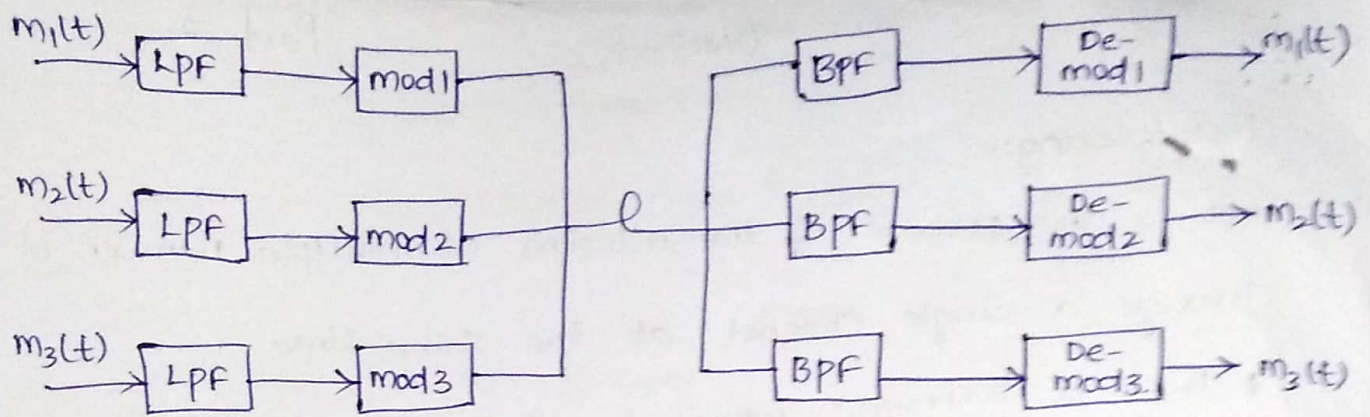


Multiplexing:-

- * It is the process of transmission of multiple number of signals through a single channel at the same time.
- * It is a technique where by a number of independent signals can be combined into a composite signal suitable for transmission over a "common channel".
- * There are two types of multiplexing techniques.
 - i) Frequency division multiplexing (FDM).
 - ii) Time division multiplexing (TDM).
- * Multiplexing requires that the signals be kept apart so that they donot interfere with each other and they can be separated at the receiving end.
- * This is accomplished by separating the signals either in frequency (or) time.
- * The technique of separating the signals in frequency is called as "FDM".
- * The technique of separating the signals in time is called as 'TDM'.

Frequency Division Multiplexing:-

- * FDM is used to multiplex continuous signals.



- * The input message signals assumed to be of the low-pass type are passed through the input lowpass filter
- * The LPF's are designed to remove high-frequency components that do not contribute significantly to signal representation but are capable of disturbing other message signals that share the common channel.
- * LPF's are used to band limit the message signals.
- * The band limited message signals are then modulated with the carrier frequencies
- * The most widely used method for modulation is FDM is Single side band modulation.
- * Which requires a bandwidth that is approximately equal to that of original message signal.
- * The BPF's following the modulators are used to restrict the band of each modulated wave to its prescribed range
- * The resulting BPF's connected to the common channel in parallel to separate the message signals on the frequency occupancy basis.
- * Finally, the original message signals are recovered by the individual demodulators.

Advantages:-

- * Large no. of signals can be transmitted simultaneously.
- * FDM does not need synchronisation between transmitter and receivers.

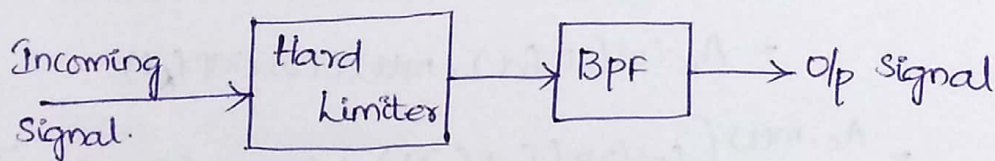
- * Demodulation of FDM is easy.

