MODULE: 4

ANGLE MODULATION

Angle modulation includes frequency modulation and phase modulation, Here the frequency of phase or carrier signal is varied in accordance with the instantaneous value of modulating signal. They are of two types
⇒ frequency modulation
⇒ phase modulation

eg: Advantage: Distortion or noise will be very less

Dis adv: ⇒ short distance transmission is possible
⇒ Requirement of high band width
⇒ Complex ckt

Application: Used in Radio broadcasting, TV sound transmission, cellular radio, microwave communication, satellite communication.

Frequency Modulation: In this modulation technique frequency of the carrier is varied in accordance with the instantaneous value of msg signal. The amplitude remains constant throughout the modulation, the general expression for msg signal and carrier signal is given by

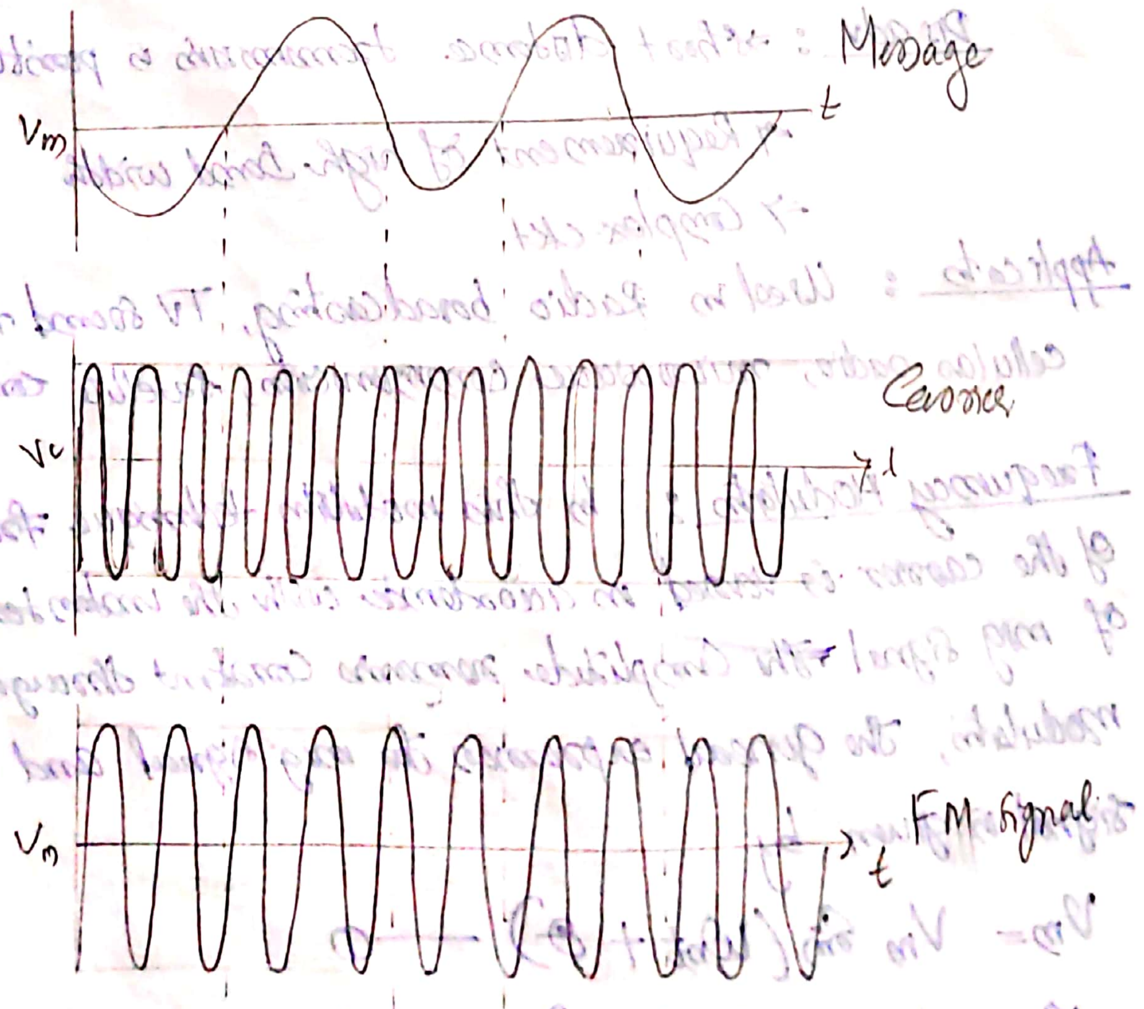
$$v_m = V_m \sin(\omega_m t + \theta) \longrightarrow (1)$$

