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Communication Electronics

Paper- DSE-3T

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Communication

Line communication (pair of two lines)

radio communication (wireless)

⊛ Structure of communication process —

It consists of three parts —

i) transmetter
ii) Medium (communication medium)
iii) reciver.

Transmetter	medium	reciver

⊛ Transmetter :=

A transmetter is the equipment which convertes a physical massage into an electrical signal.

⊛ Reciver :=

A receiver is the equipment which converts a electrical signal into a physical massage.

⊛ Line communication :=

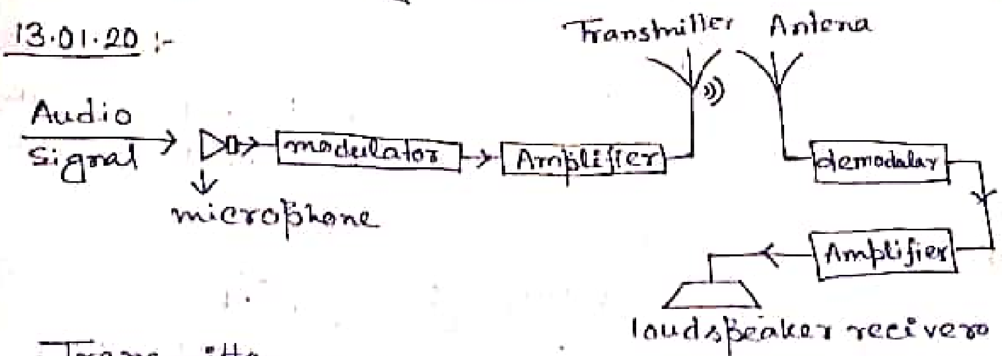
In the line communication the media of transmission is a pair of wires called transmission line.

Each transmission line can normally convay only one massage at a time and it is known as line chanel.

AM brodcast band used for audio brodcasting purposes, which frequencies are lid between 550 and 1600 kHz. FM brodcast band lies between 88 to 108 MHz.

AM → Amplitude modulation.
F.M → Frequency modulation.

13.01.20 :-



Transmitter →

frequency = 3000 Hz

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3000} = 10^5 m$$

What is noise?

⇒ Undesired electronic signal which are introduce with a massage signal during the transmission or processing of the latter are called noise.

Classification :-

Noise
- External noise
  - Erratic natural disturbence ($f < 30$ MHz) Example - lightening electric strom
  - Non-made noise ($1 MHz - 500 MHz$) Example - unde gear change,
- Internal noise
  - Shot noise (Random behaviour of charge carrier)
  - Thermal noise free

(*) The installation and mentenence :-

A transmission line is not only costly and complex but over croud in open space.

(*) Radio communication :-

A wireless massage is transmitted through open space by electro magnetic wave called radio wave.

This mood of communication is known as radio comunication.

Signal from various sourced are transmitted through the common medium i.e. open space.

radio waves are radiated from transmeter in open space trough a device called antenna. A ~~recee~~ receiving antenna intersects the radio waves at receiver.

(*) Range of Radio frequency :-

Class	range (Hz)	wave length (λ)
very low freq. (VLF)	10 KHz - 30 KHz	$3\times10^{1} - 10^{4}$ m
LF	30 - 300 KHz	$10^{4} - 10^{3}$ m
MF	300 KHz - 3 MHz	$10^{3} - 10^{2}$ m
HF	3 MHz - 30 MHz	10^{2} - 10 m
VHF	30 MHz - 300 MHz	10 - 1 m
UHF	above 300 MHz	bellow 1m.

(*) VLF and LF radio frequency is refer to as long wave and HF are called short wave.

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What is Noise:-

Undesired electrical signals which are introduced with a message signal during the transmission or processing of the latter, are called Noise.

Noise

- Internal Noise
  - Shot Noise (Random behavior of charge carriers)
  - Thermal Noise (Brownian motion of electrons)
- External Noise
  - Erratic Natural Disturbances (< 30MHz)
    Ex- Electrical storms, Lightnings
  - Mano-Made Noise (1MHz - 500MHz)
    Ex- undesired pick-up gear change, aircraft ignitions)

(ii) Signal to Noise Ratio:

The ratio of a signal power to the accompanying noise power is ~~reffer~~ referred as signal to Noise ratio and is denoted by S/N.

$$\frac{S}{N} = \frac{\overline{V_s^2}}{\overline{V_n^2}}$$

$$\text{or} \quad \frac{S}{N} = \frac{S_s(\omega)}{S_n(\omega)} = \frac{\text{power density spectrum of } \cancel{\text{Noise}} \text{ signal voltage}}{\text{power density spectrum of noise voltage}}$$

(iii) What is Amplitude Modulation:

Amplitude Modulation is the process by which amplitude of the carrier signal is varied in accordance with the instantaneous value (amplitude) of the modulating signal which typically contains information to be transmitted, but frequency and phase of carrier wave is constant

(ii) Mathematical Representation of AM:

Let the modulating signal, $V_m(t) = V_m \sin \omega_m t$ — (i)

Carrier signal, & $V_c(t) = V_c \sin \omega_c t$ — (ii)

where, V_m = amplitude of message signal in volts

V_c = " of carrier " "

According to the defination, the amplitude of the carrier signal is changed after modulation,

$$V_{AM}(t) = V_{AM} \sin \omega_c t$$

$$= V_{AM} \sin 2\pi f_c t$$

$$V_{AM}(t) = [V_c + V_m(t)] \sin 2\pi f_c t$$

$$= [V_c + V_m \sin 2\pi f_m t] \sin 2\pi f_c t$$

$$= V_c \left[1 + \frac{V_m}{V_c} \sin 2\pi f_m t\right] \sin 2\pi f_c t$$

$$\boxed{= V_c [1 + \beta \sin 2\pi f_m t] \sin 2\pi f_c t} \quad \text{(iii)}$$

where, $\beta = \frac{V_m}{V_c} \rightarrow$ modulating index of AM

(iii) What is Modulating Index?