Disadvantages:-

- * The channel must have very high bandwidth.
- * Large no. of modulators and filters are required.

Bandpass limiter:-

- * It is a non-linear circuit, whose function is to eliminate the amplitude variations of angle modulated wave.
- * It consists of hard limiter and Band pass filter.



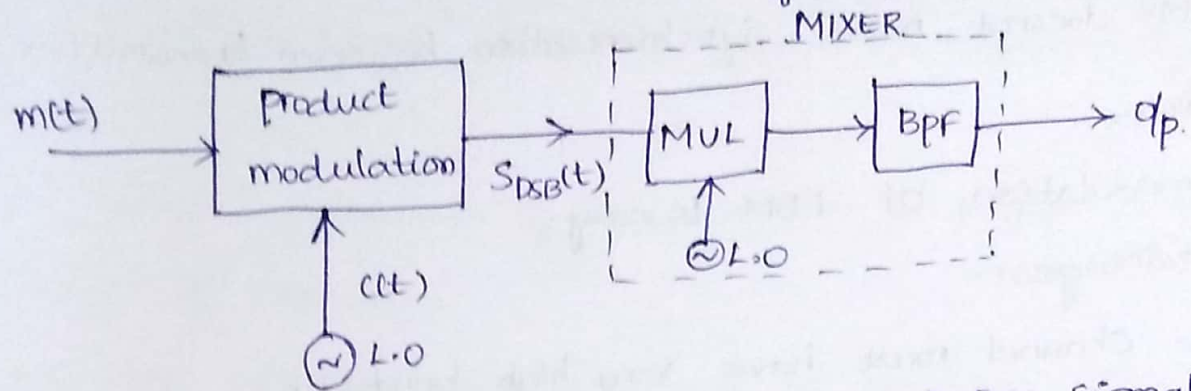
- * It converts sinusoidal signal into square signal.
- * It acts as a clipper, i.e., if taken the same amplitude with varying time period.

Frequency Mixer:-

- * It is a non-linear electrical circuit that creates new frequencies from two signals applied to it.
- * In its most common application, two signals are applied to a mixer, and it produces new signals at sum and difference of the original frequencies.
- * Mixers are widely used to shift signals from one frequency

range to another, this process is called as "heterodyning".

for convenience in transmission of signals.



* The output of the product modulator is DSBSC signal

$$\text{W.K.T } S_{DSB}(t) = A_c m(t) \cdot \cos(2\pi f_c t).$$

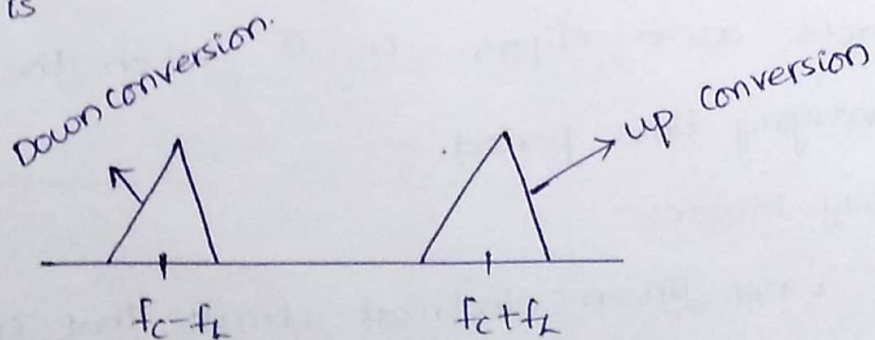
* This is the input of multiplier in mixer, which is multiplied by locally generated signal i.e., $\cos(2\pi f_L t)$.

$$\therefore (MUL)_{o/p} = S_{DSB}(t) \cdot (L.O)_{o/p}$$

$$\text{If } f_c > f_L \quad = A_c \cos(2\pi f_c t) \cdot m(t) \cdot \cos(2\pi f_L t).$$

$$= \frac{A_c \cdot m(t)}{2} \left[\cos(2\pi(f_c + f_L)t) + \cos(2\pi(f_c - f_L)t) \right]$$