$$v_c = V_c \sin(\omega_c t + \theta) \longrightarrow (2)$$

where ωt is the frequency component and θ is the phase component.

The change of Carrier Signal (unmodulated) to Modulated carrier will result in the deviation of frequency of the carrier or it can be defined as the amount by which carrier frequency is varied from its unmodulated value to modulated. This frequency deviation will be always proportional to the modulating voltage given by

$$\delta f \propto V_m$$



Frequency Variation : The FM signal has got a resultant frequency

$$f_{FM} = f_c + K V_m \sin \omega_m t$$

which will be maximum when $\sin \omega_m t = \pm 1$, ie

$$f_{FM} = f_c \pm K V_m$$

, $K \rightarrow$ proportionality constant, which is related with the frequency deviation by

$$\delta f = K V_m$$

∴ The modulated voltage of FM signal can be written as

$$V_{FM} = V_c \sin (f_c \pm K V_m) t$$

$$= V_c \sin (f_c \pm \delta f) t$$

$V_{FM} = V_c \sin (f_c + \delta f \sin \omega_m t)$ ← The general expression when sin value is not equal to 1

The frequency deviation is directly proportional to the modulating voltage and it has also got relation with the modulation freq f_m as

$\delta \rightarrow$ frequency deviation

$$\frac{\delta}{f_m} = m_f$$, where m_f is the modulation index of FM.

$$v_{FM} = V_c \sin (\omega_c t + m_f \cos \omega_m t) \quad \text{——— (1)}$$

Frequency Spectrum of FM : The equation of FM Signal

$$V_{FM} = V_c \sin(\omega_c t + m_f \cos \omega_m t)$$

we can expand the lower as well as upper side band frequency by expanding the sign function but mathematically it will be very complex since the FM signal is a function of Sine of Cosine term. To solve this function we use Bessel functions denoted by the letter 'J' which will take the general form as

$$V_{FM} = V_c \{ J_0(m_f) \sin \omega_c t + J_1(m_f) [\sin(\omega_c + \omega_m)t - \sin(\omega_c - \omega_m)t] + J_2(m_f) [\sin(\omega_c + 2\omega_m)t - \sin(\omega_c - 2\omega_m)t] + \dots$$

This shows that in the frequency Spectra FM signal Consist of a Carrier signal which is succeded by infinite no. of Side bands.

A Significant value of m_f denotes the no. of side bands as well as its amplitude.

$$\text{always } J_0 > J_1 > J_2 > \dots$$

as the value of m_f increases the J term also increases but the value of J function eventually decreases and reaches zero.

