Analog and digital communication.

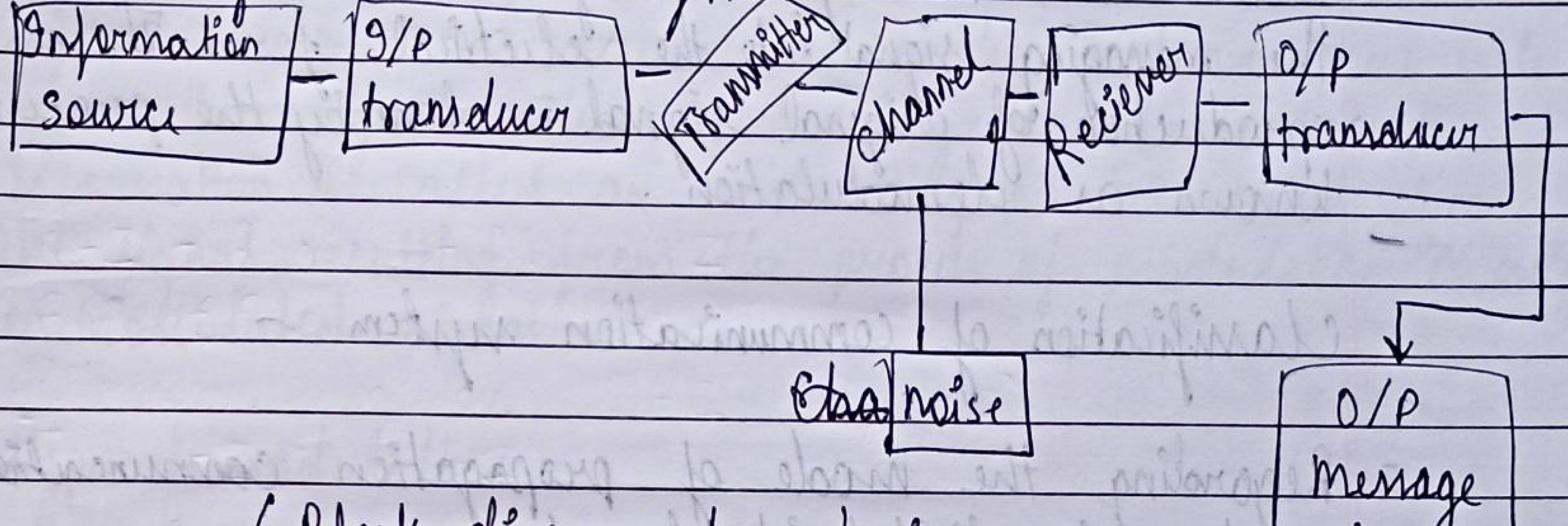
~~Communication~~ ~~Engg~~ -1

Communication –

Communication is the process by means of which message or information transitor from source of destination.

IMP 2

Elements of communication system –



(Block diagram of a basic communication system)

Information source –
or A communication system basically communicated message ~~of~~ information. This message or information orginates in the information source.

The function of information source is produce required message.

Input transducer – A transducer is a device which converts one form of energy into another form. Hence the input transducer is used to converts the non-electrical message or information into ~~ectrical~~ electrical signal.

Transmitter – The transmitter modifies the ~~et~~ messaging signal for efficient transducer. The transmitter process the electrical signal from different accepts. In the transmitter the process of modulation is done show that this will produce suitable form of the signal which can be transmited over the channel.

~~Analog~~ and

- Noise - Noise is an unwanted signal which tend to interfer with the original signal. Noise signal always random in nature.

Reciver - The main function of the reciver is to reproduce the messaging signal into the electrical form. There reproduction of original signal is done by the procuss is known as demodulation.

Classification of communication system -

- Regarding the mode of propagation communcation system is divided into two types.
  1. Line communication system
  2. Wireless ~~commun~~ or radio communication system.

Line communication system - In line communication system the medium of transmission ~~of~~ is the transmission line. These is also called the line channel. This means in line communcation the transmetor and reciver are connected ~~to a wire~~ through a wire or line.

Wireless or radio communication System - In wireless or radio communication a message is transmitted through a openspace by electromagnetic wave called as radio wave. Radio wave are ~~transt~~ radiated from the transmeter through a device called as ~~anteena~~ antenna. Again a reciving antenna intersects the radio wave at the reciver. All the TV, radio, satelite communication are wireless or radio communication.

~~Amplitude modulation system~~ -

Modulation - Modulation is defined as the proces by means of which the ~~two~~ characteristics of signal called ~~carry~~ carries signal is ~~vary~~ varied ~~in accodantion with~~ ~~accolor~~ accordance with the instantaneous value of another signal called modulating • signal = Contain the information is called as modulating or base band signal. The signal resulting from the proces of modulation is called ~~so~~ modulated signal.

Types of modulation -

Basically is of two types ① continuous wave modulation.
② Pulse modulation.

Contineous wave modulation - When the carrier wave is contineous in nature then the modulation proces is called contineous wave modulation. Ex - Amplitude modulation and Angular modulation.

Pulse modulation - When the carrier wave is a pulse type wave form then the ~~f~~ proces of modulation is called pulse modulation. Ex - PAM (Pulse amplitude modulation), PWM (Pulse width modulation), PCM (Pulse code modulation)

Need for modulation -

i) To reduce height of antenna.

ii) When the free space is used as the transmitting medium or channel then message signal are transmitted and recived by help of antenna.

ii) For efficient ~~radian~~ radiation and reciption of the signal the antenna must have the length comparably to quater wave length of the frequency used. Let the 5KHz signal is transmmited without the process of modulation then the height of the antenna required for effective radiation is

$$l = \frac{\lambda}{4} = \frac{c}{f4}$$

$$= \frac{3 \times 10^8 \text{ m/s}}{4 \times 5 \times 10^3 \text{ Hz}}$$

$$= 5 \text{ km}$$

where c = speed of light ($\approx 3 \times 10^8$ m/s)
f = frequency of modulating signal

Thus antenna height is totally ~~impracticaly~~ impraticable to construct and install. If a high frequency carrier is used for modulation. If then the modulating signal is 3 MHz. Then the antenna heigh will become

$$l = \frac{\lambda}{4} = \frac{c}{f4}$$

10^{8-6}

10^2

$$= \frac{3 \times 10^8 \text{ m/s}}{4 \times 3 \times 10^6 \text{ Hz}}$$

$$\cancel{= 25 m} = \frac{10^2}{4}$$

$$= \frac{100}{4} = 25 m$$

These antenna height may be achive practically.