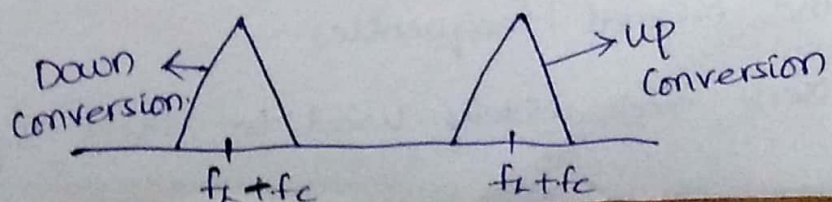
$\therefore$ Mixer o/p is



If $f_c < f_L$

$$(MUL)_{o/p} = \frac{A_c m(t)}{2} \left[\cos(2\pi(f_L + f_c)t) + \cos(2\pi(f_L - f_c)t) \right]$$

$\therefore$ Mixer o/p is



* Finally we are finding centre frequency with dp of mixer, ⁽³⁾

Up conversion $\rightarrow$ Centre freq. $= f_c + f_L$

Down conversion $\rightarrow$ centre freq $= |f_c - f_L|$.

Receivers:-

* The main requirement of receiver will be proper selection and rejection of signals.

* For that we are using two types of receivers. They are

1. Tuned Radio Frequency (TRF) Receiver.

2. Super hetrodyne Receiver (SHD).

FCC:- Federation Committee of Communication. $\rightarrow$ It was established at 1927

AM Transmitter.

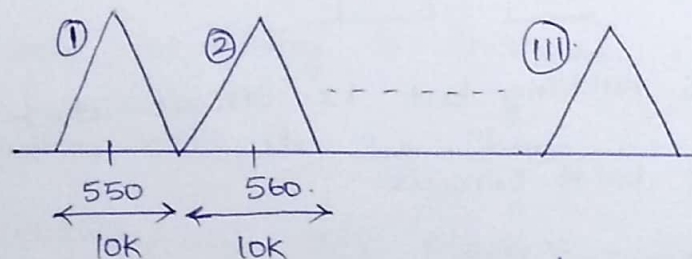
Carrier $\rightarrow$ 550KHz - 1650KHz

AM BW = 10KHz

FM Transmitter

Carrier $\rightarrow$ 88MHz - 108MHz

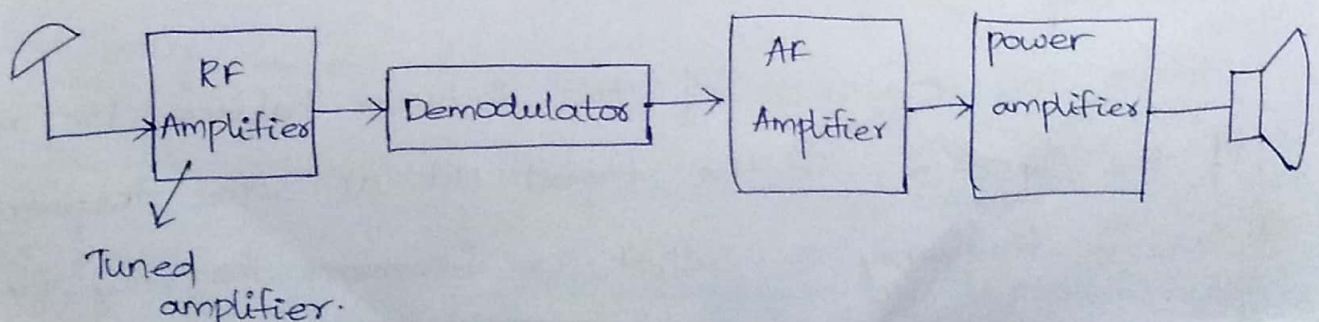
FM BW = 200KHz



$$\text{No. of Signals} = \frac{1650 - 550}{10} + 1$$

$$= 111.$$

TRF Receiver:-



* Here. RF- Amplifier is nothing but tuned Amplifier.

Tuned Amplifier:-

* These amplifiers are amplifiers that are employed for the purpose of the tuning.