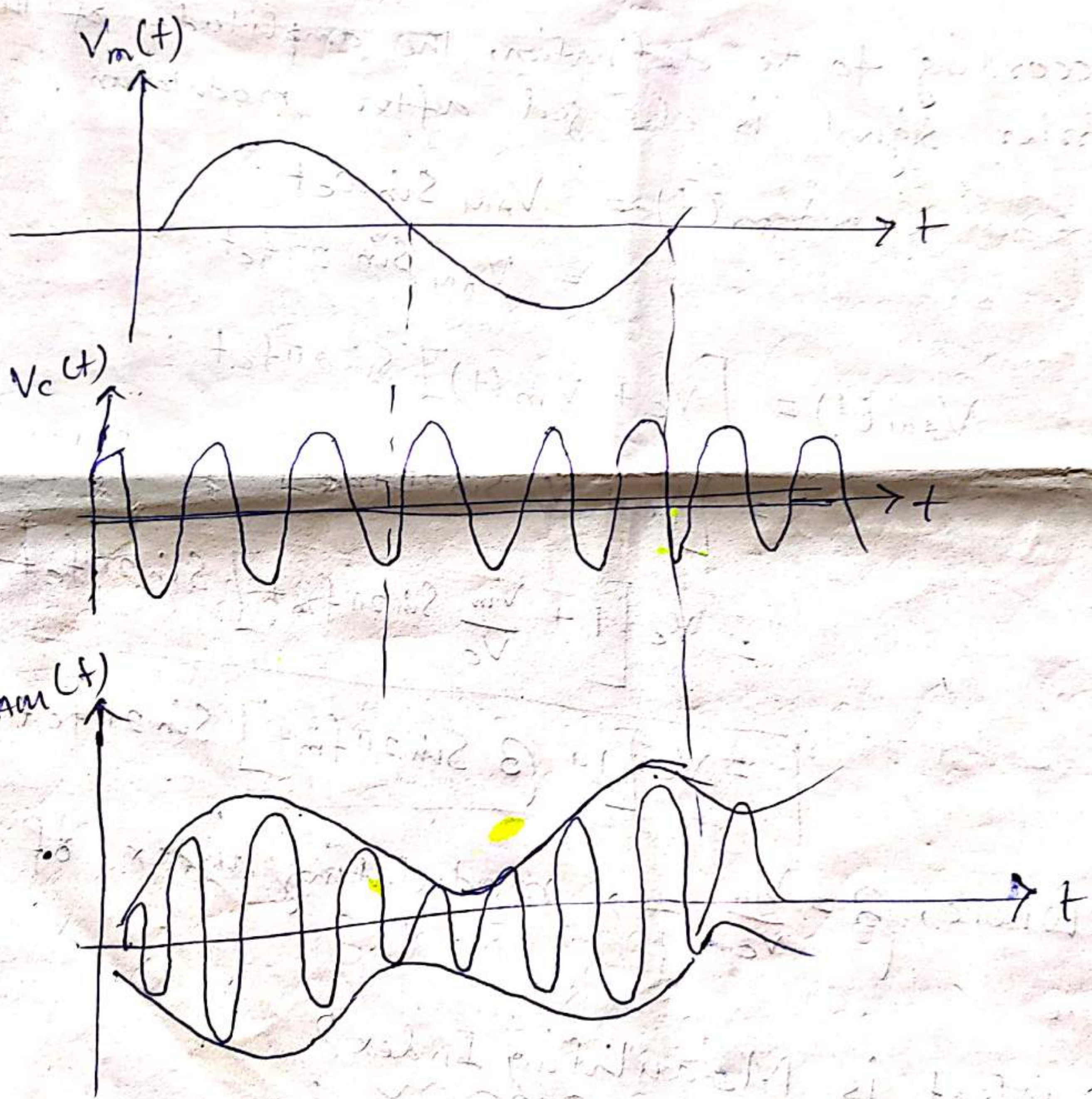
Modulation index is a term used to describe the amount of amplitude change present in a AM

Waveform: It is also called as co-efficient of modulation. Mathematically,

$$\beta = \frac{V_m}{V_c}$$

V_m = peak amplitude of the output waveform voltage

V_c = " " " of the un-modulated carrier ~~clear~~ voltage.



Percentage Modulation:-

If the Modulation index is expressed in percentage then it is called as percentage Modulation.

$$\boxed{\% \text{ Modulation} = \frac{V_m}{V_c} \times 100} \quad \text{—— (iv)}$$

Frequency Spectrum and Bandwidth of AM:-

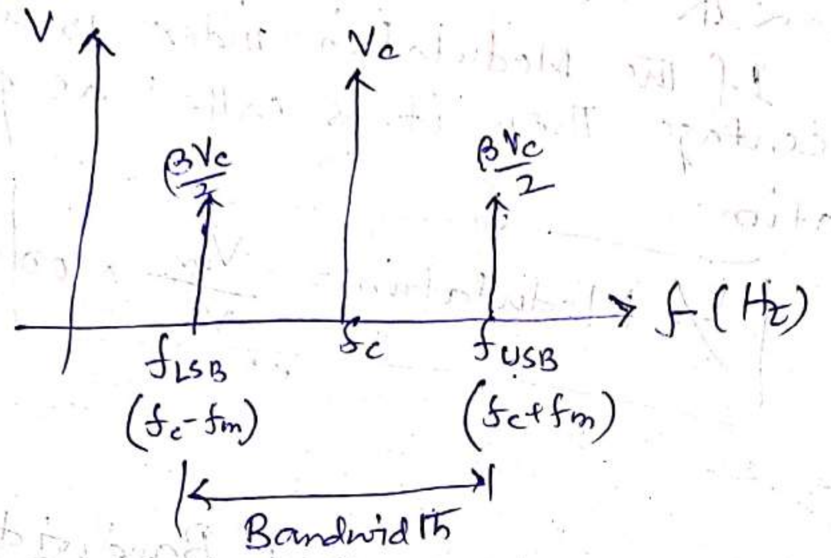
$$V_{AM}(t) = V_c(1 + \beta \sin 2\pi f_m t) \sin 2\pi f_c t$$

$$= V_c \sin 2\pi f_c t + \beta V_c \sin 2\pi f_m t \sin 2\pi f_c t$$

$$= V_c \sin 2\pi f_c t + \frac{\beta V_c}{2}\left[\cos 2\pi(f_c - f_m)t - \cos 2\pi(f_c + f_m)t\right]$$

$$= \underbrace{V_c \sin 2\pi f_c t}_{\text{Carrier}} + \underbrace{\frac{\beta V_c}{2}\cos 2\pi(f_c - f_m)t}_{\text{LSB (Lower Side Band)}} - \underbrace{\frac{\beta V_c}{2}\cos 2\pi(f_c + f_m)t}_{\text{USB (Upper Side Band)}}$$

Graphical Plot:-



So, AM wave contains full carrier, USB (upper side band) and LSB (Lower side band), hence it is also called as DSB-FC (Double side band - full carrier)

Bandwidth:-

Bandwidth of the signal can be obtained by taking the difference between highest and lower frequencies.

$$B.W. = f_{USB} - f_{LSB}$$
$$= (f_c + f_m) - (f_c - f_m)$$
$$= 2 \times f_m$$

Hence, Bandwidth of AM signal is twice of the the maximum frequency of modulating signal.

