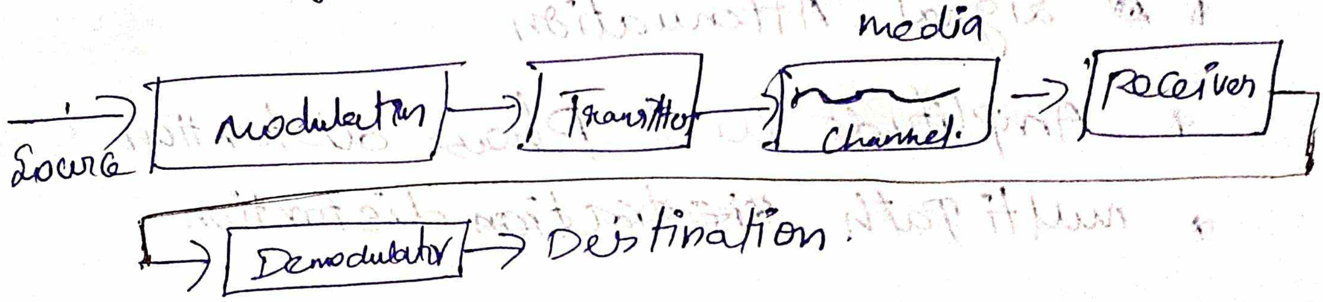
20ITT41 - Principle of communication (POC)

Communication:

Process of data from one point to another point, source to destination.

Modulation

Process of placing a message signal over some carrier to make it suitable for transmission over long distance.



Demodulation

Process of separting a message signal from the modulated carrier signals.

* message signal, carrier signal, Modulated carrier signal

Simple
↓
source to destination

Duplex
↓
Half duplex

Full duplex.

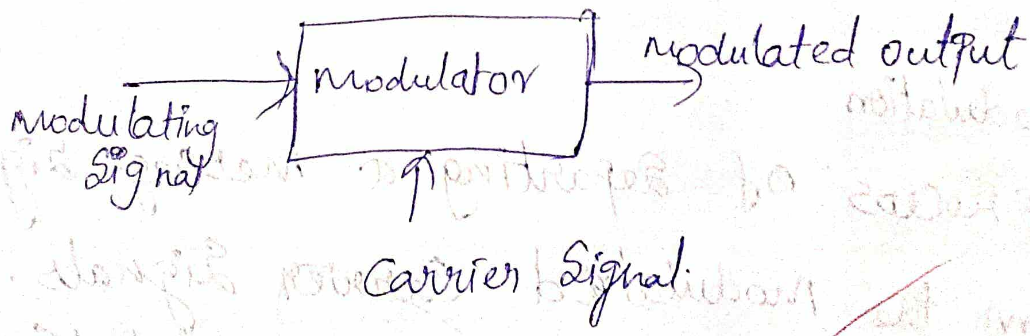
Analog and digital Communication.

Need for modulation:

* high range transmission
* Quality transmission
* To avoid overlapping of signals.

Data loss due to

* Additive noise ~~interferens~~ interference
* Signal Attenuation
* Amplitude and Phase distortion
* multi path ~~distraction~~ distortion



Types of modulation.

* Analog modulation
  * Amplitude modulation (AM) (Low range)
  * Angle modulation
    * Frequency (FM)
    * Phase (PM)
* Pulse modulation.
* Digital modulation

* From a low frequency they have high noise interference
* From a high frequency they have low noise interference.

* multiplexing

* Transmission Antenna height

$$h = \frac{\lambda}{2}$$

$\lambda = \frac{c}{F}$ → speed of light
→ Frequency

Calculate the height of Antenna to be install if frequency $F = 5KH_z$ and $500KH_z$ 3×10^8 m

$$\lambda = \frac{3 \times 10^8}{5KH_z}$$

$$h = \frac{c}{2f}$$

$$= \frac{3 \times 10^8}{2 \times 5 \times 10^3}$$

$$= 3 \times 10^4$$

$$= 30000$$

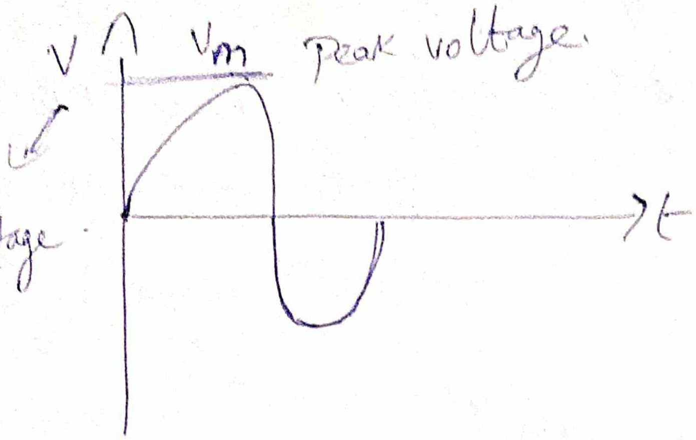
$$= 300 \times 10^2$$

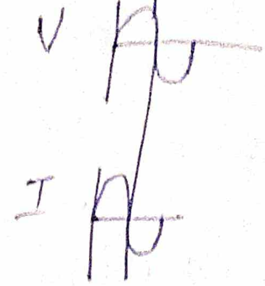
$$= 300m.$$

$$h = \frac{3 \times 10^8}{2 \times 500 \times 10^3}$$

$$= \frac{3 \times 10^8}{1000 \times 10^3}$$

$$= \frac{3 \times 10^8}{10^6}$$



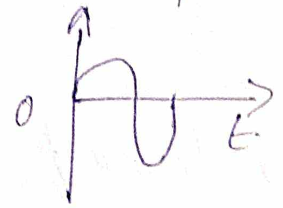


The ϕ (phase) is 0

$V = V_m \sin \omega t$

ωt → Phase angle ϕ

V_{p-p}



For a sine signal. Find the maximum value if $V_{p-p} = 10V$ also find the value of voltage $\theta = 90°, 45°$.

