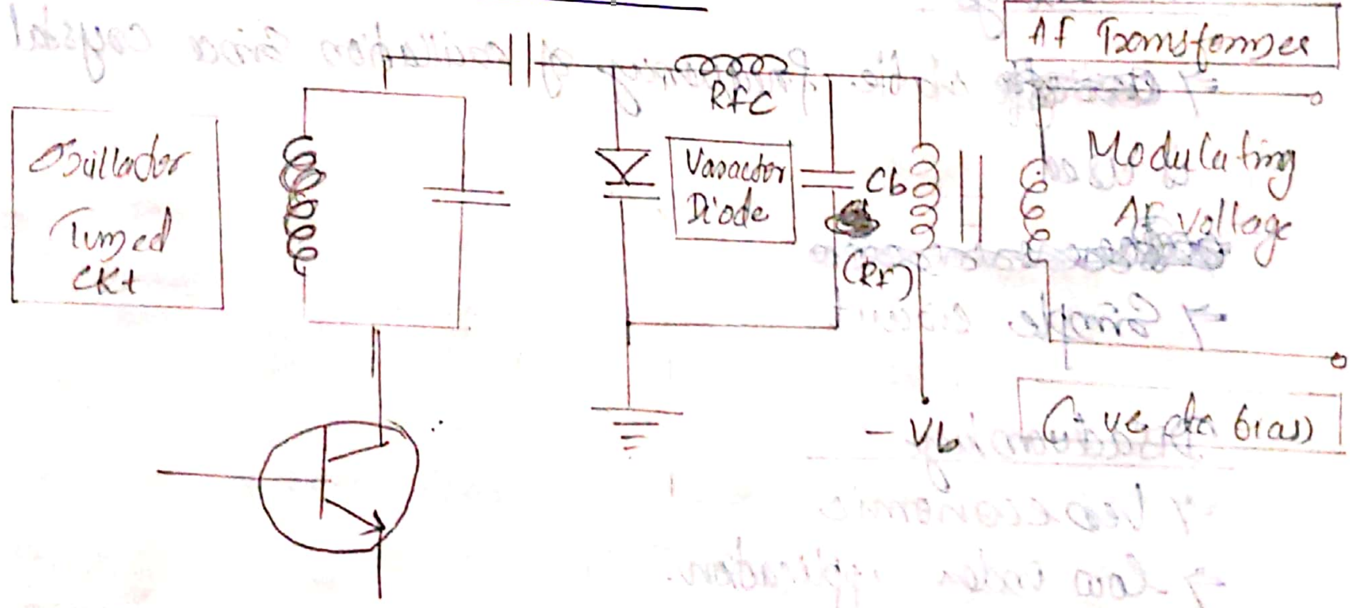
⇒ good bit error rate

→ Maximum utilisation of allocated channel

Guassian MSK : In which a filter (LPF) is used to reduce the extending of side bands beyond its allocated band width towards carrier. The filter used as a Guassian filter.

Angular Modulators

(1) Varactor diode Modulator



The property of Varactor diode is exploited in this circuit. Varactor diode is always connected in reverse bias with respect to its battery. When reverse biasing is increased depletion region increases thereby capacitance decreases.

In this modulator ckt msg signal is given in series to the varactor diode and a crystal oscillator is used to generate the carrier signal. RFC (Radio frequency choke) and Cb (Bypass capacitor) is used as a filter to cancel out high frequency signals entering into the AF module.

When positive half cycle of modulating signal approaches and − Vbb is very much greater then diode capacitance will be very less leading to the maximum transmission of AF voltage to modulate the carrier signal. When negative half cycle approaches, − Vbb is very less then capacitance will be greater almost all the AF signal will be bipassed through varactor diode to ground, leading to less modulation at negative half cycle. This generates an FM signal as the o/p of varactor diode modulator, so varactor diode modulator is an FM modulator or generator.

Advantage

⇒ Stable frequency of oscillation since crystal oscillator is used.