Advantages, Disadvantages and Applications of AM:-

⇒ **Advantages:-**

(i) AM wave can travel a long distance

(ii) Simple Modulators and demodulators.

(iii) AM is inexpensive

(iv) It covers longer area than FM

⇒ **Disadvantages:-**

(i) Wastage of Bandwidth is high

(ii) Poor performance due to Noise.

(iii) Inefficient use of transmitter power

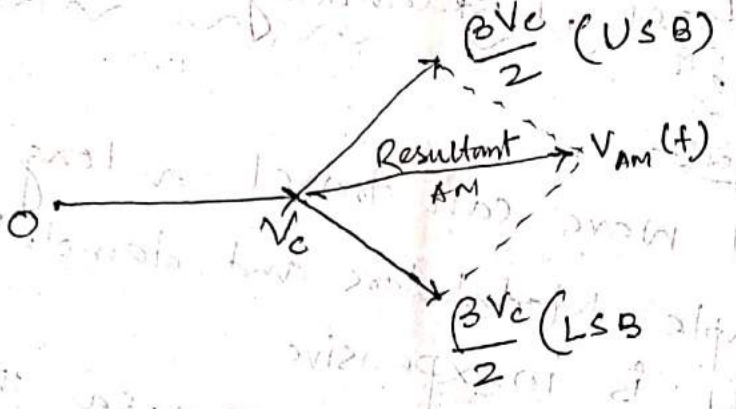
⇒ **Applications:-**

(i) Two way mobile radio communications such as citizens band (C.B.) radio.

(ii) Aircraft communication in the VHF frequency Range.

(iii) Low quality form of modulations that is used for commercial broadcasting of both audio and video signals.

⊙ Phasor (or) Vector Representation of AM:-



* The phasor for USB rotates in anticlockwise at an angular frequency of ω_m.
* The phasor for LSB rotates in clockwise at the same angular frequency ω_m.
* The upper side frequency rotates faster than the carrier ($\omega_m > \omega_c$) and the lower side frequency rotates slower ($\omega_m < \omega_c$)
* The resulting amplitude of the modulated wave at any instant is the vector sum of the two side-band phasors.
* V_c is carrier wave phasor taken as reference phasor and the resulting phasor is $V_{AM}(t)$
* The resultant phasor and carrier phasor are different in amplitude and has same phase (in phase) with each other.

Need for Modulation :-

Modulation is extremely necessary in communication system because of the following reasons —

(i) Avoids mixing of signals :-

One of the basic challenges facing by the communication engineering is transmitting individual messages simultaneously over a single communication channel. A method by which many signals or multiple signals and transmitted over a single communication channel is called multiplexing.

~~After~~ By using modulation, the baseband sound signals of same frequency range (i.e., 20 Hz to 20 KHz) are shifted to different frequency ranges. Therefore now each signal has its own frequency range within the total bandwidth.

(ii) Increase the range of communication:-

The energy of a wave depends upon its frequency. The greater the frequency of the wave, the greater the energy possessed by it. The baseband audio signals frequency is very low so they cannot be transmitted over large distances. On the other hand, the carrier signal has a high frequency or high energy. Therefore the carrier signal can travel large distances if radiated directly ~~at~~ into space.

After modulation the low frequency or low energy baseband signal is shifted from low frequency to high frequency. Hence it becomes possible to transmit information over large distances.

(iii) Reduces the effect of Noise:-

Noise is an unwanted signal that enters the communication system via the communication channel and interferes with the transmitted signals.

In modulation technique, a low energy or low frequency message signal is mixed with the high energy or high frequency carrier signal to produce new high energy signal which carries information to a long distance which getting affected by the external noise.

(iv) Reduces height of antenna :-

When the transmitted signal occurs over free space, the transmitting antenna radiates the signal out and receiving antenna receives it. In order to effectively transmitt and receive the signal, the antenna height should be approximately equal to the wavelength of a signal to be transmitted.

For instance, to radiate an audio signal frequency of 20 KHz directly ~~to~~ into space, we would need an antenna ~~big~~ height of 15000 meters.

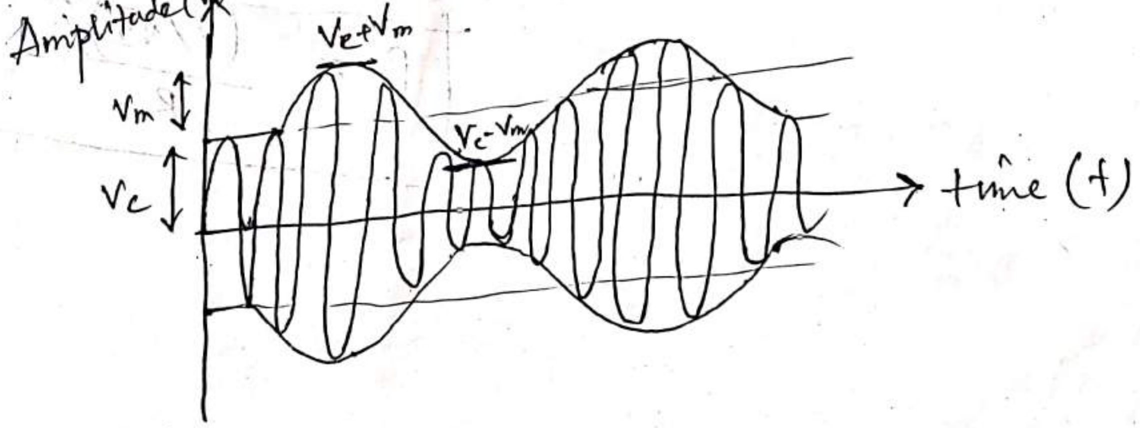
On the other hand, if the signal has been modulated by a carrier wave of 200 MHz. Then we would need an antenna length of 1.5 meter.