$$V_m = \frac{\sin \omega t}{V}$$

$$V_{p-p} = \frac{10V}{2}$$

$$\boxed{V_m = 5V}$$

$V = V_m \sin\theta$

$= 5 \sin 45°$

$= \frac{5}{\sqrt{2}}$

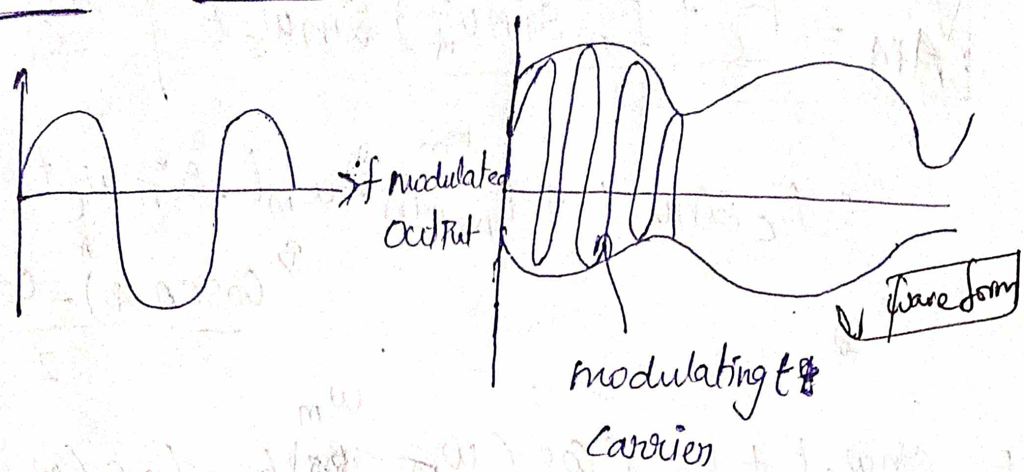
$= \frac{5}{1.414}$

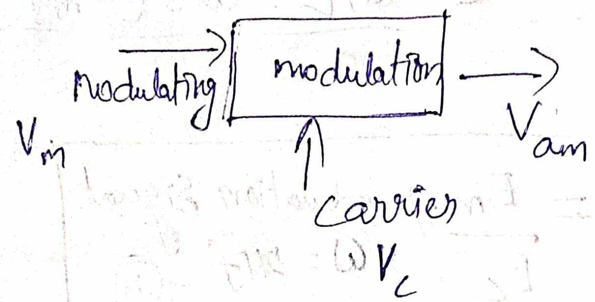
$\boxed{V = 3.536}$

$V = 5 \sin 90°$

$\boxed{V = 5}$

Amplitude modulation





$V_m = E_m \sin \omega_m t$ ∴ $\omega = 2\pi f$

Instantaneous Value $V_m = E_m \sin 2\pi f_m t$ ∴ f_c - frequency of carrier signal

$= E_m \sin \omega_m t$ f_m - frequency of modulating signal

$V_c = E_c \sin \omega_c t$

$= E_c \cdot \sin 2\pi f_c t$

V_{am}

- The process of changing the characteristics (amplitude) of carrier signal with respect to instantaneous change in modulating signal is known as Amplitude modulation.
- As modulating signal is superimposed with carrier signal to get modulated output, the equation for modulated output is given by

$$\boxed{V_{AM} = (E_c + E_m \sin \omega_m t) \sin \omega_c t}$$

E_m

$$= E_c \sin \omega_c t + E_m \sin \omega_m t \cdot \sin \omega_c t$$

$$\frac{\cos(A-B) - \cos(A+B)}{2}$$

$$= E_c \sin \omega_c t + E_m \left[\frac{\cos(\omega_c - \omega_m)t - \cos(\omega_m + \omega_c)t}{2} \right]$$

$$\boxed{\text{Modulation index } (m) = \frac{E_m}{E_c} \; ; \; \omega = 2\pi f \quad -②}$$

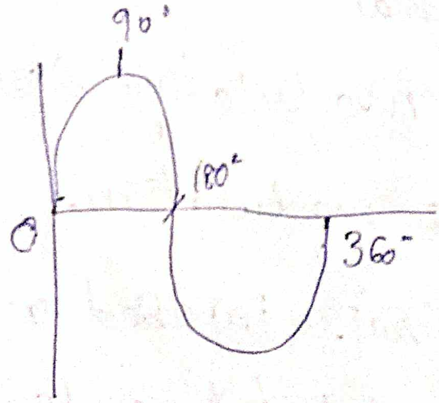
E_m → modulation signal

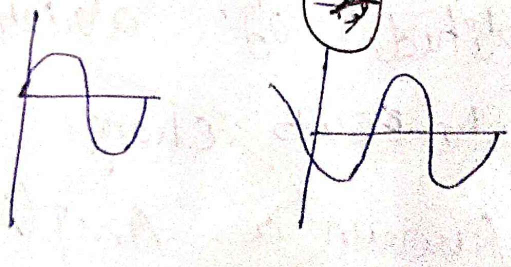
E_c → Carrier signal.