To reduce the noise – Noise can't completely eliminated from the communication system but with the help of several modulation scheme the effect of the noise minimize. To remove interference. ~~Another rear~~

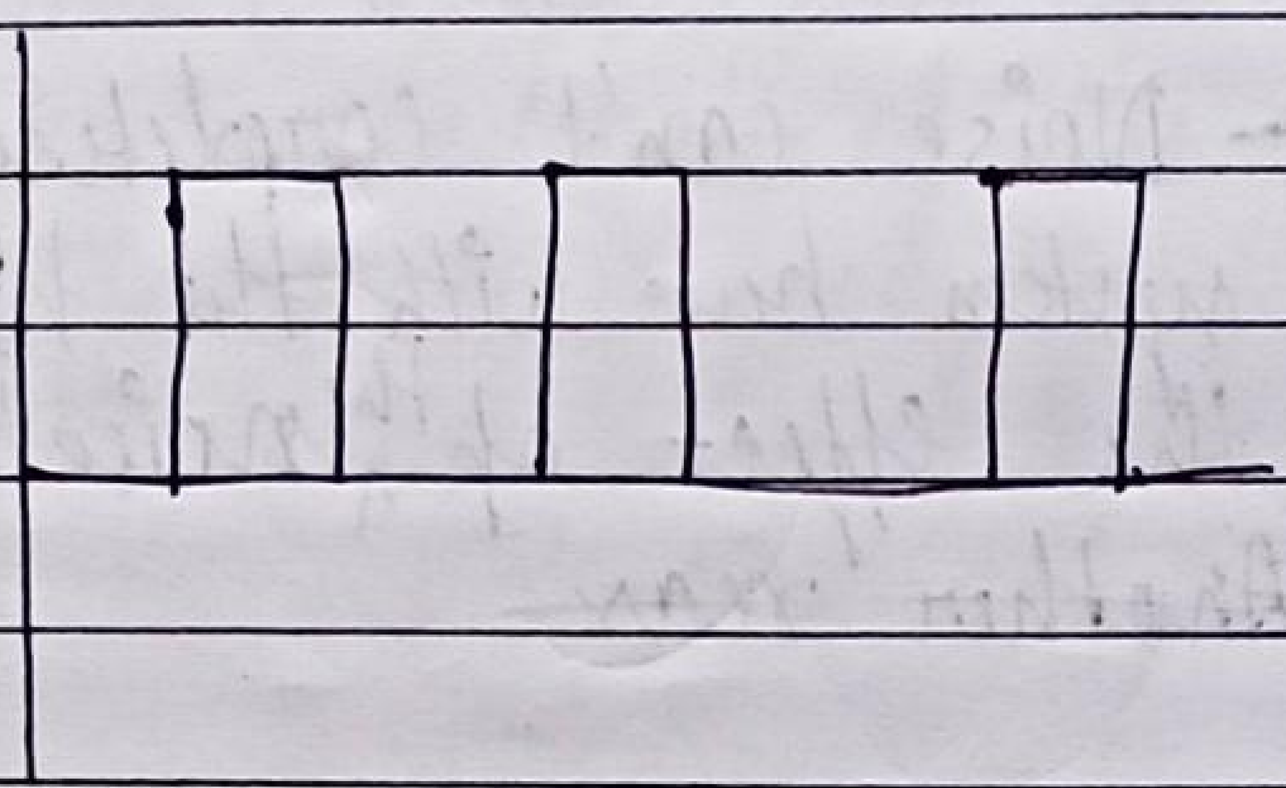
Another reason for not radiating ~~modul~~ modulating signal itself is the frequency wave ~~the~~ of the audio signal is 20Hz to 20KHz. In radio broadcasting their are several radio station. If modulation is not be use then all the station transmits the signal in the range of 20Hz to 20KHz. Due to tranmission of the same range the programe of the different station will get mixed of resulting interference.

~~Multipl~~

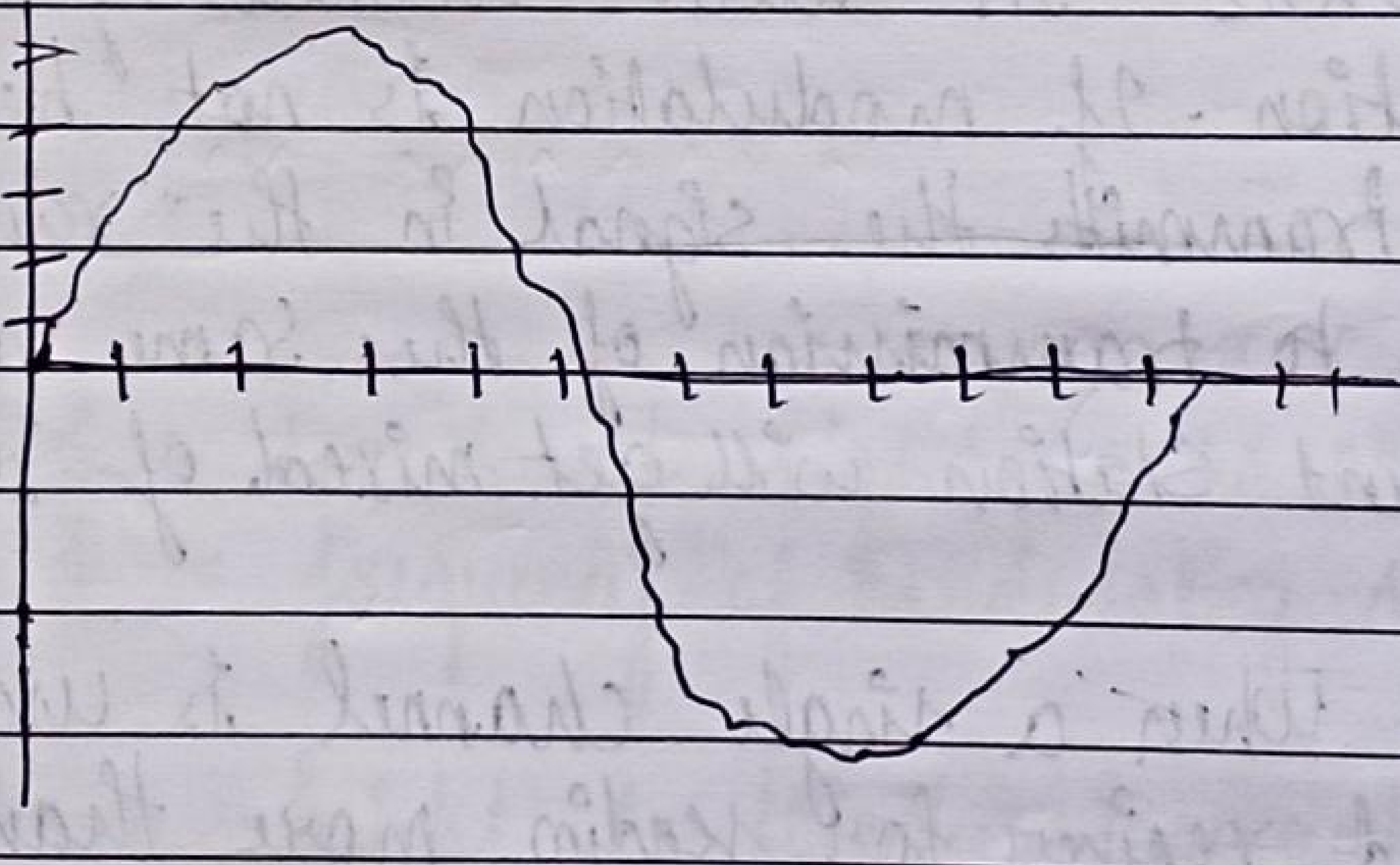
Multiplexion – When a single channel is used between the tranmeter and reciver for sending more than one signal at the same time then these is called multiplexing. These ~~is~~ multiplexing can be done using the process of multiplexion.

Analog signal – The analog signal is that type of signal which varries smothly and contineously with time. These means that analog signal's are defined for every value of time and they take on contineous value's of given times interval.