The antenna of this height is easy to construct.

(iii) The modulating signals preserved in the envelope of amplitude modulated signal only if,

$V_m < V_c$ then $\boxed{\beta < 1}$

(*) The envelope of AM signal does not reach the zero amplitude axis. Therefore the message signal is fully preserved in the AM envelope. An envelope detector can recover the message signal without any distortion.



AM Power distribution:

We know that AM signal has 3-components —

(i) Unmodulated carrier
(ii) Lower sideband
(iii) Upper sideband

∴ Total Power of AM wave is

$$P_t = P_c + P_{USB} + P_{LSB}.$$

$$V_{AM}(t) = V_c \sin 2\pi f_c t + \frac{\beta V_c}{2} \cos 2\pi (f_c - f_m)t$$
$$- \frac{\beta V_c}{2} \cos 2\pi (f_c + f_m)t$$

We know that,

$$\text{Ave. Power } (P) = \frac{(\text{RMS Voltage})^2}{\text{Load resistance}}$$

$$\boxed{P = \frac{(V/\sqrt{2})^2}{R} = \frac{V^2}{2R}.}$$

For carrier power (P_c):-

$$P_c = \frac{V_c^2}{2R}.$$

For sideband power (P_{SB}):-

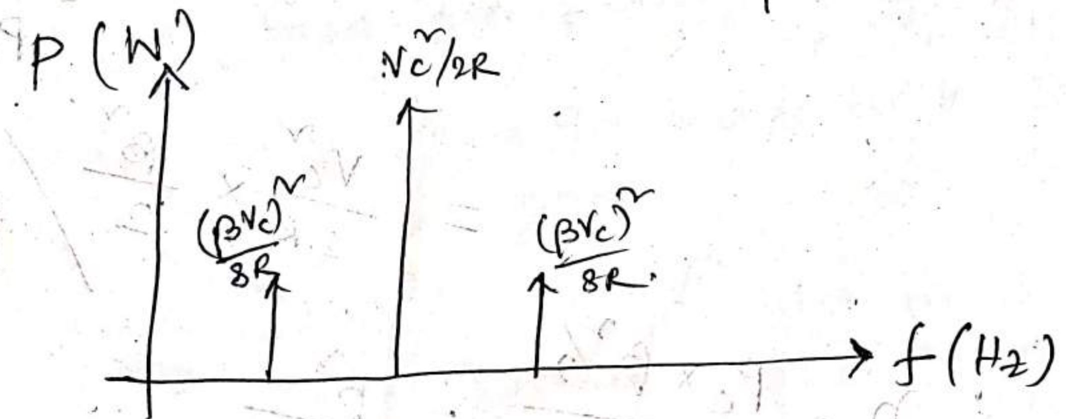
$$P_{USB} = P_{LSB} = \frac{\left(\frac{\beta V_c}{2}\right)^2}{2R} = \frac{(\beta V_c)^2}{8R}.$$

$$\therefore P_t = \frac{V_c^2}{2R} + \frac{(\beta V_c)^2}{8R} + \frac{(\beta V_c)^2}{8R}.$$

$$= \frac{V_c^2}{2R}\left[1 + \frac{\beta^2}{2}\right]$$

$$= P_c\left[1 + \frac{\beta^2}{2}\right]$$

$$\Rightarrow \frac{\beta^2}{2} = \frac{P_t}{P_c} - 1 \quad \Rightarrow \boxed{\beta = \sqrt{2\left(\frac{P_t}{P_c} - 1\right)}}$$



Power Spectra of AM

⊙ To find transmission efficiency (η):-

⇒ **Defn** :- Ratio of power contained in both sidebands to the total transmitted power. The amount of usefull message power present in AM wave is expressed by a term called transmission efficiency

$$\text{Efficiency}, \eta = \frac{\text{output}}{\text{input}}$$

$$= \frac{P_{USB} + P_{LSB}}{P_t}$$

$$= \frac{\frac{\beta^2 V_c^2}{8R} + \frac{\beta^2 V_c^2}{8R}}{P_c\left(1+\frac{\beta^2}{2}\right)}$$

$$= \frac{\beta^2 V_c^2/4R}{P_c(1+\beta^2/2)}$$

$$= \frac{V_c^2}{2R} \times \frac{\beta^2}{2} \Big/ P_c\left(1+\frac{\beta^2}{2}\right)$$

$$\therefore \eta = \frac{P_c \times \beta^2/2}{P_c(1+\beta^2/2)} = \frac{\beta^2}{2+\beta^2}$$

$$\therefore \% \eta = \left(\frac{\beta^2}{2+\beta^2}\right) \times 100$$

& $\eta_{max} = \left(\frac{1}{1+2}\right) \times 100$ $\quad \boxed{\beta_{max} = 1}$

$= 33.33\%$

Conclusion :-

Only 33.33% of power is used for transmission and the remaining power is wasted in the carrier transmission along with the sidebands.

Generation of AM waves :-

Non-Linear modulation :-

- Modulation is done at low power level
- The devices used in these modulators are operated in Non-linear region of its V-I characteristics.