$$E_m = m \cdot E_c \quad -①$$

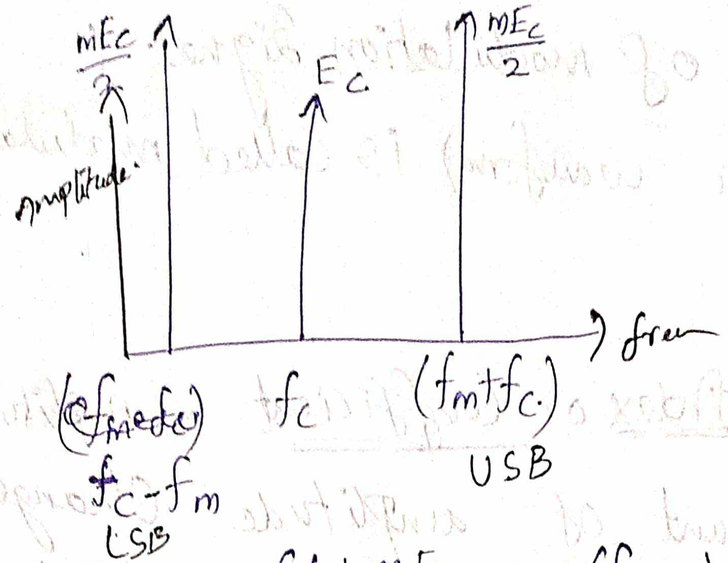
~~$V_{AM} = E_c \sin \omega_c t + \frac{m E_c}{2} \cos 2\pi f$~~

$$V_{AM} = \underbrace{E_c \sin 2\pi f_c t}_{①} + \underbrace{\frac{m E_c}{2} \cos 2\pi (f_c - f_m) t}_{②} - \underbrace{\frac{m E_c}{2} \cos 2\pi (f_m + f_c) t}_{③}$$





$$\cos \theta = \sin(90 - \theta)$$



$$V_{AM} = E_c \sin 2\pi f_c t + \frac{mE_c}{2}\cos 2\pi (f_{LSB}) t - \frac{mE_c}{2}\cos 2\pi (f_{USB}) t$$

Bandwidth = higher − lower

$$= f_{USB} - f_{LSB}$$

$$= \cancel{f_c} + f_m - (f_c - f_m)$$

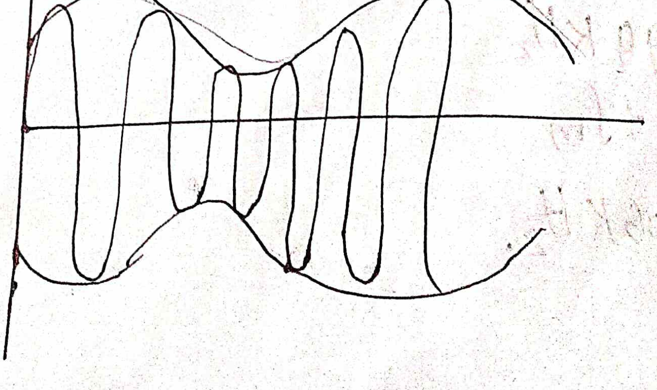
$$- \cancel{f_c} + f_m$$

$$\boxed{= 2f_m}$$

Bandwidth

The difference between upper side band frequency and lower side band frequency is called bandwidth (B) or (BW)

Amplitude envelope



The slope of modulation signal (modulation waveform) is called modulation envelope.

<u>Modulation Index</u> or <u>Coefficient</u> or Amplitude

The amount of amplitude change (modulation) present in a output of modulation waveform is termed as Modulation Coefficient.

$$M = \frac{E_m}{E_c}$$

① For an amplitude modulated wave carrier signal frequency is 200 KHz and modulating frequency is 6 KHz. Find

i) frequency limits (upper & lower side band)

ii) Bandwidth

iii) Draw the frequency spectrum.

$f_c = 200\,KH_z$, $f_m = 6\,KH_z$

i) $LSB = f_c - f_m$

$= 200 - 6$

$= 194\,KH_z$

$USB = f_c + f_m$

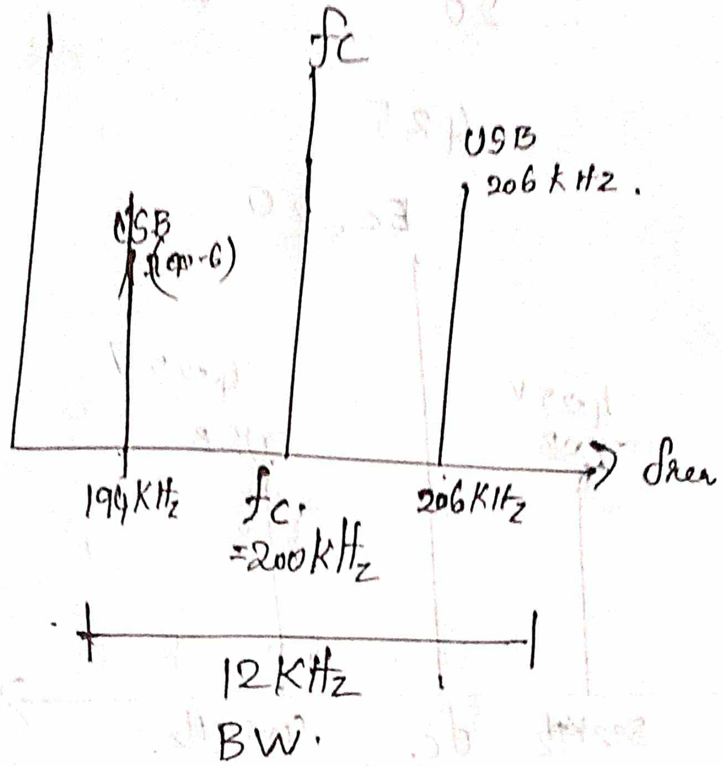
$= 206\,KH_z$.

ii) Bandwidth $= 2f_m$

$= 2(6)$

$= 12\ kHz$

iii)



5) For an amplitude modulation, carrier frequency = 400 kHz with, $20V_c$ maximum and modulating frequency = 8 kHz and with 8.5 V max :

i) Side band limits & modulation coefficient.

ii)