Digital signal – An alternating form of signal representation is that of a sequence of numbers, each number representing the signal magnitude at an instant of time. The resulting signal is called a digital signal. A digital signal is represented by only by digits therefore we can use binary number system to repres a digital signal. In a binary system each digit in the number takes on only two possibel values denoted 0 and 1.



digital signal



analog signal

The wave form is a pulse strain with zero voltage reprenting zero signal and positive five voltage reprenting logic 1.

Converstion of anlog to digital ~~ooo~~ signal -

Sampling Theorem -

The statement of sampling theorem can be giving as the following -

1) A band limited signal of finity energy which has no freq components higher than fm Hz is completly described by its sample values at uniform intervals less than or equal to $\frac{1}{2 \text{ times of } fm}$ 1/2 times of fm second a part

2) ~~A~~ band limited signal of finity energy which have no frequency components higher than fm Hz may be completly recovered ~~by~~ from the Knoledge of its samples taken at the ~~ratio~~ rate of two fm samples per sec.

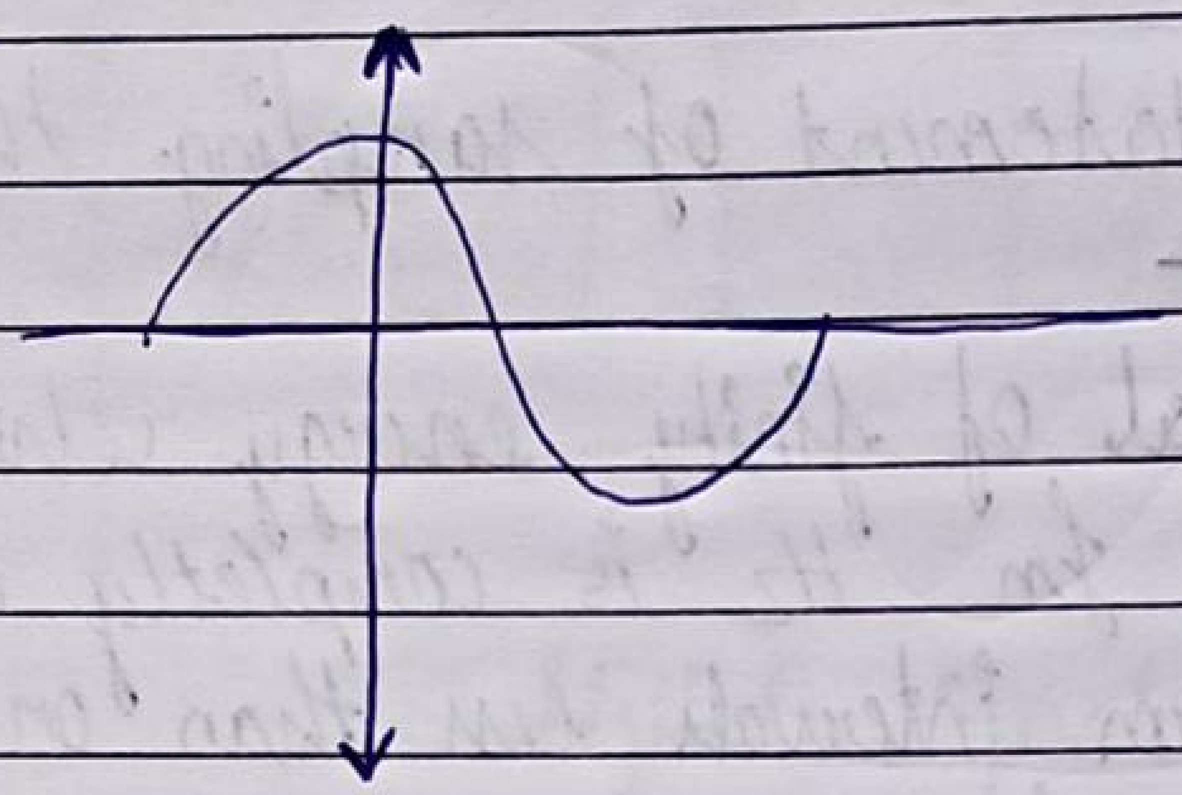
3) Combining these two parts the sampling Theorem states that a continious time signal may be completly represented in its sample and recover back if the sampling frequency

$$f_s \geq 2f_m$$

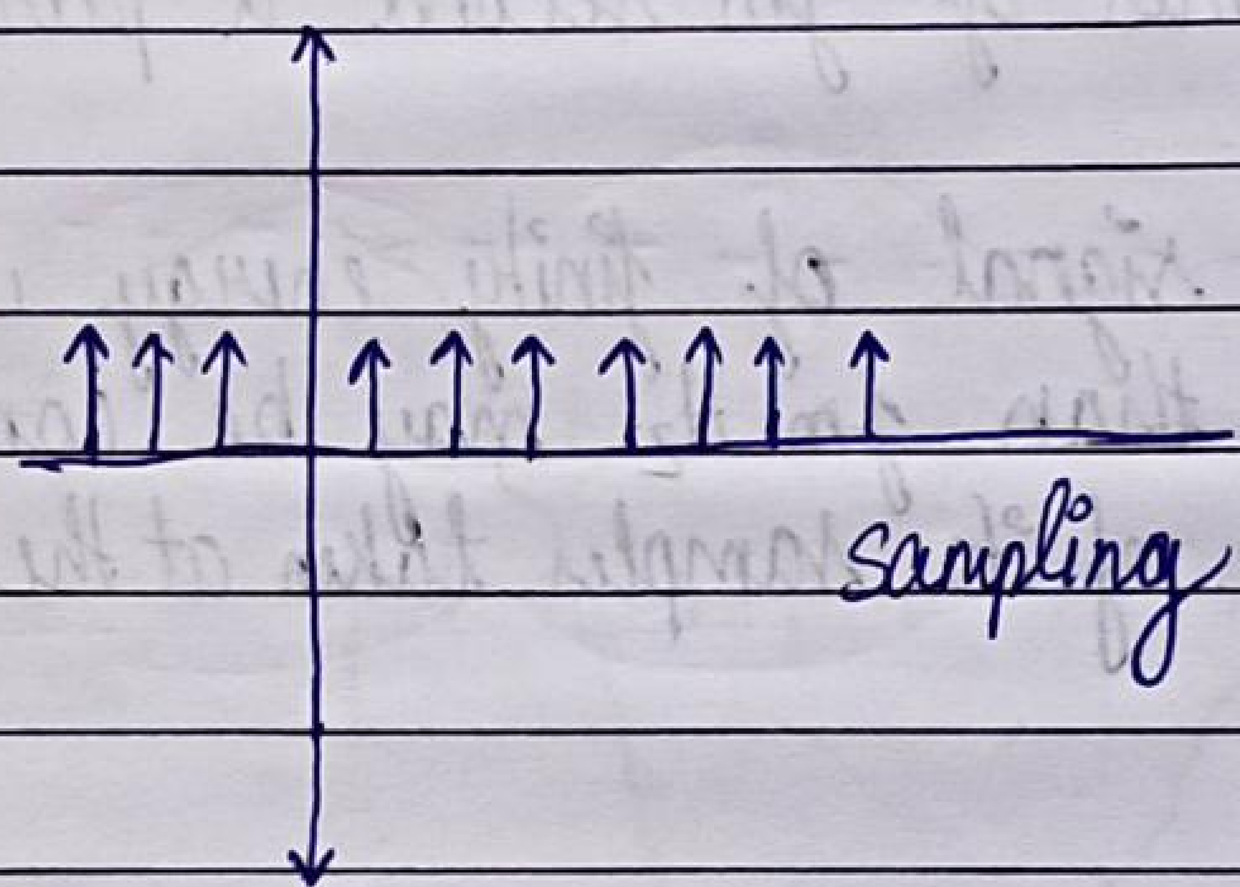
where f_s ~~is~~ ~~sam~~ the sampling frequency.
f_m is the maximum frequency component present in the signal.