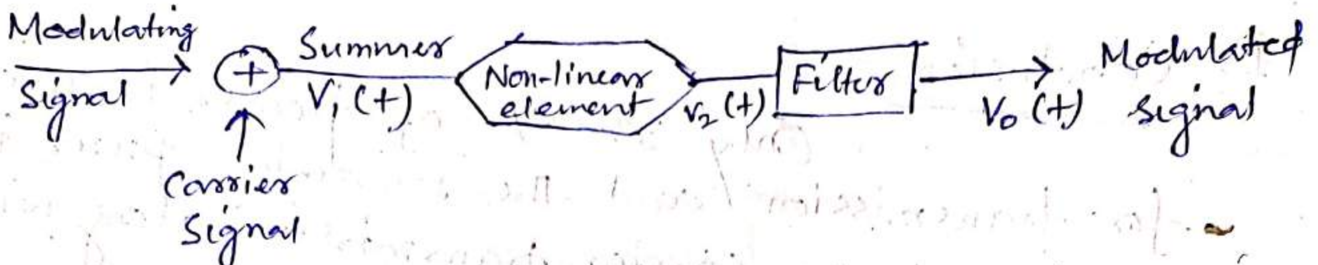
Square law modulator :-

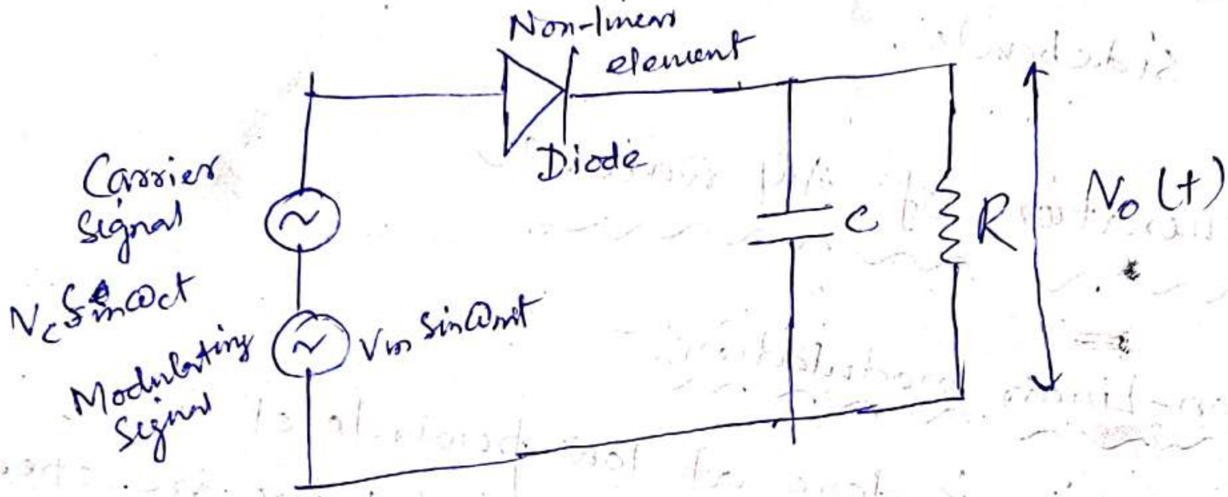
- Square law modulator consists of 3 parts :-

(i) **Summer** :- It is used to add both carrier and message signal

(ii) **Non-linear device** :- It can be used as a active elements like Diode, BJT (or) FET

(iii) **Filter** :- The filter can be BPF (Band pass Filter) used for extracting desired Modulated signal.





Operation:~

Message signal (audio frequency) and Carrier Signal (Radio frequency) applied at the input are super-imposed each other and makes the diode more forward biased during positive half cycle of input signal and Less forward biased during negative half cycle of message signal.

⊛ Thus the magnitude of the carrier component is greater during positive half cycle and lesser during negative half cycle of the modulating signal.

Analysis:

The modulating and carrier signals are connected in series with each other and their sum $V_1(t)$ is applied at the input of the non-linear ~~driving~~ devices such as diode (or) transistors.

$$V_1(t) = V_m(t) + V_c(t)$$

$$\therefore V_1(t) = V_m \sin\omega_m t + V_c \sin\omega_c t \quad \text{--- (1)}$$

Input-output relationship for non-linear device is,

$$V_2(t) = a_1 V_1(t) + a_2 V_1^2(t) \quad \text{--- (2)}$$

where a_1 and a_2 are constants.

By substituting equ^n (1) in equ^n (2)

$$V_2(t) = a_1\left[V_m \sin\omega_m t + V_c \sin\omega_c t\right] + a_2\left[V_m \sin\omega_m t + V_c \sin\omega_c t\right]^2$$

$$= a_1 V_m \sin\omega_m t + a_1 V_c \sin\omega_c t + a_2 V_m^2 \sin^2\omega_m t + a_2 V_c^2 \sin^2\omega_c t + 2a_2 V_m V_c \sin\omega_c t \sin\omega_m t$$

$$= a_1 V_m \sin\omega_m t + a_1 V_c \sin\omega_c t + 2a_2 V_m V_c \sin\omega_m t \sin\omega_c t$$

$$= a_1 V_m \sin\omega_m t + a_1 V_c \sin\omega_c t + \frac{\cancel{2}a_2 V_m V_c}{\cancel{2}}\left[\cos(\omega_c-\omega_m)t - \cos(\omega_c+\omega_m)t\right]$$

$$= a_1 V_m \sin\omega_m t + a_1 V_c \sin\omega_c t + a_2 V_m V_c\left[\cos(\omega_c-\omega_m)t - \cos(\omega_c+\omega_m)t\right]$$

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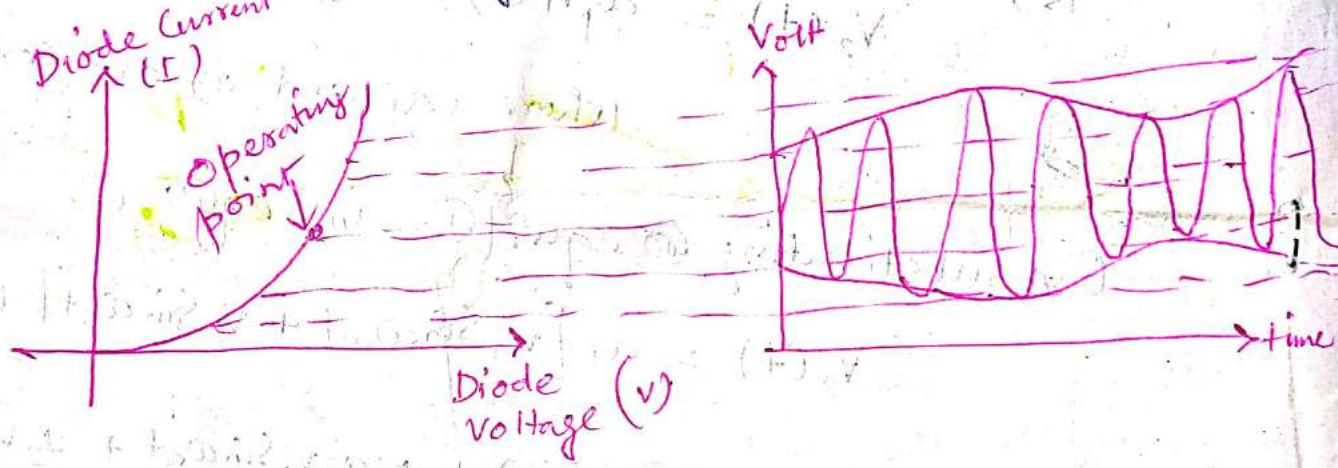
⇒ When BPF (LC tuned circuit) tuned to carrier frequency, so it allows only high frequencies lets ω_c; $(\omega_c-\omega_m)$ and $(\omega_c+\omega_m)$ and Block low frequency like ω_m.