$LSB = f_c - f_m$

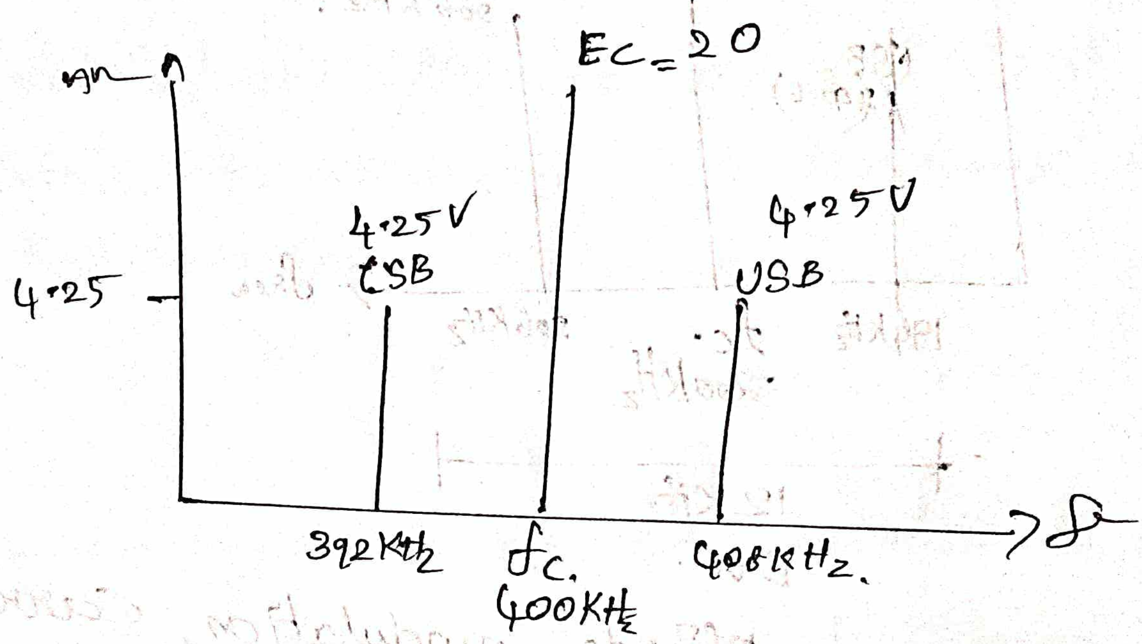
$= 400 - 8$

$= 392\ kHz$

$USB = 408\ kHz$

$$m = \frac{E_m}{E_c} = \frac{8.5}{20} = 0.425$$

$$= \frac{0.425 \times 20}{2} = 4.25\,V$$



DSBFC → Double side band Full Carrier

Problems:

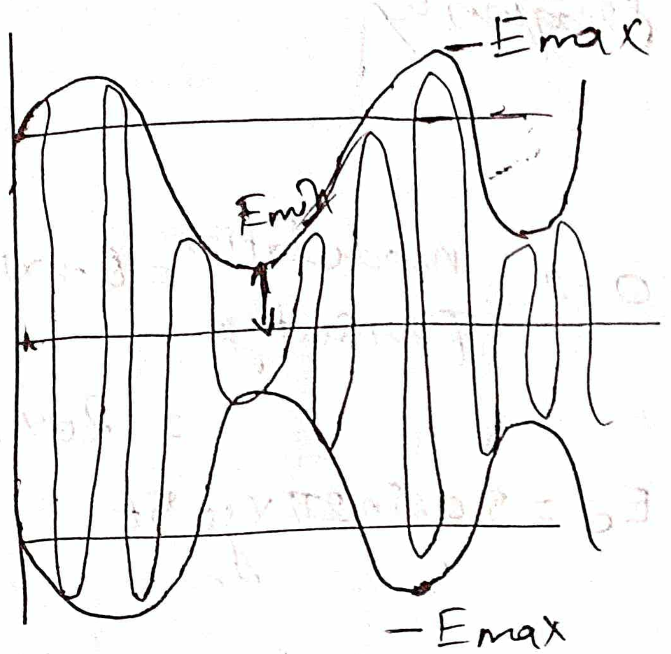
1) amplitude modulation DSBFC is modulated with a carrier of $60 \sin \omega_c t$ & modulated signal of $30 \sin \omega_m t$. determine the modulation index & percentage modulation

(2) Define amplitude modulation? mention their needs of modulation

(3) Show the amplitude modulation envelope.

(4) Draw the frequency spectrum for $LSB = 121 \frac{KH}{2}$ $USB = 139 kHz$ with $E_c = 8V$ and $m = 0.4$

(5) derive the amplitude modulation output with voltage equation.



$$E_m = \frac{E_{max} - E_{min}}{2}$$

$$E_c = \frac{E_{max} + E_{min}}{2}$$

$$\boxed{m = \frac{E_m}{E_c} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}}$$

(1) In carrier Amplitude after amplitude modulation various between 4V & 1V. Calculate the depth of modulation.

$$m = \frac{3}{5} = \frac{4-1}{4+1}$$

$$= 0.6 V$$

(2) An audio frequency signal $10 \sin 2\pi \times 500t$ is used to amp modulate a carrier of $50 \sin 2\pi \times 10^5 t$. Calculate

i) modulation Index.

ii) Sideband frequency

iii) Amp of sideband frequency

iv) bandwidth.

i) $m = \frac{10}{50} = \frac{1}{5} = 0.2$ modulation percentage $= 0.2 \times 100$