* Types of sampling -
Imp There are ~~two types~~ three types of sampling techqniquies -
① Impulse / ideal / Instaneous Sampling
② Natural Sampling
③ flat top / rectangular sampling

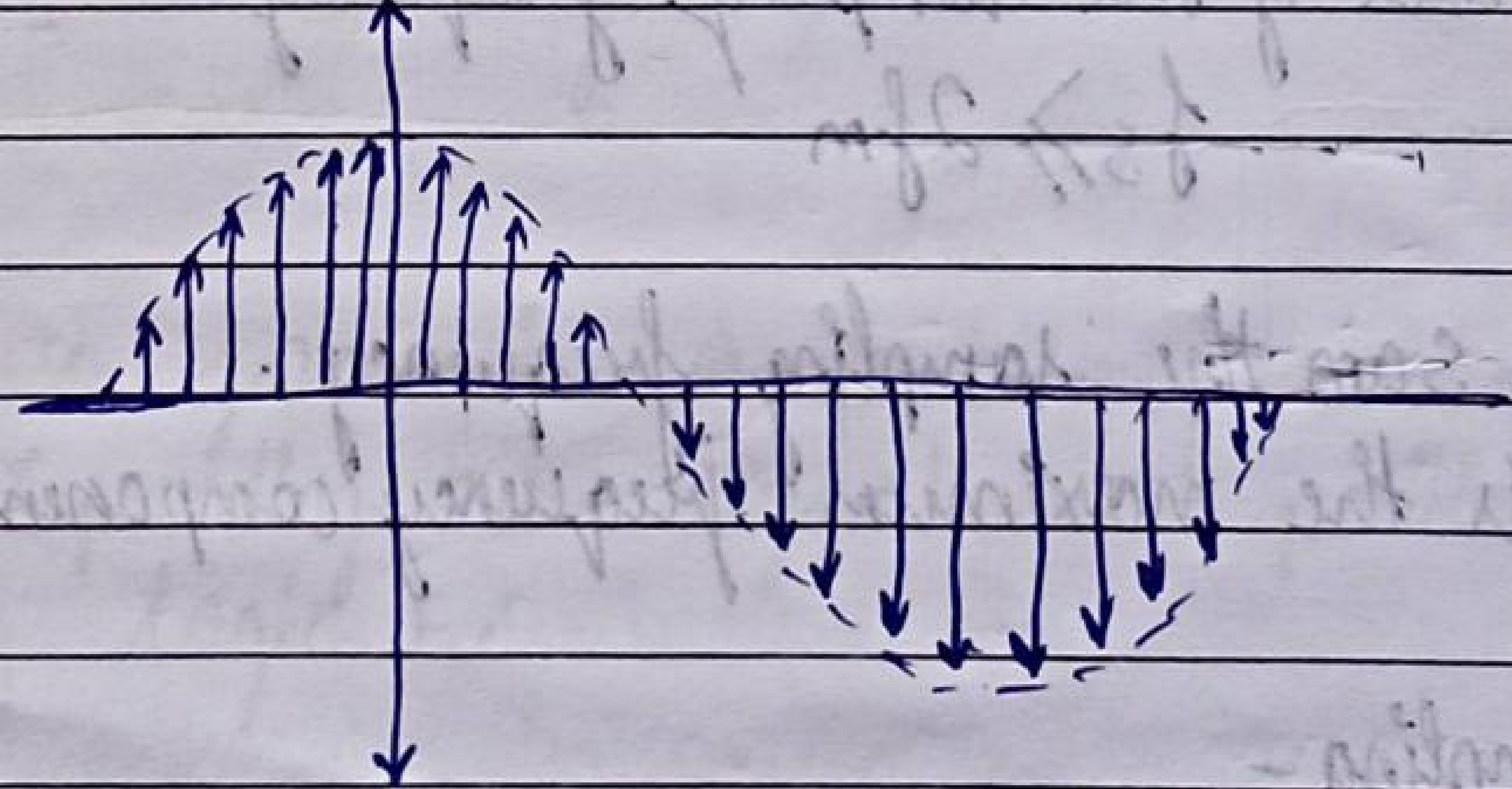
① Impulse / edeal / Instaneous Sampling - Here the principle used as multiplication