$$\therefore V_o(t) = \underbrace{a_1 V_c \sin\omega_c t}_{\text{Carrier}} + a_2 V_m V_c \left[\underbrace{\cos(\omega_c-\omega_m)t}_{\text{LSB}} - \underbrace{\cos(\omega_c+\omega_m)t}_{\text{USB}}\right]$$

Hence AM wave is generated.



Angle Modulation :-

Definition :- The angle (frequency or phase) of the Carrier signal is varied according to the baseband (modulating signal) then it is called as Angle Modulation.

⇒ In angle modulation amplitude and frequency should remains constant.

⇒ Advantage of this Angle modulation is it provide Improved Immunity against Noise and distortion

Angle Modulation

→ Phase Modulation

→ Frequency Modulation

General Representation :-

Carrier signal ⟶ $V_c(t) = V_c \cos \omega_c t = V_c \cos 2\pi f_c t$

where, ω_c = angular carrier frequency

$$\boxed{V(t) = V_c \cos \theta(t)} \quad \text{—— (1)}$$

for phase modulation, $V_{PM}(t) = V_c \cos \theta_i(t)$ —— ②

where $\theta_i(t)$ = phase of the carrier signal

for frequency modulation, $V_{FM}(t) = V_c \cos f_i(t)$; where $f_i(t)$ = freq. of the carrier —— ③

Phase Modulation:-

⇒ Definition:- The phase of the carrier signal is changed in accordance with the modulating signal is called as phase modulation.

⇒ Representation of PM:-

$$\theta_i(t) = \omega_c t + K_p V_m(t) \quad \text{—— ④}$$

where K_p = phase sensitivity deviation unit = radians/volt.

Substitude equ^n ④ in ②,

$$V_{PM}(t) = V_c \cos[\omega_c t + K_p V_m(t)]$$

$$\boxed{V_{PM}(t) = V_c \cos[\omega_c t + K_p V_m \cos \omega_m t]} \rightarrow \text{PM wave}$$

⇒ Modulation index of PM:-

$$m_p \propto V_m.$$

$$\boxed{m_p = K_p V_m}$$

where, m_p = modulation index of PM signal

K_p = phase sensitivity deviation

V_m = Amplitude of modulating signal

⇒ Phase modulation index (m_p) is defined as a product of phase deviation and amplitude of modulating signal.

Frequency Modulation :-

⇨ **Definition :-** The frequency of the carrier signal is changed in accordance with the modulating signal remains other phase and amplitude maintained as constant. is called as Frequency Modulation.

⇨ **Representation of FM :-**

$$f_i(t) = \omega_c t + \int_0^t K_f V_m(t) \quad \text{———} \ (5)$$

where K_f = frequency sensitive deviation unit → Hertz/Volt.

Substituda equation (5) in equn (3),

$$V_{FM}(t) = V_c \cos\left[\omega_c t + \int_0^t K_f V_m \cos\omega_m t\right]$$

$$\boxed{V_{FM}(t) = V_c \cos\left[\omega_c t + \frac{K_f V_m}{\omega_m} \sin\omega_m t\right]} \rightarrow \text{FM Wave}$$

where K_f = deviation Sensitivity

⊙ **Modulation index of FM :**

$$m_f = \frac{K_f V_m}{\omega_m}.$$

or,

$$\boxed{m_f = \frac{K_f V_m}{2\pi f_m}}$$

We can rewrite this equn as follow —

$$m_f = \frac{\Delta f}{f_m} = \frac{\text{maximum frequency deviation (Hz)}}{\text{modulating frequency (Hz)}}$$

⊛ Modulating index of FM ; $\boxed{m_f >> 1}$

Frequency deviation (Δf):-

Δf is defined as change in the frequency of carrier with respect to unmodulated value after frequency modulation

$$\boxed{\Delta f \propto V_m}.$$

Percentage Modulation of FM:-

Percentage modulation is defined as the ratio of actual frequency deviation produced by the message signal to the maximum allowable frequency deviation in terms of percentage.

$$\% \text{ Modulation} = \frac{\text{Actual frequency deviation}}{\text{Maximum allowable frequency deviation}} \times 100$$

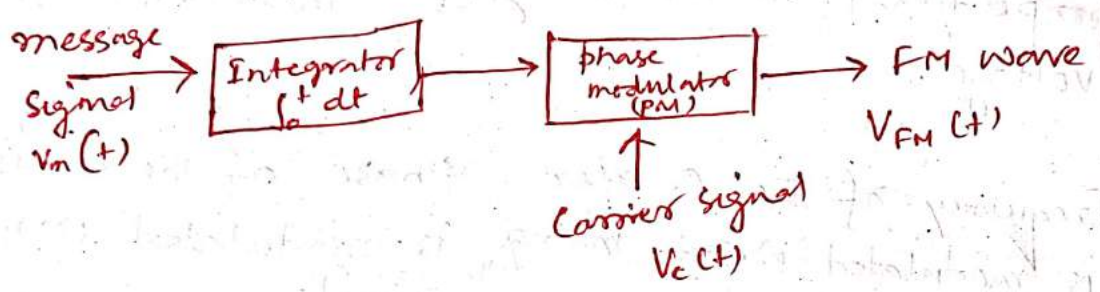
$$= \frac{\Delta f_{actual}}{\Delta f_{max}} \times 100$$