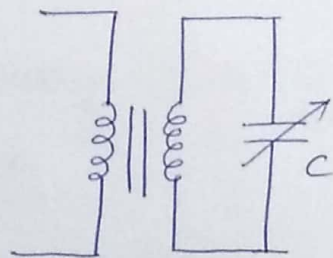
* Tuning means selecting.

* Among set of frequencies available, if there occurs a need to select a particular frequency, while rejecting all other frequencies, such process is called as Selection.

* This selection is done by using a circuit called as Tuned circuit.

* When the amplifier ckt has its load replaced by a tuned ckt, such an amplifier is called as tuned amplifier circuit.

* The basic tuned amplifier ckt as shown below.



* Tuned ckt is nothing but LC circuit which is also called as resonant (or) tank circuit.

* A tuned circuit is capable of amplifying a signal over a narrow band of frequencies that are centered at resonant frequency.

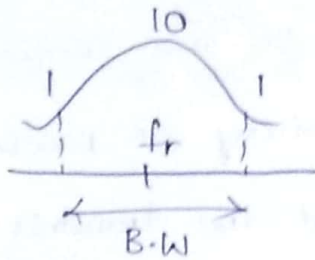
When the reactance of the inductor balances the reactance of the capacitor, in the tuned ckt at some frequency, such a frequency is called as "resonant frequency", (f_r).

(4)

* The resonant frequency is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

* In general



$$B.W \propto \frac{1}{Q}$$

$$\therefore B.W = \frac{f_r}{Q}$$

$Q \rightarrow$ Quality factor.

* For the design of tuned amplifier, Q can not be changed.

$\therefore f_r$ can be varied by varying 'C'.

* To tune the TRF receiver to different possible stations, correspondingly f_r of the tuned amplifier has to be changed such that f_r should be equal to selected frequency f_s .

$$\therefore \boxed{f_r = f_s}$$

* For proper selectivity of receiver, BW of tuned amplifiers should be 10kHz.

* For TRF receiver, as tuning is changed, correspondingly BW of tuned amplifiers will also be changed.

* So, that selectivity of TRF receiver will be poor.

Characteristics parameters of Receivers:-

1. Selectivity:- It specifies the ability of receiver to allow only desired frequency components and rejecting all possible undesired frequency components.

* It mainly depends on characteristics of tuned amplifier.

2. Sensitivity:- It specifies the minimum possible strength of the receiver input to be maintained to produce corresponding faithful output.

* It mainly depends on gain of the amplifier stage.

3. Fidelity:- It specifies the ability of receiver to produce all the frequency components of the transmitted audio signal.

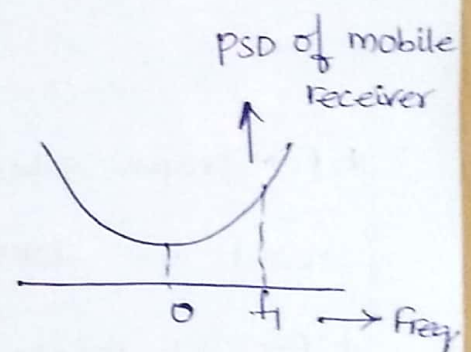
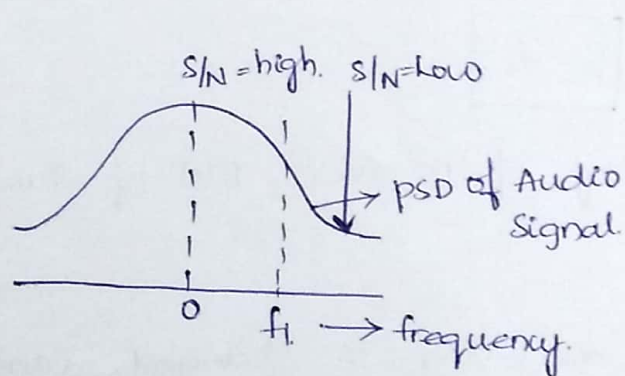
* In FM, fidelity is low

In AM, fidelity is high.