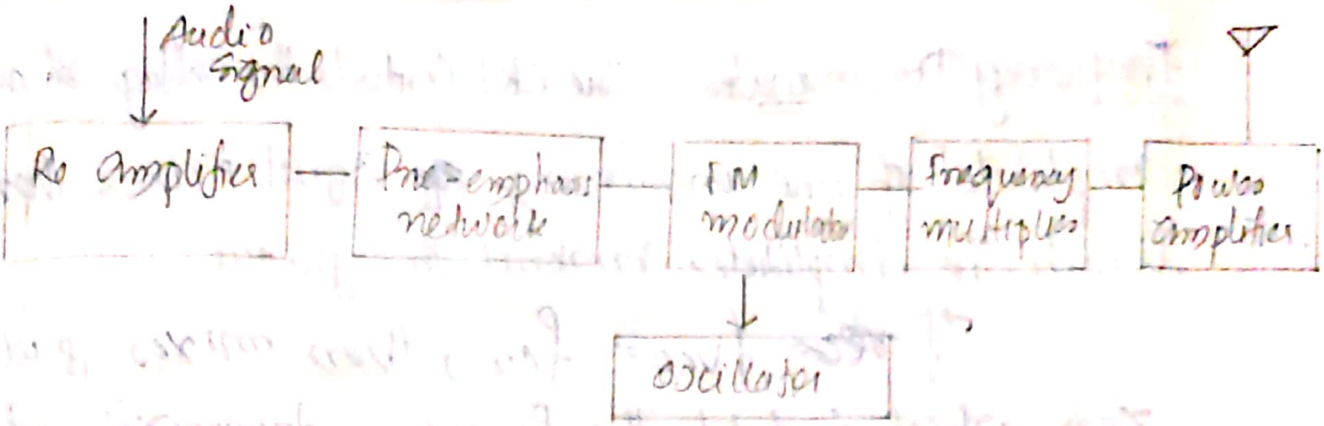
⇒ Simple circuit

Disadvantage

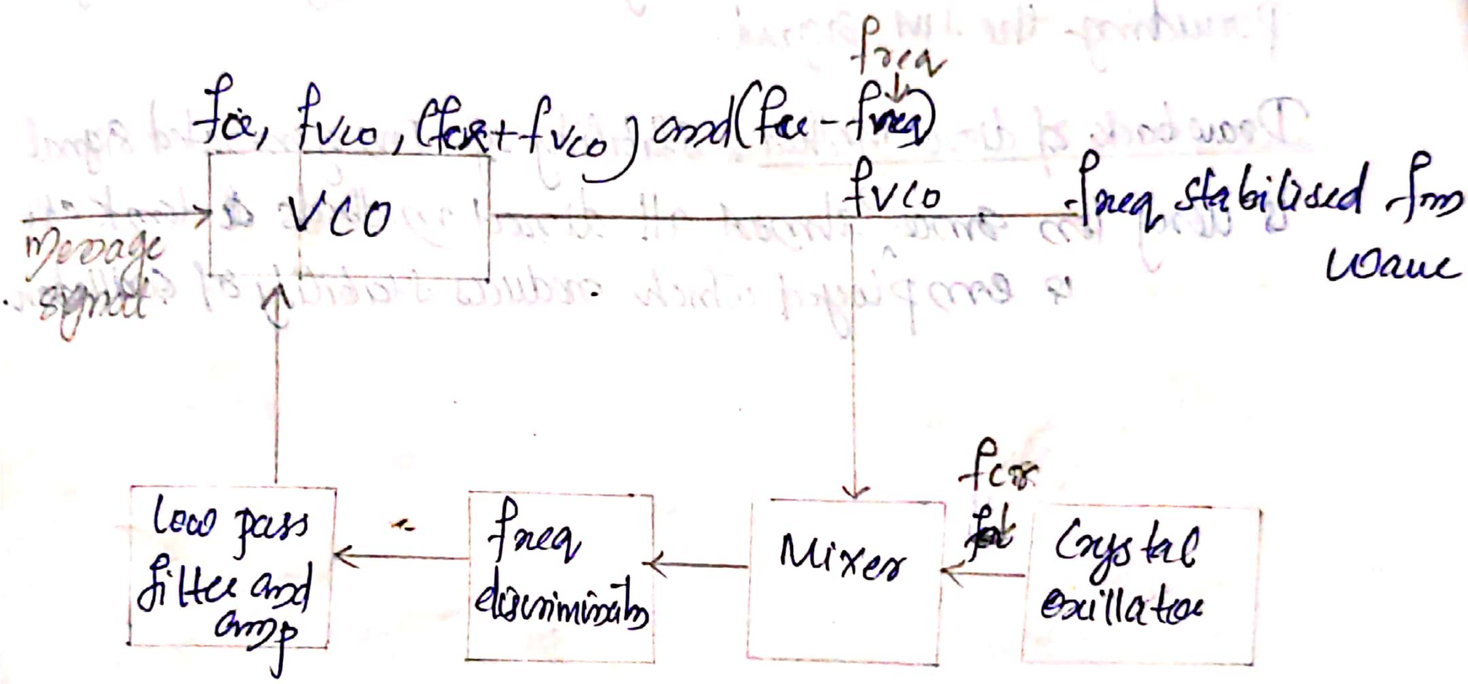
⇒ less economic

⇒ low index application. (draw FM signal, msg signal, carrier signal, FM signal)