Deviation Ratio (DR):-

Deviation ratio (DR) is a ratio of maximum peak frequency deviation to the maximum modulating signal.

$$D.R. = \frac{\Delta f_{max}}{f_{m,max}}$$

⊙ Generation of FM wave from phase modulation:-



⊙ Consider a PM wave from which the FM waves are generated

$$V_{PM}(t) = V_c \cos\left[\omega_c t + K_p V_m \cos\omega_m t\right]$$

⇒ message signal gets integrated after passing through a Integrator with respect to a time interval of (0 to t)

$$= V_c \cos\left[\omega_c t + K_p \int_0^t V_m \cos\omega_m t\, dt\right]$$

$$\boxed{V_{FM}(t) = V_c \cos\left[\omega_c t + \frac{K_p V_m}{\omega_m}\sin\omega_m t\right]}$$

(iv) Comparision of FM and PM:-

S.No.	FM	PM
1.	Frequency deviation is proportional to modulating voltage.	Phase devation is proportional to modulating voltage.
2.	Frequency of the carrier is modulated w.r.t. message signal	Phase of the carrier signal is modulated w.r.t. message signal.
3.	Modulation index is increased as modulation frequency reduced $m_f = \frac{\Delta f}{f_m}$	Modulation index remains same if the modulating frequency is changed $m_p = K_p V_m$
4.	Better SNR	Less SNR
5.	Noise immunity is better than AM	Noise immunity is worst than AM
6.	FM is used widely in all application	PM is used in some mobile System.

Generation of FM:-

FM Modulators
- Direct method (Reactance modulator)
- Indirect Method

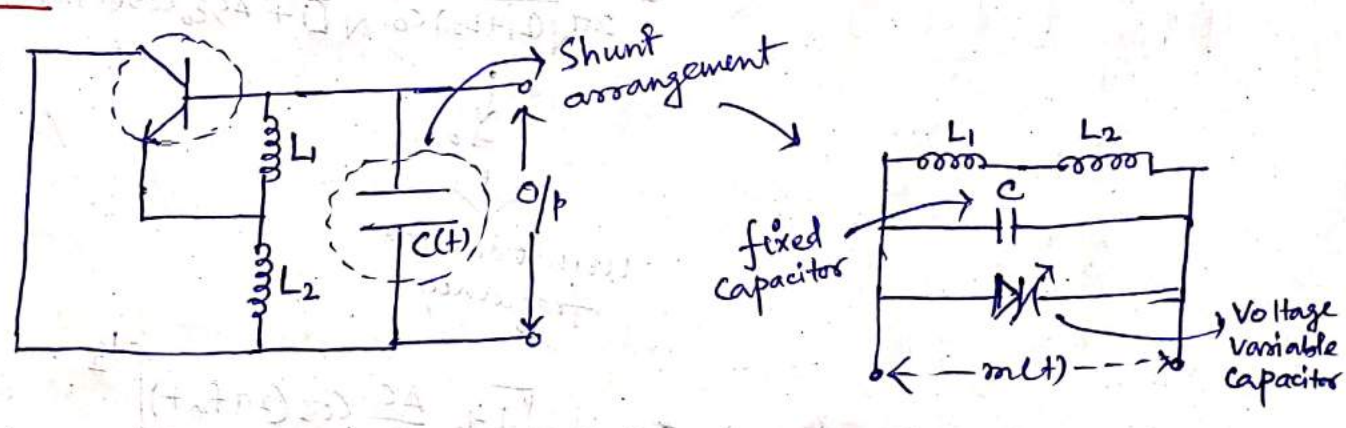
Direct method for generation of FM signal:-

→ In this method, frequency modulation is done by using a voltage controlled oscillator (VCO).

VCO ≈ Sinusoidal oscillator with the reactive element (i.e. capacitive element)

"The frequency of an oscillator is directly controlled by the message signal m(t) i.e. voltage signal"

An FM generator which uses Hartley oscillator is shown in fig. —



Assume; $c(t)$ ≈ Instantaneous value of capacitance

The frequency of oscillation,

$$f_i(t) = \frac{1}{2\pi\sqrt{(L_1+L_2)\,C(t)}}$$

The frequency determining network consist of two inductors L_1 and L_2 and a capacitor C. The capacitor is assumed to consists of a fixed capacitor shunted by voltage variable capacitor such as Varactor diode ($C' \propto \frac{1}{W}$)

W → width of depletion region

Here, $\boxed{C(t) = C_0 + \Delta C \cos(2\pi f_m t)}$

C_0 → Total Capacitance in absence of modulation

ΔC → Max. change in capacitive value

After substitution,

$$f_i(t) = \frac{1}{2\pi\sqrt{(L_1+L_2)(C_0+\Delta C\cos 2\pi f_m t)}}$$

$$= \underbrace{\frac{1}{2\pi\sqrt{(L_1+L_2)C_0}}}_{f_0 \text{ — unmodulated frequency}} \cdot \frac{1}{\sqrt{[1+\Delta C/C_0 \cos(2\pi f_m t)}}$$

$$\therefore f_i(t) = f_0\left[1+\frac{\Delta C}{C_0}\cos(2\pi f_m t)\right]^{-1/2}.$$

If, $\Delta C << C_0$

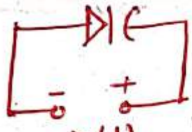
$$\therefore f_i(t) \approx f_0\left[1 - \frac{1}{2}\frac{\Delta C}{C_0}\cos(2\pi f_m t)\right]$$

$$\boxed{f_i(t) = f_0 + \Delta f \cos(2\pi f_m t)}$$ Here, $\frac{\Delta C}{2C_0} = -\frac{\Delta f}{f_0}$

↓

Generally, NBFM is generated by this method

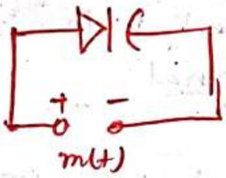
Case (i) :- $m(t) = +ve$

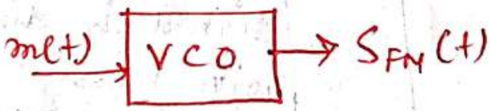


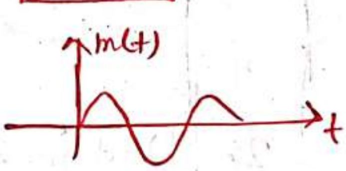
$$f_i = \frac{1}{2\pi\sqrt{(L_1+L_2)(C+C')}}$$