* To improve fidelity of Receiver in FM transmission of audio signals pre-emphasis and De-emphasis mechanisms will be used.

Pre-emphasis and De-emphasis:-

We know that



For low frequency components, $S/N = \text{high}$,

if S/N is high then the signal can be reconstructed.

For high frequency components, $S/N = \text{low}$,

It has some ~~interference~~ interference, therefore signal cannot be reconstructed back at receiver.

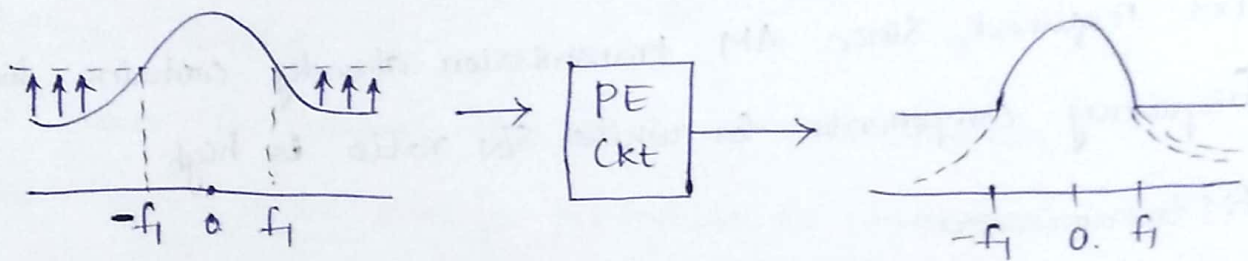
* Up to f_1 , S/N is high, so these low frequency components can be comfortably reproduced.

* Above f_1 , S/N is low, so there cannot be reproduced.

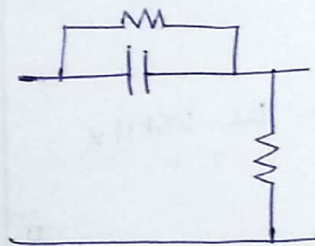
Pre-emphasis:-

- * It is the process of artificial boosting of high frequency components of message signal to increase corresponding S/N.
- * pre-emphasis can be done in the transmitter before the modulation.

Before modulation:-



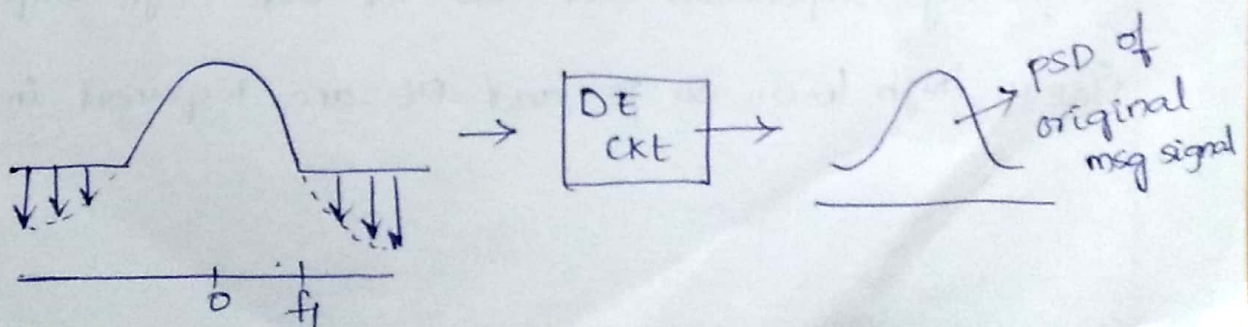
Pre-emphasis ckt is nothing but 2nd order HPF.



De-emphasis:-

- * It is the reverse of pre-emphasis to get back to original message signal.
- * It will be done in the receiver after demodulation.