$= 20\%$

$E_m = 10 \sin 2\pi \times \underset{f_m}{500} t$ $E_c = 50 \sin 2\pi \times \underset{f_c}{10^5} t$

ii) $USB = f_c + f_m$

$= 100000 + 500$

$= \frac{100500}{1000}$

$= 100.5$ KHz

& $LSB = f_c - f_m$

$= 100000 - 500$

$= \frac{99500}{100}$

$= 99.5$ KHz

iii) $\frac{ME_c}{2}$

$= \frac{(0.2)\times 50}{2}$ 	$\frac{5.0\times 2}{100}$

$= \frac{10.0}{2}$

$\boxed{= 5V}$

iv) $2f_m$

$= 2\times 500$

$= \frac{1000}{1000}$

$\boxed{= 1KHz}$

AM Power distribution

$P = V \cdot I$

$V_{Am}(t) = \frac{E_c}{2} \sin \omega_c t + \overbrace{\frac{mE_c}{2} \cos 2\pi (f_c - f_m)t}^{LSB} -$

$\underbrace{\frac{mE_c}{2} \cos 2\pi (f_c + f_m)t}_{USB}$

A signal has 3 components

* Carrier signal
* LSB
* USB

hence total power is given by

$$P_{Total} = P_C + P_{LSB} + P_{USB}$$

$$P_C = \frac{V^2}{R} \rightarrow \frac{V_{Rms}^2}{R} = \frac{\left(\frac{V_m}{\sqrt{2}}\right)^2}{R} \quad \left[\because V_{Rms} = \frac{V_m}{\sqrt{2}}\right]$$

$$P_C = \left(\frac{V^2}{R}\right) = \frac{(E_C/\sqrt{2})^2}{R}.$$

$$\boxed{= \frac{E_C^2}{2R}} \text{ — } (1)$$

Power of sidebands given by

$$P_{LSB} = P_{USB}$$

$$= \frac{V_{Rms}^2}{R}$$

$$= \frac{\left(\frac{mE_c}{2}/\sqrt{2}\right)^2}{R} = \frac{m^2 E_C^2}{4 \times 2}$$

$$= \frac{m^2 E_c^2}{8R} \quad — (2)$$

Substitute the eqn (1) and (2) -

$$P_{Total} = \frac{E_c^2}{2R} + \frac{m^2 E_c^2}{8R} + \frac{m^2 E_c^2}{8R}$$

$$= \frac{E_c^2}{2R}\left[1 + \frac{m^2}{4} + \frac{m^2}{4}\right]$$

$$= \frac{E_c^2}{2R}\left[1 + \frac{m^2}{2}\right]$$

$$\boxed{P_{Total} = P_c\left(1 + \frac{m^2}{2}\right)}$$

Problem

1) Find the total power delivered to 600Ω the load. $E_c = 50 \sin 2\pi \times 10^5 t$ and

$E_m = 10 \sin 2\pi \times 500t$

$$m = \frac{10}{50} = \frac{1}{5} = 0.2$$

$$P_c = \frac{E_c^2}{2R}$$

$$= \frac{50^2}{2(600)} = \frac{2500}{1200} = 2.08.$$

$$= 2.08\left(1+\frac{(0.2)^2}{2}\right)$$

$$= 2.08\,(1+0.02)$$

$$= 2.08\,(1.02)$$

$$\boxed{= 2.125\,W}$$

(2). A 400W carrier is modulated to a depth of 80%. Calculating total power.

$$P_{Total} = P_c\left(1+\frac{m^2}{2}\right)$$

$$= 400\left(1+\frac{(0.8)^2}{2}\right)$$

$$= 400\,(1+0.32)$$

$$= 400 \times 1.32$$

$$\boxed{= \cancel{401.32.00}}$$

$$= 528\,W$$

1. For an AM envelope $V_{max} = 30\,Vp$ & $V_{min} = 10\,Vp$ determine a) unmodulated carrier amplitude
b) modulated carrier amplitude
c) percentage modulation.

a) $V_{max} = 30\,Vp$ and $V_{min} = 10\,Vp$

$$E_C = \frac{V_{max} + V_{min}}{2}$$

$$= \frac{30+10}{2}$$

$$= \frac{40}{2}$$

$$\boxed{E_C = 20}$$

b) $\frac{30+10}{2} = \frac{40}{2} = \boxed{20}$ modulated carrier amplitude

c) $m = \frac{E_m}{E_C} = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{30-10}{30+10} = \frac{\cancel{20}}{\cancel{40}} = \frac{1}{2}$

$$\boxed{M = 0.5}$$

$$m = 0.5 \times 100$$

$$\boxed{= 50\%}$$

(2) Am amplitude modulation DSBFC Peak unmodulated carrier voltage $E_c = 15V$ and load resistance $R_c = 15\Omega$ Determine the following for $m=1$, $m=0.5$

a) Power of carrier

b) Upper and lower side bands

c) Total side band power.

a) $P_c = \frac{E_c^2}{2R} = \frac{15^2}{2 \times 15} = \frac{255}{30}$

$$\boxed{P_c = 7.5}$$

b) $m=1$

$$LSB = USB = \frac{m^2 E_c^2}{8R}$$

$$= \frac{1 \times 15 \times \cancel{15}}{8 \times \cancel{15}} = \frac{15}{8}$$

$$\boxed{= 1.875W}$$

$m = 0.5$

$$= \frac{m^2 E_c^2}{8R} = \frac{(0.5)^2 \times 15 \times \cancel{15}}{8 \times \cancel{15}}$$

$$\frac{0.25 \times 15}{8} = \frac{3.75}{8} = \boxed{0.4688\,W}$$

c. $m = 1$

Total side band power

$$= 1.875 + 1.875 = 3.7W$$

$m = 0.5$

$$0.4688 + 0.4688 = 0.9376W$$

d. $m = 1$

$$P_{total} = P_C\left(1 + \frac{m^2}{2}\right)$$

$$= 7.5\left(1 + \frac{1}{2}\right)$$

$$= 7.5\left(\frac{3}{2}\right)$$

$$\boxed{= 11.25W}$$

$M = 0.5$

$$P'_{Total} = P_c\left(1 + \frac{M^2}{2}\right)$$

$$= 7.5\left(1 + \frac{0.25}{2}\right)$$

$$= 7.5\left(\frac{2.25}{2}\right)$$

$$= 7.5 \times 1.125$$

$$\boxed{P_{Total} = 8.4375\,W}$$

Categories of modulation Index (m)