Reverse bias ↑ ⟶ W ↑ ⟶ C′ ↓ ⟶ f_i ↑

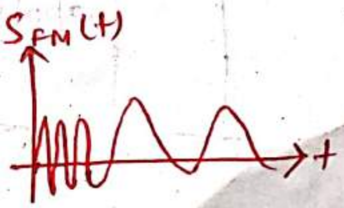
Case (ii) :- $m(t) = -ve$







Forward bias ↑ ⟶ W ↓ ⟶ C′ ↑ ⟶ f_i ↓



Advantages of Direct method :-

i) Less expensive
ii) Circuit is very simple to design

Disadvantages of Direct method :-

i) LC oscillator frequency is not stable
ii) Very high distortion
iii) Not suitable for broadcasting and communication

Comparision of direct and Indirect FM :-

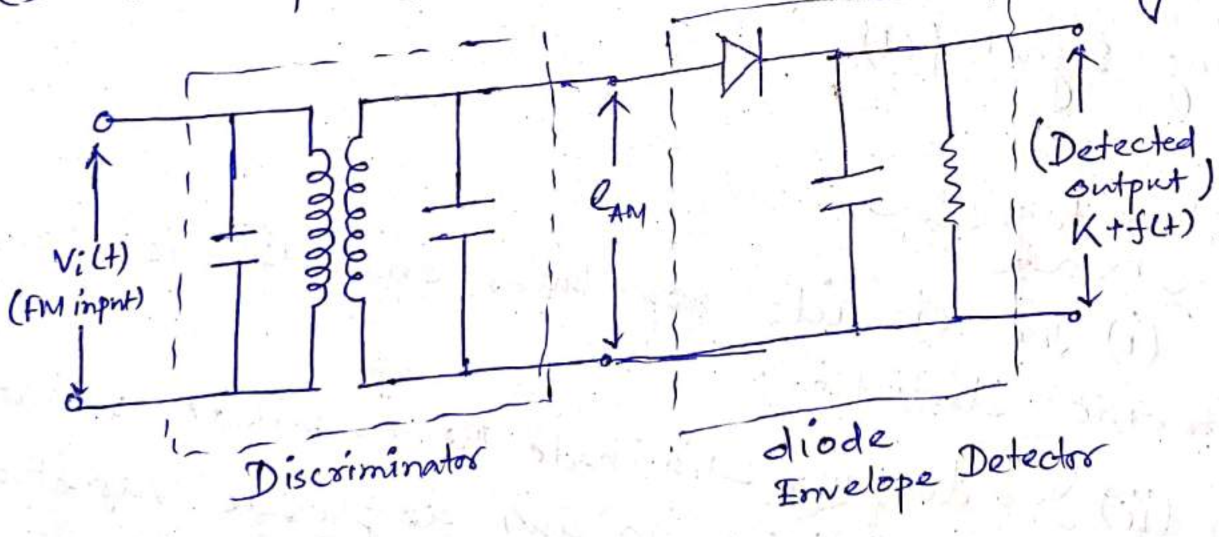
SL.No.	Direct method	Indirect Method
1.	Frequency of carrier signal is directly varied with message signal	Frequency of carrier signal is indirectly varied with message signal
2.	Used in low-capacitance application Ex- Remote Control	Radio and TV Broadcasting

☐ Demodulation of FM:-

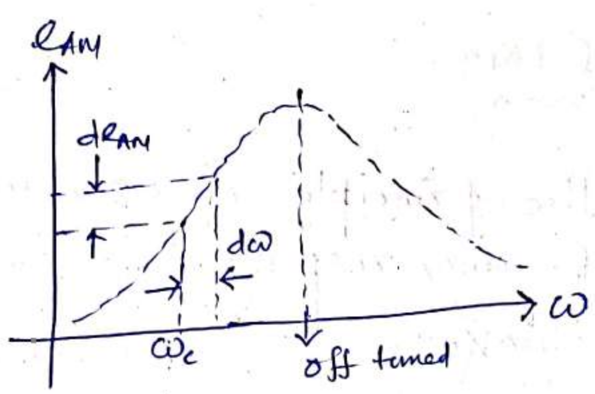
➡ **Slope detector:-** The principle of operation depends on the slope of the frequency response characteristic of a frequency selective network.

⊙ Simple slope Detector (Single-tuned Circuit):

The circuit diagram of this detector is shown in fig. (a). The circuit consists of a tuned circuit which is slightly detuned from the carrier frequency ω_c. The circuit converts the FM signal into an AM signal. The AM signal is then detected by a diode detector. The frequency response characteristic of this detuned (slightly off-tuned at ω_c) is shown in fig. (b). The slope of the characteristic curve is given as.



(a)



(b)

$$\alpha = \frac{de_{AM}}{d\omega}$$

A small variation in the frequency $(\Delta\omega)$ of the input signal will produce a change in the amplitude of e_{AM} by an amount $\alpha(\Delta\omega)$. Thus, frequency variations at the input of the discriminator produces amplitude variations at its output. In this way, the FM signal is converted to an AM signal, which is detected by an envelope detector to recover the modulating signal $f(t)$.

Disadvantages:-

(i) The circuit's non-linear characteristic causes a harmonic distortion.

(ii) It does not eliminate the amplitude variations and the output is sensitive to any amplitude variations in the input FM signal, which is not a desirable feature.

Comparision of FM and AM:-

SL. NO.	Frequency Modulation	Amplitude Modulation
1.	Frequency of the carrier is varied accordance with modulating signal.	Amplitude of the carrier is varied accordance with modulating signal.
2.	Less Noise and interference	More Noise and interference
3.	All power is used for transmission	Carrier power and one sideband power is useless
4.	Bandwidth is large $\boxed{B.W. = 2(f_m + \Delta f)}$	Narrow Bandwidth $\boxed{B.W. = 2f_m}$
5.	FM transmission and reception equipment are more complex	AM equipment is less complex

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