After demodulation:-



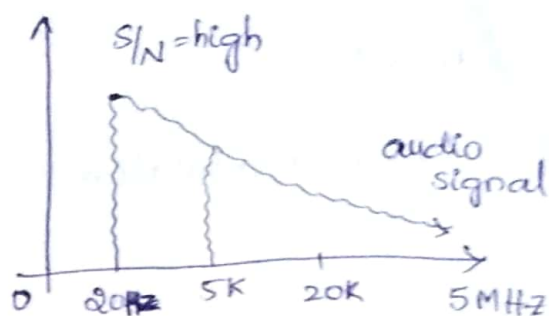
* It is nothing but LPF.

Note:- for Video signals PE and DE are optional but for audio signals it is essential for FM.

AM Transmission:-

$$\text{AM BW} = 10\text{KHz} = 2W$$

$$\text{Message BW} = 5\text{KHz} = W$$



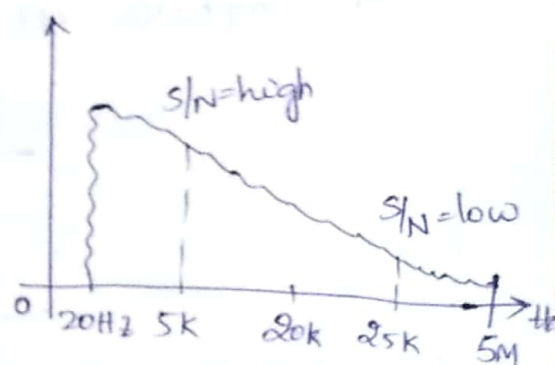
* for AM transmission, PE and DE are not required, since AM transmission already contains low frequency components for while S/N ratio is high.

FM transmission:-

$$\text{FM BW} = 200\text{KHz} = 2(\Delta f + W)$$

$$\Delta f_{\text{std}} = 75\text{KHz}$$

$$\text{message signal BW} = W = 25\text{KHz}$$



WKT

Voice signal $\rightarrow$ 300Hz - 3.5kHz.

This range of frequency components are contained in low frequency components.

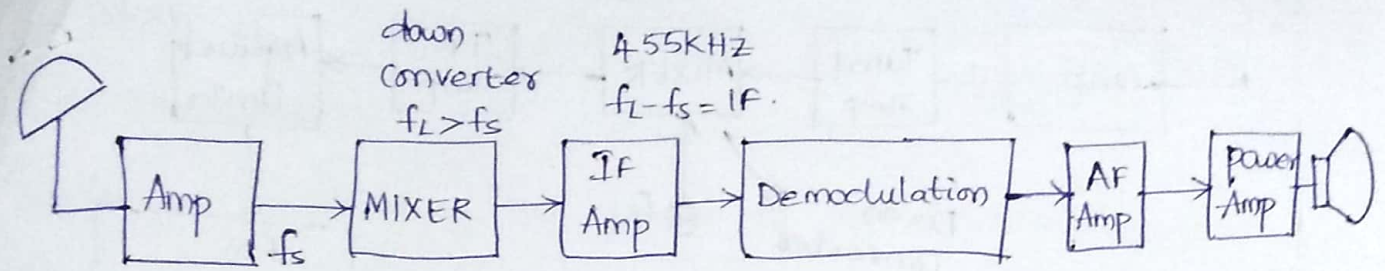
$\therefore$ PE and DE is not required for voice signals.

* In FM, the audio signals to be transmitted, contains high frequency components, and also for these high frequency components

S/N is high low. so PE and DE are required in FM.

Super Heterodyne Receiver:-

(6)



IF Amplifier $\rightarrow$ Standard tuned Amplifier.

$$f_L - f_s = IF = 455 \text{ KHz}$$

$$f_r = 455 \text{ KHz}$$

$$BW = 10 \text{ KHz}$$

$$Q = \frac{f_r}{BW} = 45.5$$

* The mixer is designed to work as a down converter.