I/p baseband samp. signal



sampling function

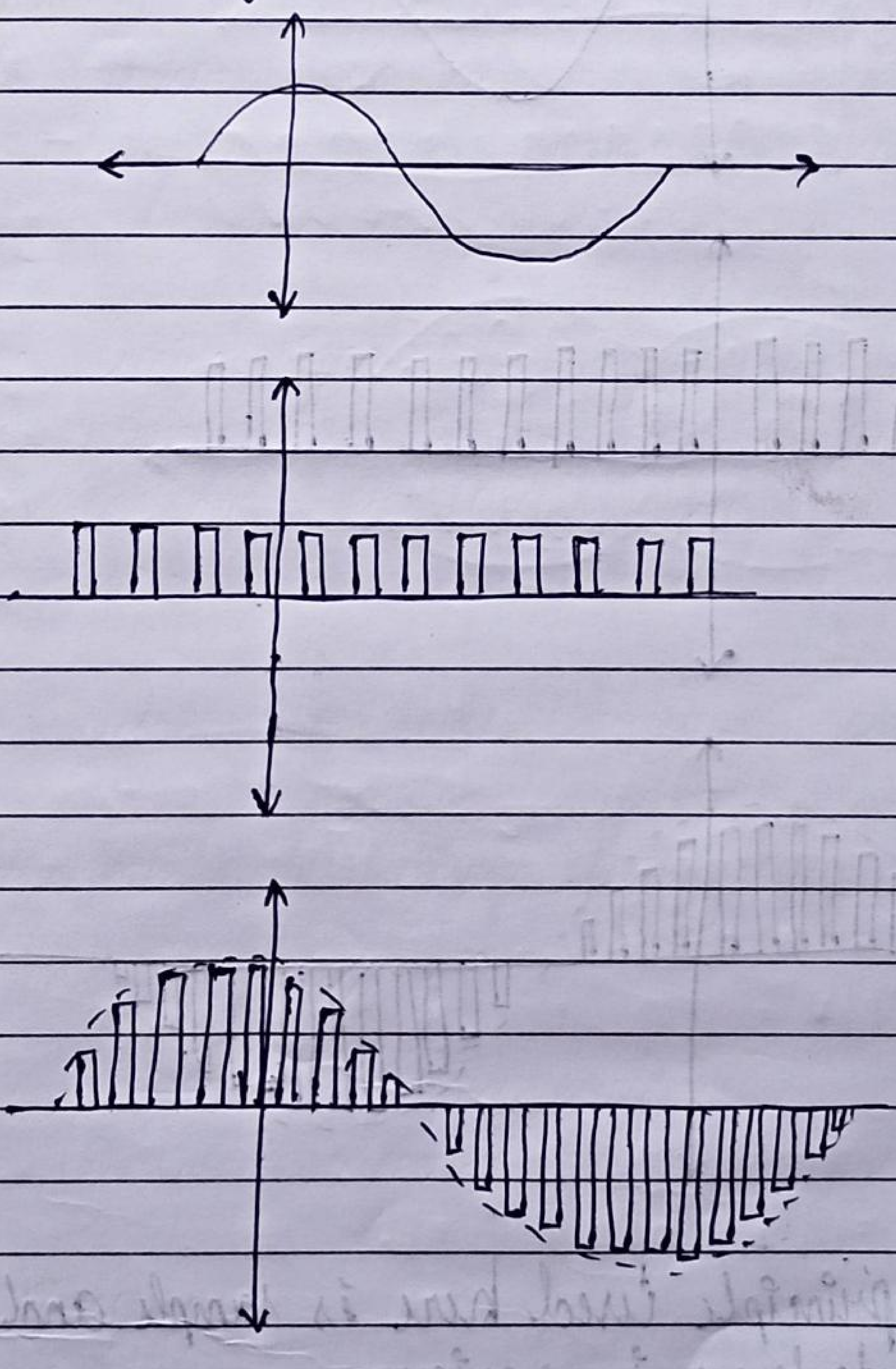


Sampling signal

→ Noise Interference is maximum
→ The sampling function is trend of inpulse having weidth ($\tau = 0$)
→ At any instant the amplitude of the sample signal ~~at~~ = Input signal.

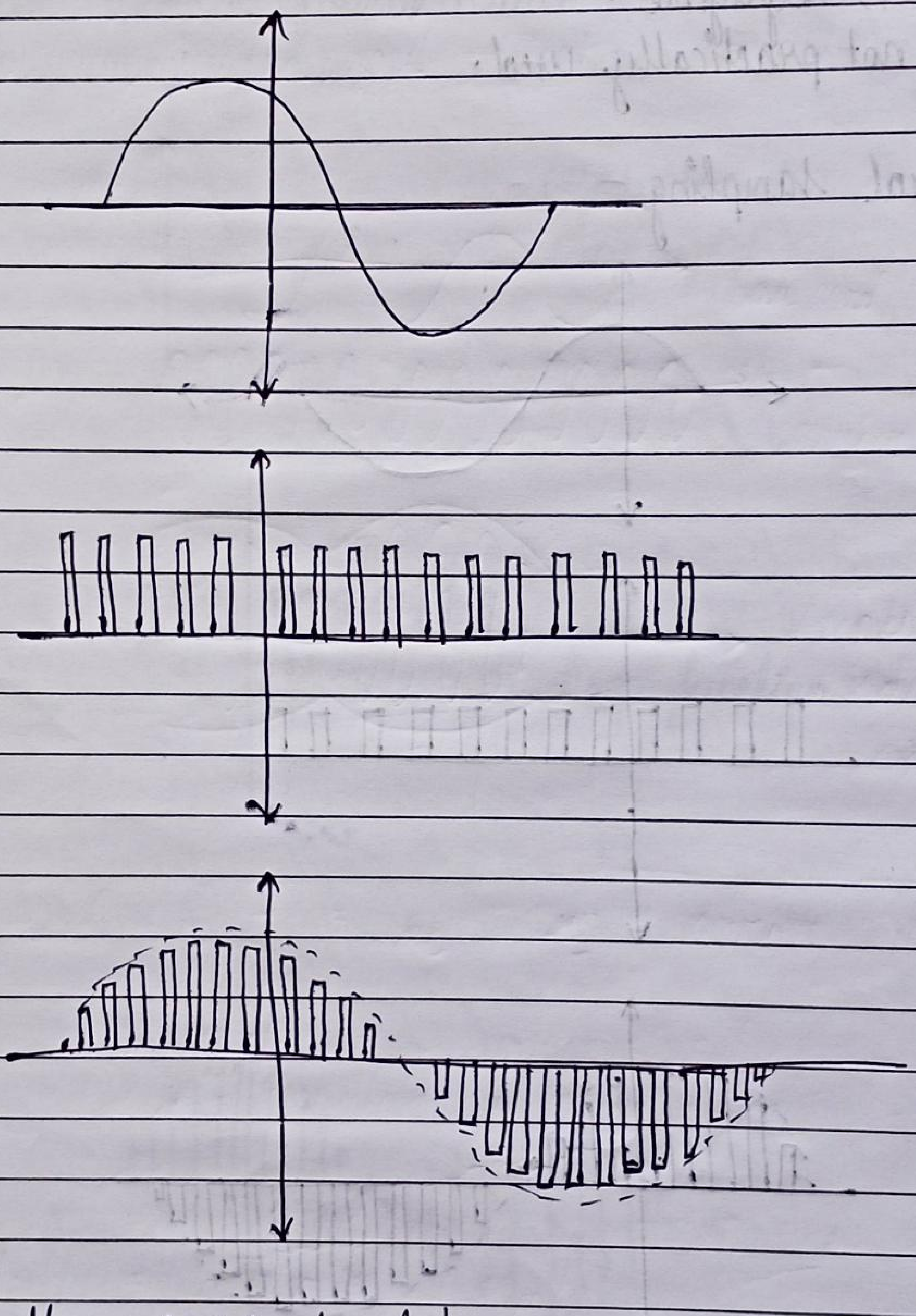
→ As the weidth of sample ~~sigl~~ signal trends to zero the transmiss power is negligible.
→ It is not practically used.

② Natural sampling –



Here the principle used is chopping.
→ The noise interference is minimum
→ The sampling function is trend of ~~fo~~ pulse weidth having ~~tall~~. τ.
→ At any instant the amplitude of the sample signal = input signal.
→ It is practically used.

③ Flat top / rectangular sampling –



~~Here~~ the principle used here is sample and hold.
-> The noise interference is maximum
-> The sampling function is a trend of pulse
-> At any instant the amplitude of sampling signal = amplitude of the input signal at the instant of starting edge of the pulse.

Bandwidth limitation -

→ The frequency range or the band of frequency needed for a particular given transmission is known as Bandwidth.

→ The information theory states that the greater is the transmission bandwidth of a communication system the more is the information that can be transmitted. Therefore an AM radio reciver cannot reproduce all the information contain in the music because there will ~~be~~ required the bandwidth of 30KHz.