FM TRANSMITTERS



Frequency stabilised FM generator



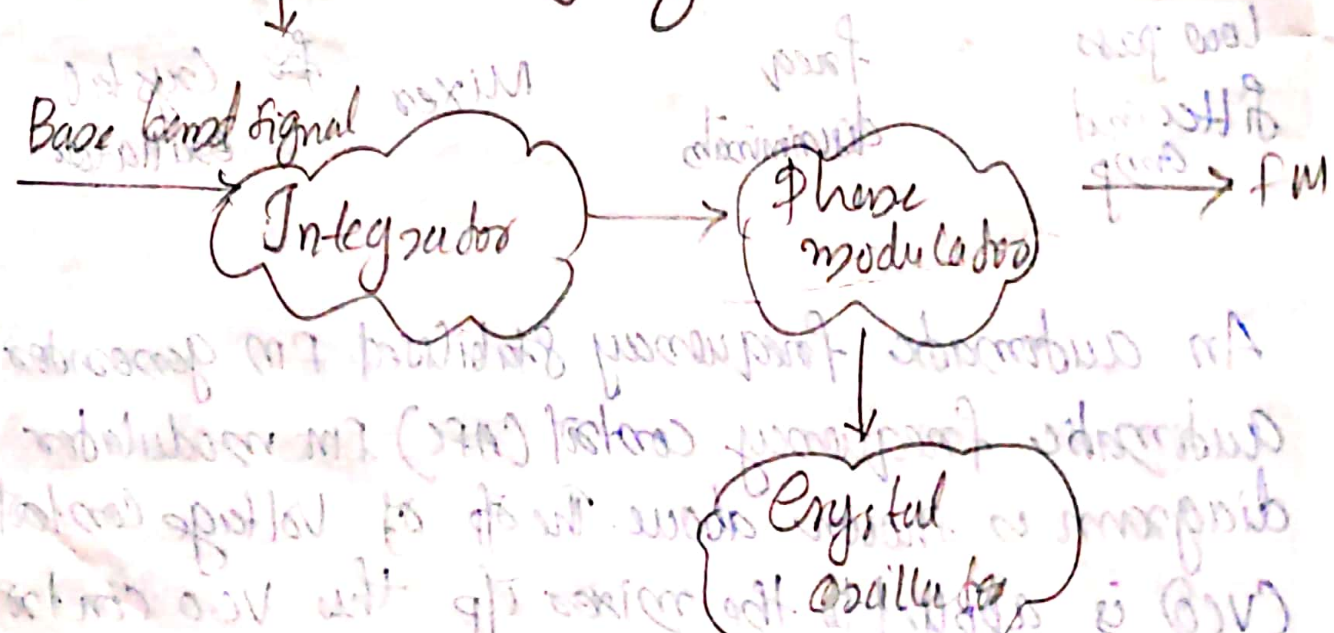
An automatic frequency stabilised FM generator or an automatic frequency control (AFC) fm modulator block diagram is shown above. The o/p of Voltage Control Oscillator (VCO) is applied to the mixer i/p thus VCO controls the frequency of oscillation of the carrier signal with respect to the instantaneous voltage of msg signal. The VCO o/p frequency denoted by fvco which gets mixed up with the crystal oscillator o/p fcr to produce signals fcr+fvco and fcr−fvco. The difference term fcr-fvco is only extracted using ~~the~~ a ~~Band~~ pass filter, and fed to the frequency discriminator.

Frequency Discriminator : The ckt controls the voltage of or amplitude of the incomming signal mixer thereby limits the amplitude constant through out.