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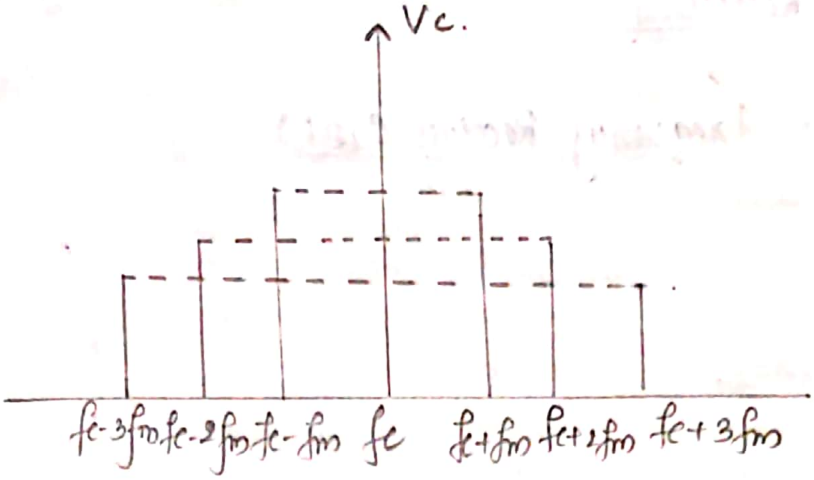
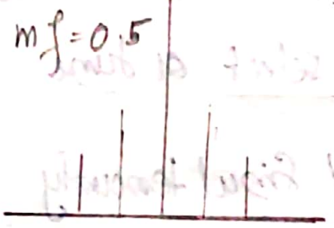
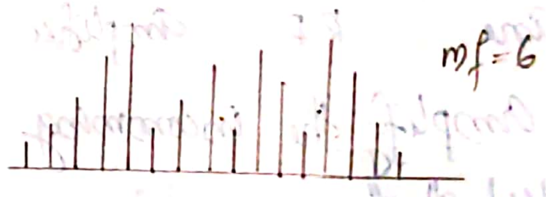
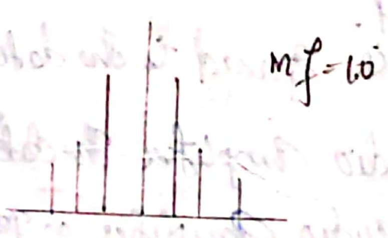


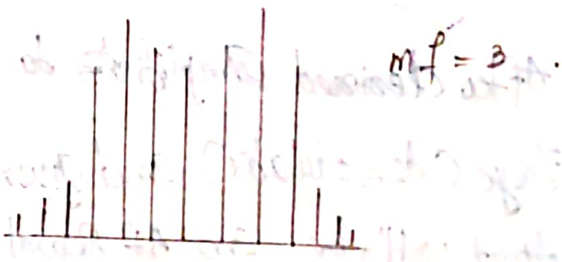
$$m_f = \frac{\delta}{f_m}$$

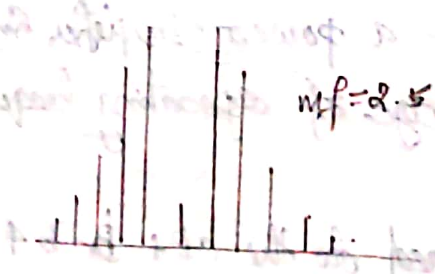
Constant fm increasing δ	Constant 'δ' increasing fm