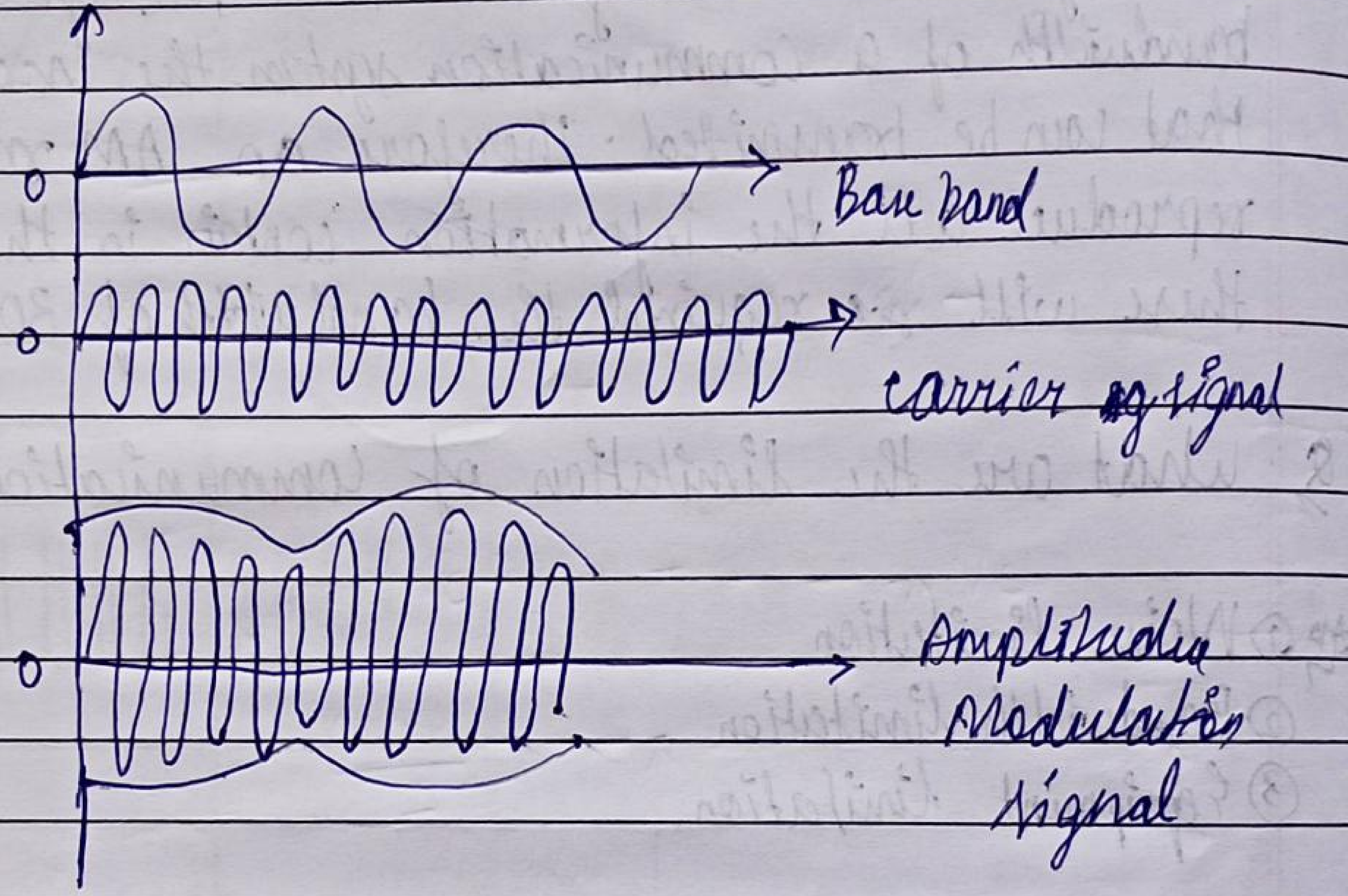
Q. What are the limitation of communication system?.

Ans. ① Noise limitation
② Bandwidth limitation
③ Equipment limitation

Q. What is the role of bandwidth in ~~the~~ communication?

Ans. Bandwidth is the total range of frequency

• Amplitude modulation - In Amplitude modulation amplitude of the carrier signal is changed with respect to base band signal keeping frequency and phase constant.



Let $V_c(t) = V_{mc} \sin w_c t$ → carrier signal.

V_m = amplitude of carrier signal
w_c = Angular of carrier signal

$V_m(t) = V_m \sin w_m t$

V_m = amplitude of the modulating signal
$w_m t$ = Angular of modulating signal.

$V_c \propto V_m(t)$

$= \underset{(\text{constant})}{K} V_m(t)$ If $k = 1$

$M_a = \frac{V_m}{V_c}$ is - modulation index

Derive the expression of amplitude modulation signal.

$$V_c = V_m(t)$$

Here, amplitude of the modulated signal, -

$$V_c + V_m \sin W_m t$$

Now the expression the amplitude modulated signal

$$S_{A.M}(t) = (V_c + V_m \sin W_m t) \sin W_c t$$

$$= V_c \left(1 + \frac{V_m}{V_c} \sin W_m t\right) \sin W_c t$$

$$= V_c (1 + m_a \sin W_m t) \sin W_c t$$

$$= V_c (\sin W_c t + m_a \sin W_m t \times \sin W_c t)$$

$$= V_c \sin W_c t + M_a V_c \sin W_m t \times \sin W_c t$$

$$\cos C - \cos D = -2 \sin\left(\frac{C+D}{2}\right) \cdot \sin\left(\frac{C-D}{2}\right) = 2 \sin\left(\frac{C+D}{2}\right) \sin\left(\frac{D-C}{2}\right)$$