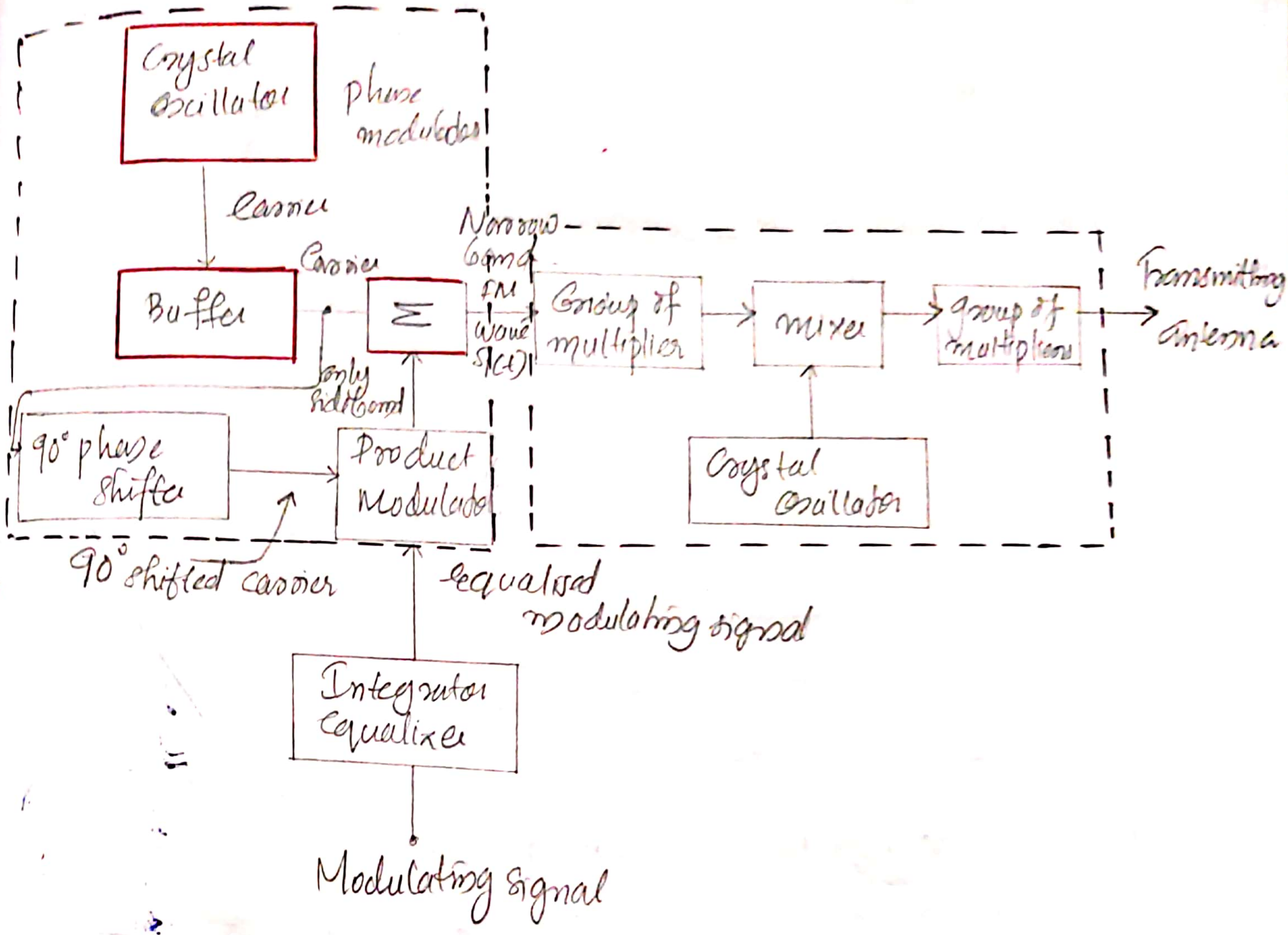
If $f_{vco} = f_{cr}$, then mixer o/p will be zero, which is fed to the frequency discriminator which determines that no control of amplitude or voltage is necessary for the incomming carrier voltage, there by providing the FM signal.

Drawback of direct Method : Stability of FM generated signal is very less since in almost all direct methods tank ckt (LC ckt) is employed which reduces stability of oscillation.

(If I don't know anything)



ARMSTRONG METHOD


Crystal oscillator
phase modulator
carrier
Buffer
Carrier
Σ
Narrow band FM wave S(t)
only sideband
90° phase shifter
Product Modulator
90° shifted carrier
equalised modulating signal
Integrator equalizer
Modulating signal
Group of multiplier
mixer
group of multipliers
Crystal oscillator
Transmitting antenna