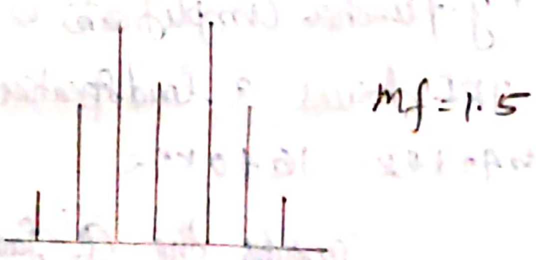


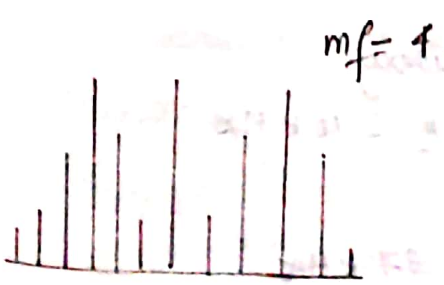


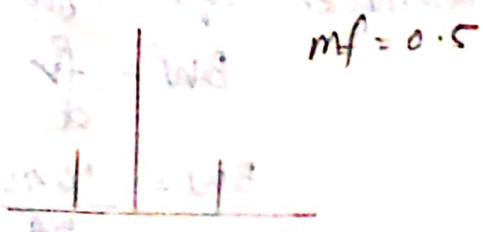








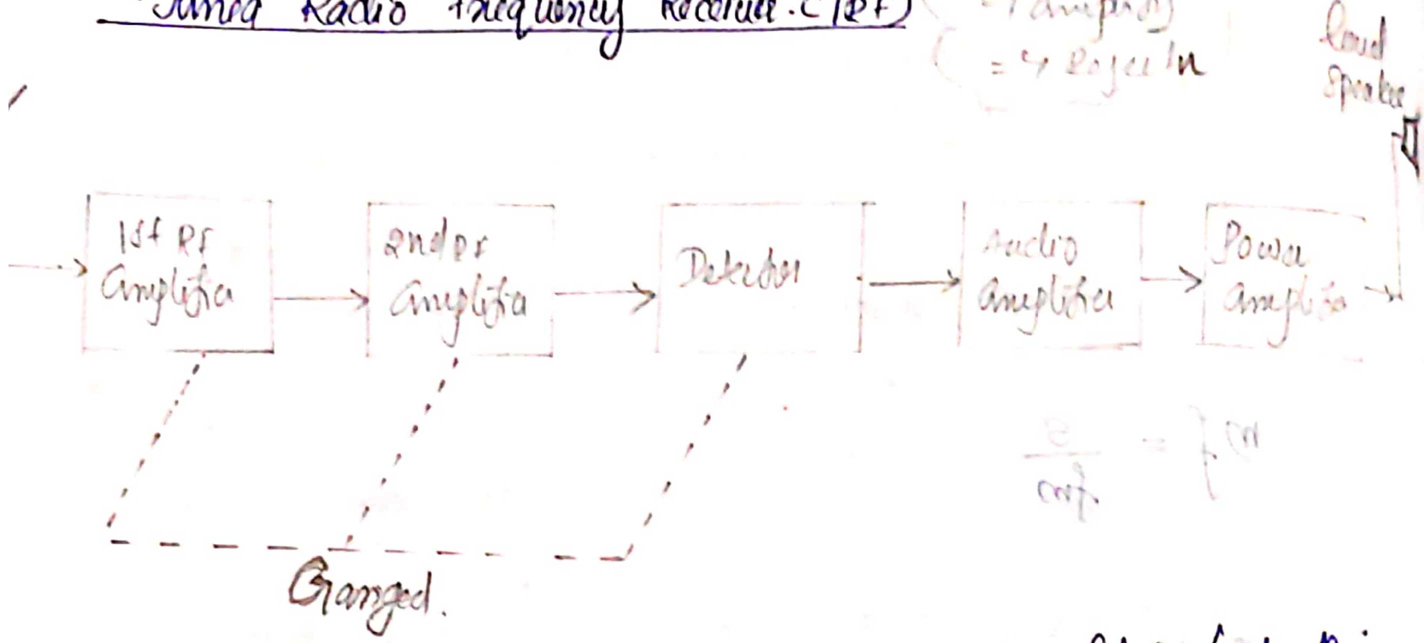




AM and FM Receivers

Tuned Radio Frequency Receiver (TRF)

(Uses of RF amp are
→ Sens
→ Selectivity
→ amplify
→ Rejection)



Used in radio receivers to obtain back the message signal and to drive a loud speaker. Two or three stages are RF amplifier is provided to select or tune and amplify the incomming RF signal and simultenously reject all others.

After desired amplification to a suitable level. it is spread to the detector stage (demodulator) and given to an audio amplifier. The detected output will be an AF signal so an audio amplifier is provided initially. Further amplification is done by a power amplifier since the TRF drives a loud speaker. The range of operating frequency is 540 KHz – 1640 KHz