$$= V_c \sin W_c t + \frac{M_a V_c}{2} 2 \sin W_m t \cdot \sin W_c t$$

$$= V_c \sin W_c t + \frac{M_a V_c}{2} [\cos(W_c - W_m) t - \cos(W_c + W_m) t]$$

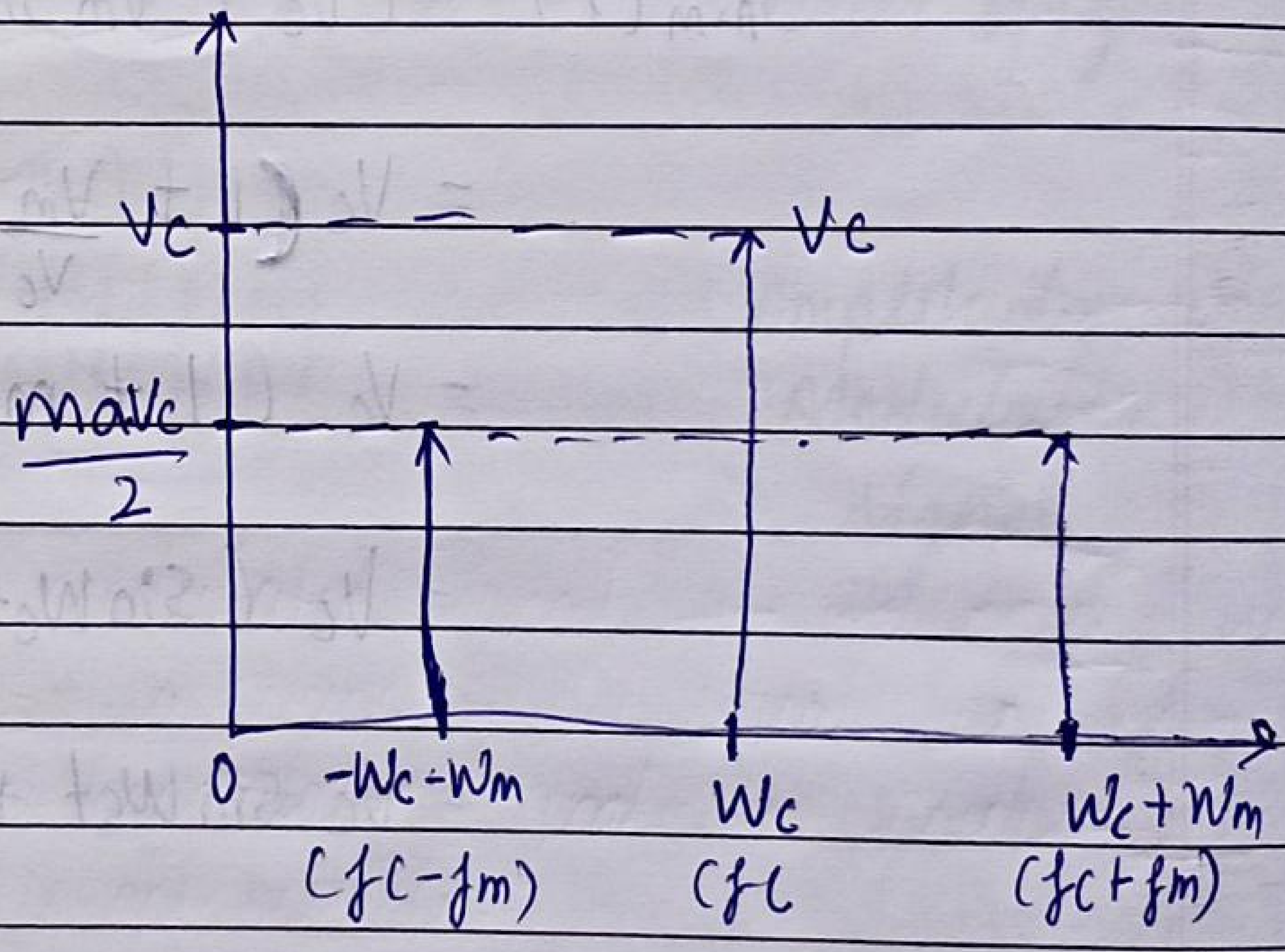
$$= V_c \sin W_c t + \frac{M_a V_c}{2} \cos(W_c - W_m) t - \frac{M_a V_c}{2} \cos(W_c + W_m) t$$

frequency – reciprocal of time period

The expression contains three terms first term is the unmodulated carrier having amplitude V_c.
Second term is the upper sign band having amplitude $\frac{M_a V_c}{2}$

Third ~~term~~ term is the Lower sign band (L.SB) having amplitude $-\frac{M_a V_c}{2}$.

Frequency spectrum of modulated signal –



Q. Define communication channel ?

Ans. ~~It is~~ The connection between the transmitter and receiver are linked through the communication channel. Communication channel may be wireline or wireless ~~or~~, optical fiber ?

Q. Define channel bandwidth ?

Ans. ~~I~~ These is the maximum possible range of frequency that can be used for the trasmission.

$$B \cdot W = f_2 - f_1 = \Delta f$$

Scanned by TapScanner

Q2 Define tranformation power ?

Ans There is the power that can be put in the signal being transmitted.

CALCULATION the bandwidth of amplitude modulated signal -

for $BW = \Delta f = f_c + f_m - (f_c - f_m)$

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

$= f_m + f_m$

$= 2 f_m$

$f_m \rightarrow$ orginal frequency.

- Modulation index - $M_a = \frac{V_m}{V_c}$

It is the ratio of maximum aplitude of modulating signal to the maximum amplitude of carrier signal.
There are three dgree of modulation depending upon amplitude of carrier signal and modulating signal.

1) Under modulation ($M_a < 1$) - For under modulation index M_a is less than 1.

$M_a < 1$

$\frac{V_m}{V_c} < 1 \quad V_m < V_c$

Here the ~~envolpe~~ envelope of the amplitude modulated signal will not reach to the zero ~~axis~~ amplitude axis. So, modulating signal can be properly recovered from the modulated signal.

using envelope detector.

2) Critical modulation :- ($M_a = 1$) ← $V_m = V_c$

Here envelope of modulated signal just reaches the zero amplitude axis and the modulated signal can be recoverd by using envelope detector.

3) Over modulation $M_a > 1$ —

$$\frac{V_m}{V_c} = 1$$

$$V_m > V_c$$

Here the envelope of modulated signal ~~cro~~ ~~pr~~ crosses the zero amplitude axis. So a person of the signal can't be ~~prever~~ preserved in the modulated signal. So proper recovery of modulating signal is not possible.

Imp Power relation in amplitude modulated signal -

We know that amplitude modulated signal has three components. Those are unmodulated carrier upper side band and lower side band. So the total power of AM wave is the sum of carrier power and the powers ~~in the~~ into side band.

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

where,

P_T = Total power

P_C = On modulated carrier power

P_{USB} = Power of upper side band.
P_{LSB} = Power of lower side band

$$= \frac{(V_{carrier})^2}{R} + \frac{(V_{USB})^2}{R} + \frac{(V_{LSB})^2}{R}$$

where, all the three ~~pr~~ voltages are in RMS value and ~~R~~ R is the characteristics impedance of antenna in which power is ~~dise~~ dissipated. So, the carrier power is ~~$P_c = \frac{(V_{carrier})^2}{R}$~~

$$P_c = \frac{(V_{carrier})^2}{2}$$
$$= \frac{V^2 carrier}{R}$$
$$= \frac{(V_c/\sqrt{2})^2}{R}$$
$$= \frac{V_c^2}{2R}$$