* For mixer it is always preferable to maintain

$$f_L > f_s$$

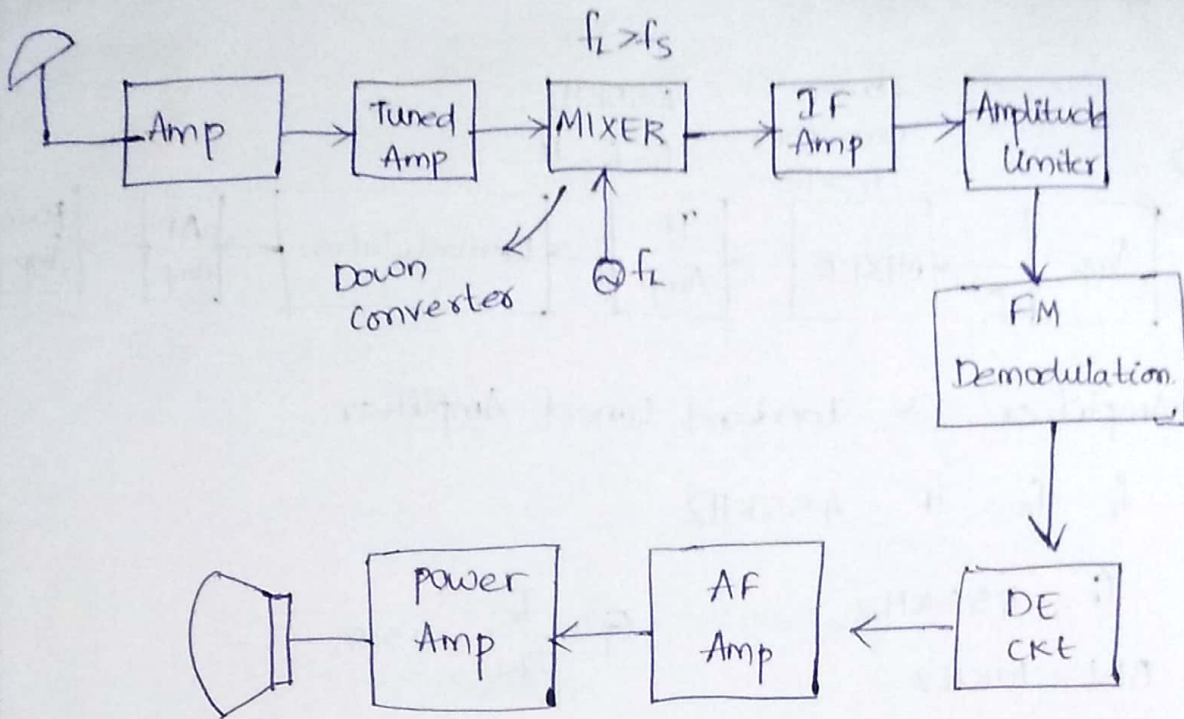
So, that the centre frequency of tuned station at mixer output will be $f_L - f_s$

$$\text{i.e., } f_L - f_s = IF = 455 \text{ KHz (standard)}$$

* Tuning of TRF receiver is achieved by changing f_r of tuned amplifiers whereas tuning of STD receiver is achieved by changing f_L of the mixer.

* In STD, BW of tuned amplifiers i.e., IF amplifier is standardized to 10 KHz. So that its selectivity will be superior.

FM Receiver:-



- * To avoid the Voltage fluctuations in peak amplitude, amplitude limiter is used before FM demodulator.
- * Operation of FM demodulation is sensitive to amplitude Variations also, which is drawback of FM demodulation.
- * To overcome the drawback of FM demodulation, Amplitude limiter is essential.
- * In AM, message signal is stored in the form of peak voltage Variations and there peak Voltage variations will be affected by most of the channel BW, so that AM transmission is highly noisy.
- * In FM, msg signal is stored in the form of frequency Variations and these frequency variations will be little effected by channel noise. So that FM transmission is very much noise free.
- * The operation of FSD is highly sensitive to peak Voltage fluctuations of FM signal. So that amplitude limiter is essential.

* Ratio Detector provides high stabilization towards Voltage fluctuations of FM signal. So that amplitude limiter is optional phase Modulation:-

* In Angle modulation, the phase of the carrier signal varies with respect to Amplitude Variation of message signal is called phase modulation.