Consider the Q factor required for the ckt be 54

the bandwidth required for low frequency

$$BW = \frac{f_r}{Q} = \frac{540k}{54} = 10\,KHz$$

$$BW = \frac{1640}{54} = 30.37\,KHz$$

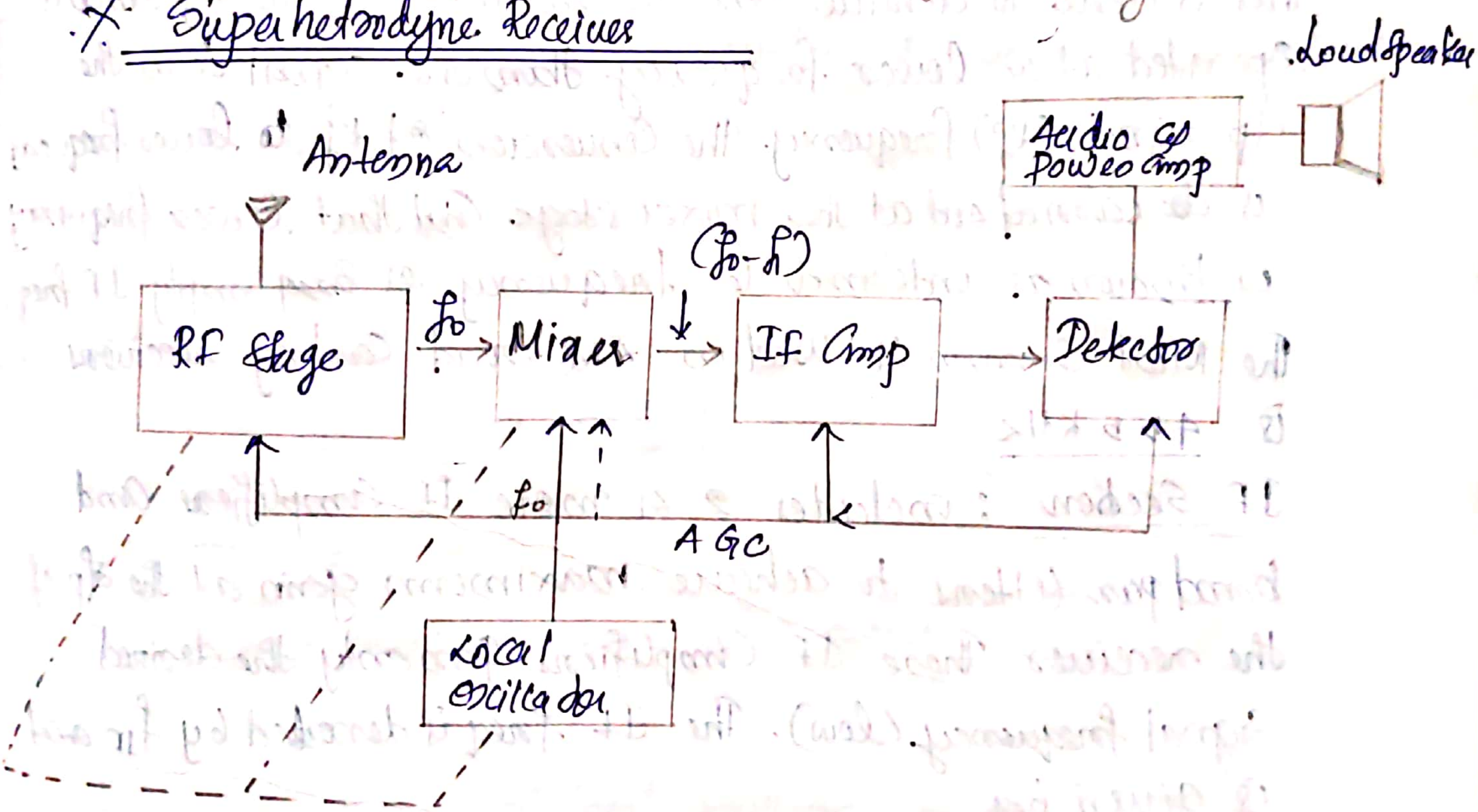
This is the biggest disadvantage since the TRF receiver picks up adjacent channel stations as well as the once to which it is tuned to. Other disadvantages include

(i) Instability
(ii) Insufficient -
(iii) Adjacent channel rejection
(iv) Bandwidth variation

The problems can be solved by using a ~~superheterodyne receiver~~ Superheterodyne receiver, which is the most commonly and recently used AM-FM receivers

Dyne - mixing

Superheterodyne Receiver



Ganged tuning

Includes an RF Amplifier to eliminate channel noise incurred in the receiver. The need for RF Amplifier such that

(i) Improves selectivity
(ii) Improves sensitivity

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(iii) Rejects image frequency signal