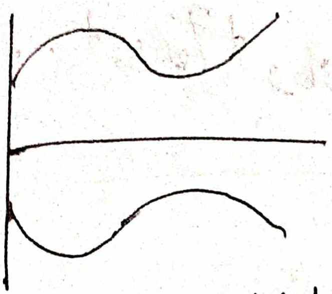
1) Critical modulation, $m = 1$ $E_m = E_c$

2) under modulation, $E_m < E_c$

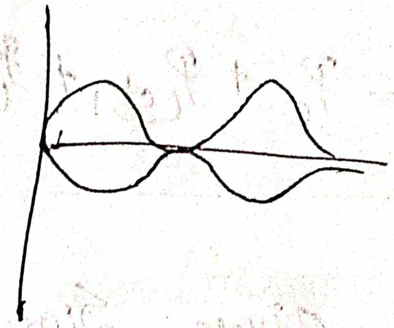
3) over modulation. $E_m > E_c$

~~wecant~~

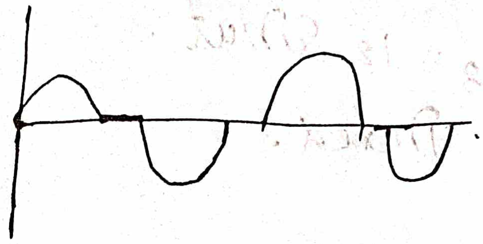
In over modulation the amplitude of message signal is greater than the amplitude of carrier signal So the envelope no longer resembles the modulating signal. Hence the information cannot be retrieved also the information is lost to same extend in this case



under modulation



critical modulation.



over modulation

when modulating signal has several frequencies with one carrier signal we have combined coefficient has the sequence of Quadratic same of individual modulation. index.

$$m = \frac{E_m}{E_c}, \quad m_1 = \frac{E_{m1}}{E_c}, \quad m_2 = \frac{E_{m2}}{E_c}$$

$$m = \sqrt{m_1^2 + m_2^2 + \cdots m_n^2}$$

$$P_{USB} = P_{CSB} = \frac{m^2 E_c^2}{8R} \Rightarrow P_{USB_1} = P_{CSB_1} = \frac{m_1^2 E_c^2}{8R}$$

$$\boxed{P_t = P_c + P_{CSB_1} + P_{USB_1} + P_{CSB_2} + P_{USB_2} + \dots}$$

(1) For the given signals.

$e_c = 10 \sin \omega t$, $e_{m_1} = 25 \sin \omega t$

$e_{m_2} = 15 \sin \omega t$ $e_{m_3} = 12 \sin \omega t$.

Find the modulation index.

$$m_1 = \frac{E_{m_1}}{E_c} = \frac{25}{10} = 2.5$$

$$m_2 = \frac{E_{m_2}}{E_c} = \frac{15}{10} = 1.5$$

$$m_3 = \frac{E_{m_3}}{E_c} = \frac{12}{10} = 1.2.$$

$$m = \sqrt{m_1^2 + m_2^2 + m_3^2}$$

$$= \sqrt{(2.5)^2 + (1.5)^2 + (1.2)^2}$$

$$= \sqrt{6.25 + 2.25 + 1.44}$$

$= \sqrt{9.94}$

$\boxed{= 3.152.}$

(2) For in the Am wave carrier power $P_C = 150W$ it is simultaneously with 3 modulating signal $m_1 = 0.3$, $m_2 = 0.4$ $m_3 = 0.5$ find.

1) Total coefficient of modulation
2) Total side band power
3) Total transmitter power

$$P_T = P_C\left(1 + \frac{m_t^2}{2}\right)$$

Req

i) $m_1 = 0.3$, $m_2 = 0.4$, $m_3 = 0.5$

$$m_t = \sqrt{(0.3)^2 + (0.4)^2 + (0.5)}$$

$$= \sqrt{0.09 + 0.16 + 0.25} = \sqrt{0.5}$$

$$\boxed{= 0.707}$$

ii) Total side band power $E_C = 15V, R = 100$

$m_1 = 0.3$

$$P = LSB_1 = USB_1 = \frac{m_1^2 E_C^2}{8R}$$

$$= \frac{m_1^2}{4}\left(\frac{E_C^2}{2R}\right)$$

$$= \frac{0.09}{4}\left(\overset{37.5}{\cancel{150}}\right)$$

$$= 3.375 W$$

$m_2 = 0.4$

$$P = LSB_2 = USB_2 = \frac{m_2^2 E_c^2}{8R}$$

$$= \frac{m_2^2}{4}\left(\frac{E_c^2}{2R}\right)$$

$$= \frac{0.16}{4}(150)$$

$$= 0.04 \times 150$$

$$= 6 W$$

$m_3 = 0.5$

$$P = LSB_3 = USB_3 = \frac{0.25}{4}(150)$$

$$= 0.0625 \times 150$$

$$= 9.375 W$$

ii)

$$P = LSB_1 = USB_1 = \frac{0.09 \times 15 \times 15}{8 \times 100}$$

$m = 0.3$

$$= \frac{20.25}{800}$$

$$= 0.0253 W$$

$m = 0.4$

$$\Rightarrow \frac{(0.4)^2 (15)^2}{800} = \frac{(0.16)(225)}{800} = 0.045 W$$

$$m = 0.5 \Rightarrow \frac{(0.5)^2 (15)^2}{800} = \frac{(0.25)(225)}{800} = 0.070 W$$

Total side band power:

$m = 0.3 \Rightarrow 0.025 + 0.025 = 0.05 W$

$m = 0.4 \Rightarrow 0.045 + 0.045 = 0.09 W$

$m = 0.5 \rightarrow 0.070 + 0.070 = 0.14\,W$

Total side band power $= 0.28\,W$

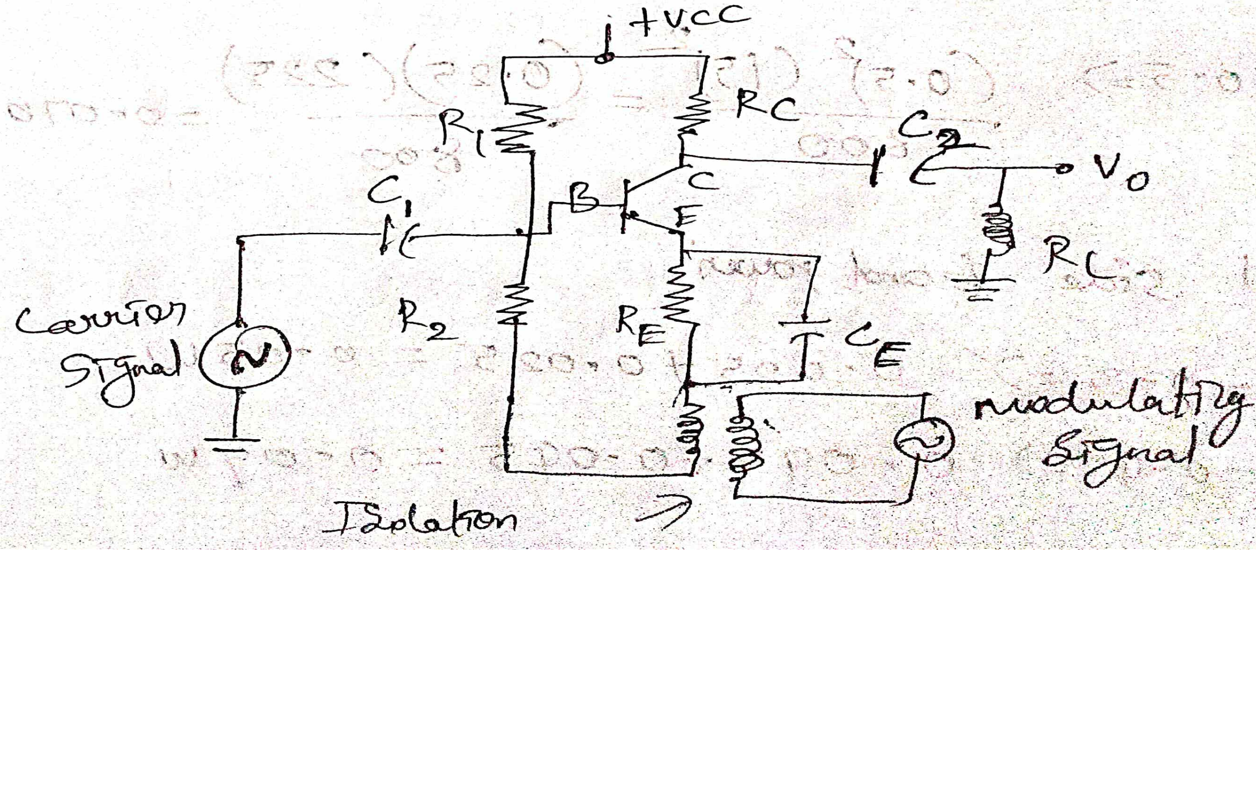
iii) $P_{Total} = P_C +$ Total side Band Pow

$= 150 + 0.28$

$\boxed{P_T = 150.28\,W}$

Nilesh 28/2/23

Low level AM circuits



The modulating signal is applied through Isolation ~~transmission~~ transformer to the emitter of Transistor. ~~and~~ and carrier signal is applied directly to the base with emitter modulation, the amplitude of output signal depends on amplitude of input carrier and voltage gain of the amplifier.

The coefficient of the modulation Index depends entirely on the amplitude of modulating signal.

The primary disadvantage of emitter modulation is. The amplifier operates at class A which is extremely inefficient emitter modulation are incapable of producing high power output waves forms.