Let us consider the carrier signal before modulation.

$$C(t) = A_c \cos(2\pi f_c t)$$

After modulation

$$S_{PM}(t) = A_c \cos[2\pi f_c t + \phi(t)]$$

where $\phi(t) = k_p m(t) \rightarrow$ phase deviation.

$$\therefore S_{PM}(t) = A_c \cos[2\pi f_c t + k_p m(t)]$$

Let the message signal $m(t) = A_m \cos(2\pi f_m t)$ (or)

$$A_m \sin(2\pi f_m t)$$

Maximum phase deviation

$$\Delta\phi = \max[k_p m(t)] \text{ radians.}$$

Single tone PM:-

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

$$\text{Assume } m(t) = A_m \cos(2\pi f_m t)$$

$$\therefore S_{PM}(t) = A_c \cos[2\pi f_c t + k_p A_m \cos(2\pi f_m t)]$$

$$\beta = k_p \cdot A_m$$

$$\therefore S_{PM}(t) = A_c \cos[2\pi f_c t + \beta \cos(2\pi f_m t)]$$

* For the given message signal the expression of PM and FM will be same except 90° phase shift of message frequency component.

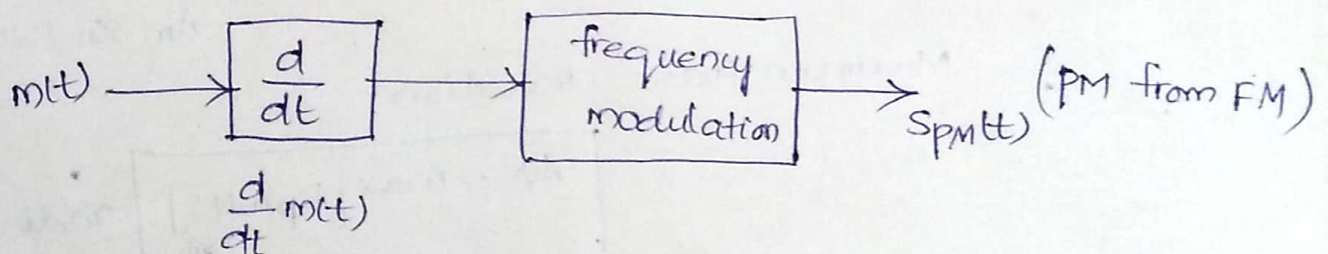
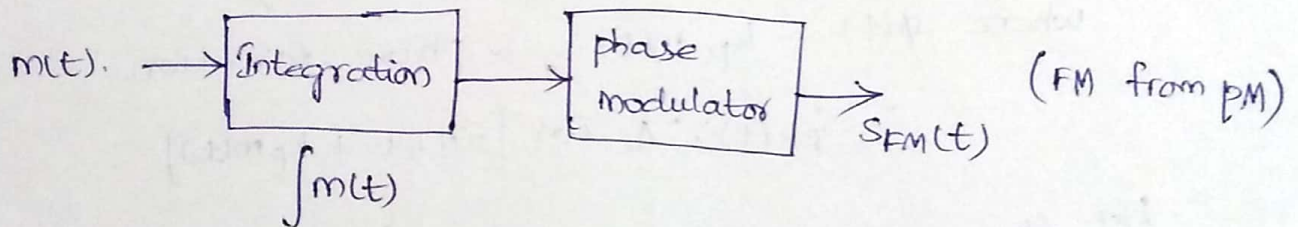
$$\therefore B.W = (\beta + 1) 2f_m = 2(\Delta f + f_m).$$

$$\therefore \text{power of PM, } P_t = \frac{A_c^2}{2R}$$

Generation of PM from FM and Vice-Versa:-

WKT, $S_{PM}(t) = A_c \cos [2\pi f_c t + k_p m(t)]$

$$S_{FM}(t) = A_c \cos [2\pi f_c t + 2\pi k_f \int m(t) dt].$$



$$\begin{aligned} FM(m(t)) &= PM \left[\int m(t) dt \right] \\ PM[m(t)] &= FM \left[\frac{d}{dt} m(t) \right] \end{aligned}$$