(iv) Improves SNR

(v) Better coupling of receiver to the Antenna

Mixer Stage : In this stage 2 i/ps are comming from the RF stage and the local oscillator stage. the o/p of a mixer will be either the sum of 2 signals or the difference of 2 signals i.e ______ if fs is the signal frequency term and fo is a local oscillator frequency then the o/p of mixer will be $f_s \pm f_o$. This mixing up of signals is known as Heterodyning. This is done to acheive an intermediate frequency which is operated at a lower frequency from the signal than the i/p signal (RF) frequency. The conversion of Rf to lower frequency is carried out at the mixer stage and that lower frequency is known as intermediate frequency or simply IF freq. The Most Common IF used in AM broad casting receivers is 455 KHz

IF Section : includes 2 or more IF amplifiers and band pass filters to achieve maximum gain at the o/p of the receiver. These IF Amplifiers pass only the desired signal frequency (low). The IF freq is denoted by f_{IF} and is given by

$$f_s - f_o = f_{IF}$$

Detector Stage : The purpose of detector is to convert the IF signal back to the original information hence this detector is known as an audio detector.

Local Oscillator : Is designed such that the freq. f_o is always kept higher than incomming RF signal i.e f_s. This is done to covers all the sweep of incomming signal after ganged tunning.

Q. Let the AM range be 540 KHz – 1650 KHz and IF selected – 455 KHz. Then usually the local oscillator range will be

$$f_s = 540$$

$$f_o = f_s - f_{IF} \quad (540 - 455)$$

$$= 85 \text{ KHz}$$

always f_o should be greater than f_s hence the o/p taken is

$$f_o + f_s = f_{IF}$$

$$f_o = f_{IF} + f_s$$

$$= 455 + 540$$

$$= 995 \text{ KHz}$$

Taking $f_s = 1650$ KHz

$$f_o = 455 + 1650 \quad (f_{IF} + f_s)$$

$$= 2105$$

So the range of local oscillator freq is 995 KHz – 2105 KHz

Tuning Range (not included in block diagram) : A ganged tunner is applied to the RF stage mixer and local oscillation. A parallel or series LC ckt known as tank ckt with resonant freq $f = \frac{1}{2\pi\sqrt{LC}}$ is used as ganged tunner by adjusting either L or C the ckt can be brought into resonance.

The frequency depends upon $f \propto \frac{1}{\sqrt{LC}}$. maximum frequency '$f_{max}$' $\propto \frac{1}{\sqrt{LC_{min}}}$ and minimum freq 'f_{min}' $\propto \frac{1}{\sqrt{LC_{max}}}$. The ratio b/wn max and min tuning freq is given by R_f.

$$R_f = \frac{f_{max}}{f_{min}} = \frac{\sqrt{C_{max}}}{\sqrt{C_{min}}} = \sqrt{R_C}$$

$$\boxed{R_f = \sqrt{R_C}} \qquad \boxed{R_C = R_f^2}$$

where R_C is the Coupling Capacitor ratio between maximum and minimum frequency given by $R_{cf} = \sqrt{R_C}$

Q. A Receiver tunes signals from 550 KHz to 1600 KHz with an IF of 455 KHz find the frequency tuning ranges and Capacitor tuning ranges of a local oscillator section and the RF section

- The output frequency tuned to for local oscillator, therefore

$f_o = f_{IF} + f_s$.

$f_s = 550$ KHz

$f_{min} = f_s + f_{IF}$

$= 550 + 455$

$= 1005$ KHz

$f_s = 1600$ KHz

$f_{max} = f_s + f_{IF}$

$= 1600 + 455 = 2055$

$\therefore R_f = \frac{f_{max}}{f_{min}} = \frac{2055}{1005} = 2.04$

$RC = R_f^2$

$RC = (2.04)^2 = 4.18$

In RF section

$f_{max} = 1600\ kHz$

$f_{min} = 550\ kHz$

$\therefore R_f =$ ~~fmax − fmin~~ $\frac{f_{max}}{f_{min}} = \frac{1600}{550} = 2.91$

$=$ ~~1600 − 550~~

$R_c = R_f^2 = (2.9)^2$

$R_c = 8.4$

The signal (base band signal) can