(1) Find the output of amplifier Circuit if gain is 5 and input voltage 1.75V

Output = gain x Input voltage

= 5 x 1.75

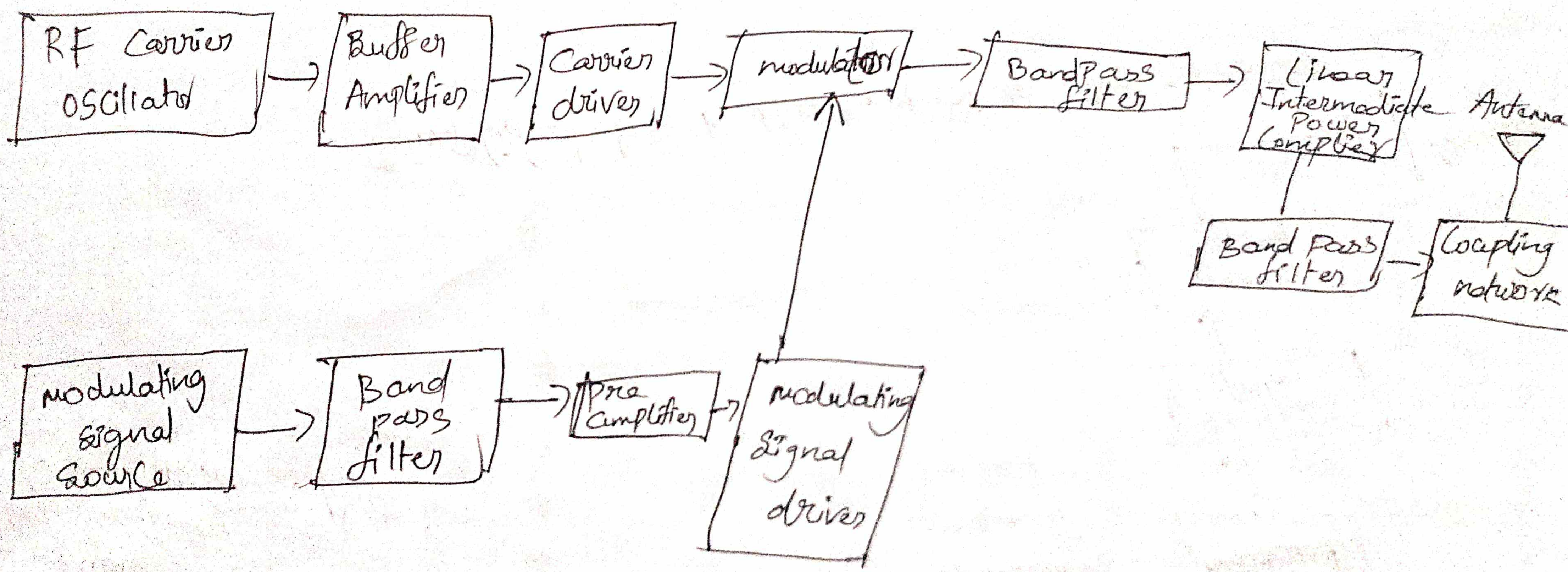
= 8.75V

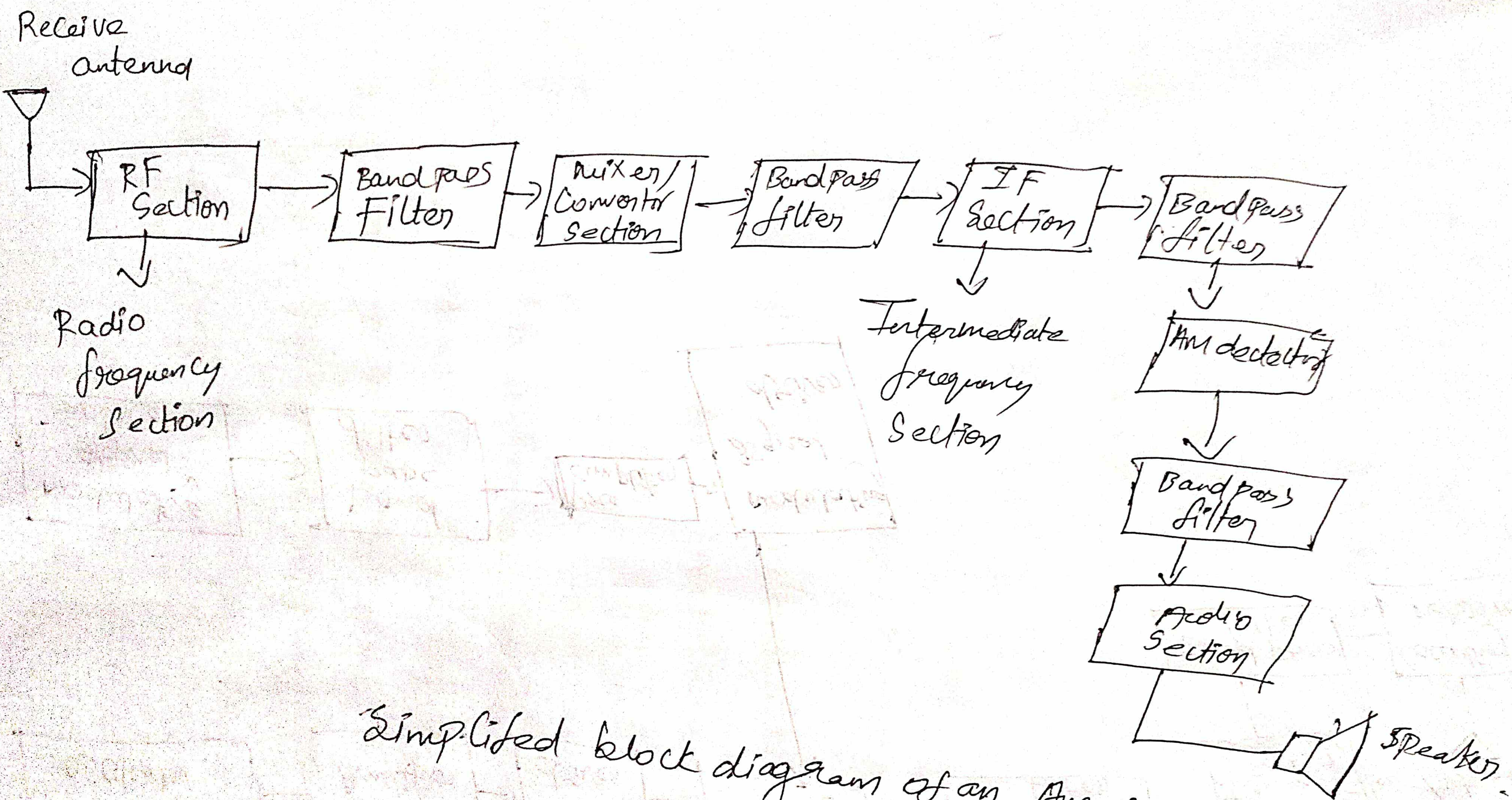
——— x ——— x ———

Block diagram at low level AM DSBFC Transmitter

Application

Low level transmitter are mainly used for low power, low capacity systems such as wireless intercome, remote control units, pages and short ~~voltage~~ range walkie talkies.


RF Carrier oscillator
Buffer Amplifier
Carrier driver
modulator
BandPass filter
Linear Intermediate Power Amplifier
Antenna
Band Pass filter
Coupling network
modulating signal source
Band pass filter
Pre amplifier
modulating signal driver



Simplified block diagram of an AM receiver.

AM Superheterodyne receiver block diagram