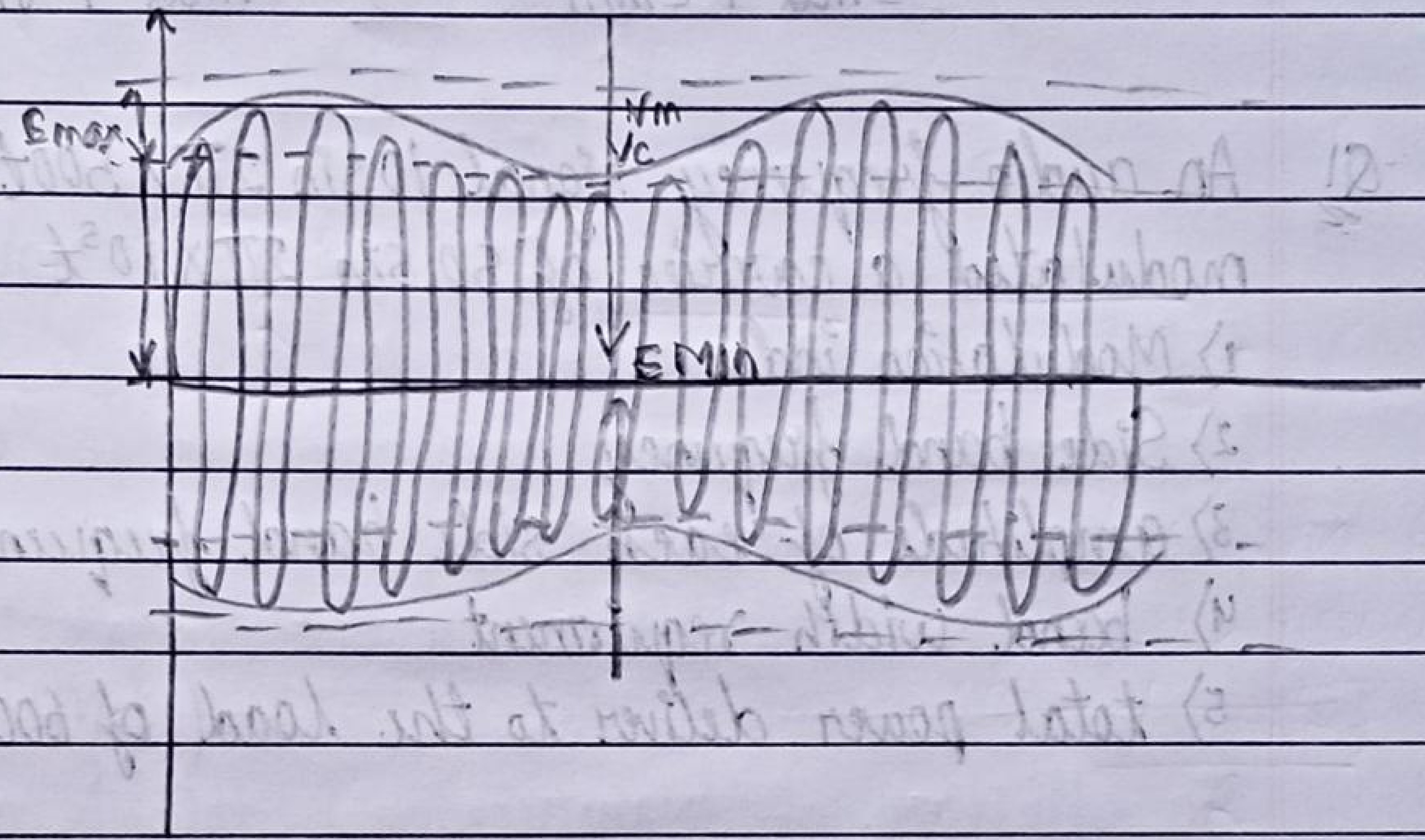
The side band power is

$$P_{USB} = P_{LSB} = \frac{V_{USB}^2}{R}$$
$$= \left(\frac{mV_c}{2\sqrt{2}}\right)^2 \times \frac{1}{R} = \frac{M^2 V^2 c}{8R}$$

$$P_T = \frac{V_c^2}{2R} + \frac{M^2 V_c^2}{8R} + \frac{m^2 V_c^2}{8R}$$

$$\Rightarrow P_T = \frac{V_c^2}{2R} + \frac{m^2 V_c^2 + m^2 V_c^2}{8R} = \frac{V_c^2}{2R} + \frac{\cancel{2} m^2 V_c^2}{\cancel{8}_{4} R}$$

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$



$$E_{max} = E_{min} + 2V_m$$

$$E_{max} - E_{min} = 2V_m$$

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

Again,

$$E_{max} = V_c + V_m$$

$$V_c = E_{max} - V_m$$

$$= E_{max} - \left(\frac{E_{max} - E_{min}}{2}\right)$$

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

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

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

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

$W_m = 2\pi f_m$

$W = \frac{2\pi}{T}, \ 1/T = f = 2\pi \times 1/T = 2\pi f_m$

$$= \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \quad or, \quad \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

Q1 An audio frequency signal $10 \sin 2\pi \times 500t$ is used to amplitude modulated a carrier of $50 \sin 2\pi \times 10^5 t$. Calculate

1) Modulation index
2) Side band frequency
3) amplitude of each side band frequency
4) band width requirment
5) total power deliver to the load of 600Ω

Ans

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

$V_c = 50 \sin 2\pi \times 10^5 t$

$R = 600\Omega$

$V_m = 10, \ V_c = 50$

$W_m = 2\pi \times 500 = 2\pi f_m$

$\Rightarrow 500 Hz = f_m$

$W_c = 2\pi \times 10^5 = 2\pi f_m$

$\Rightarrow 10^5 Hz = f_m$

1) $M_a = \frac{V_m}{V_c} = \frac{10}{50} = \frac{1}{5} = 0.2$

2) $f_c + f_m, \ f_c - f_m$

$USB = f_c + f_m$
$= 10^5 + 500 Hz$

$LSB = 10^5 - 500 Hz$

3) $\frac{M_a V_c}{2} = \frac{0.2 \times \cancel{50}^{25}}{\cancel{2}}$

$= 5V$

$-\frac{M_a V_c}{2} = -5V$

4) $2f_m = 2 \times 500$
$= 1000 Hz$

5) $P_T = P_c \left(1 + \frac{M_a^2}{2}\right)$

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

$= \frac{50^2}{2 \times 600}\left(1 + \frac{(0.2)^2}{2}\right)$

$= \frac{250\cancel{0}}{120\cancel{0}}\left(1 + \frac{0.04}{2}\right)$

$= \frac{25}{12}\left(\frac{2 + 0.04}{2}\right)$

$= \frac{25 \times 2.04}{24}$

$= 2.125$ watt

Current relation in the amplitude modulated signal -

$P_T = \cancel{pc}\ P_c\left(1 + \frac{M_a^2}{2}\right)$

$\frac{P_T}{P_c} = 1 + \frac{M_a^2}{2}$

$\Rightarrow \frac{I_t^2 R}{I_c^2 R} = 1 + \frac{M_a^2}{2}$

$$\Rightarrow I_t^2 = I_c^2 \left(1 + \frac{Ma^2}{2}\right)$$

$$\Rightarrow I_t = I_c^2 \sqrt{\left(1 + \frac{Ma^2}{2}\right)}$$

Efficiency of transmission - In the amplitude modulator signal have three frequency component but the message is transmitted by the side band.

Here, carrier doesn't contain any information

So efficiency of transmission is defined as the ratio of power associated with the side band frequency to the total power transmitted.

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

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

$$= \frac{\frac{Ma^2 Vc^2}{8R} + \frac{Ma^2 Vc^2}{8R}}{Pc\left(1 + \frac{Ma^2}{2}\right)}$$

$$= \frac{\frac{Ma^2Vc^2 + Ma^2Vc^2}{8R}}{Pc\left(1 + \frac{Ma^2}{2}\right)}$$

$$= \frac{\frac{2Ma^2Vc^2}{_4 8R}}{Pc\left(1 + \frac{Ma^2}{2}\right)}$$

$$= \frac{\frac{Ma^2}{2}}{1 + \frac{Ma^2}{2}}$$

$$= \frac{\frac{Ma^2}{2}}{\frac{2 + Ma^2}{2}}$$

$$n = \frac{Ma^2}{2 + Ma^2}$$

$$n\% = \frac{Ma^2}{2 + Ma^2} \times 100$$

If $Ma = 1$

$$= \frac{(1)^2}{2 + (1)^2} \times 100$$

$$= \frac{1}{2 + 1} \times 100$$

$$= \frac{1}{3} \times 100$$

$$= 33.3\%$$

From the above calculation it is concluded that when =1, then 33.3% of total power is carried by the side band and the rest of the power that's nearly 67% of the carried by the carrier which is not used. Because no, useful information carried out by the unmodulated carrier. These is the major reason of limitation of AM system (DSB-FC) for which another modulation techniques DCB-SC will come into the picture.

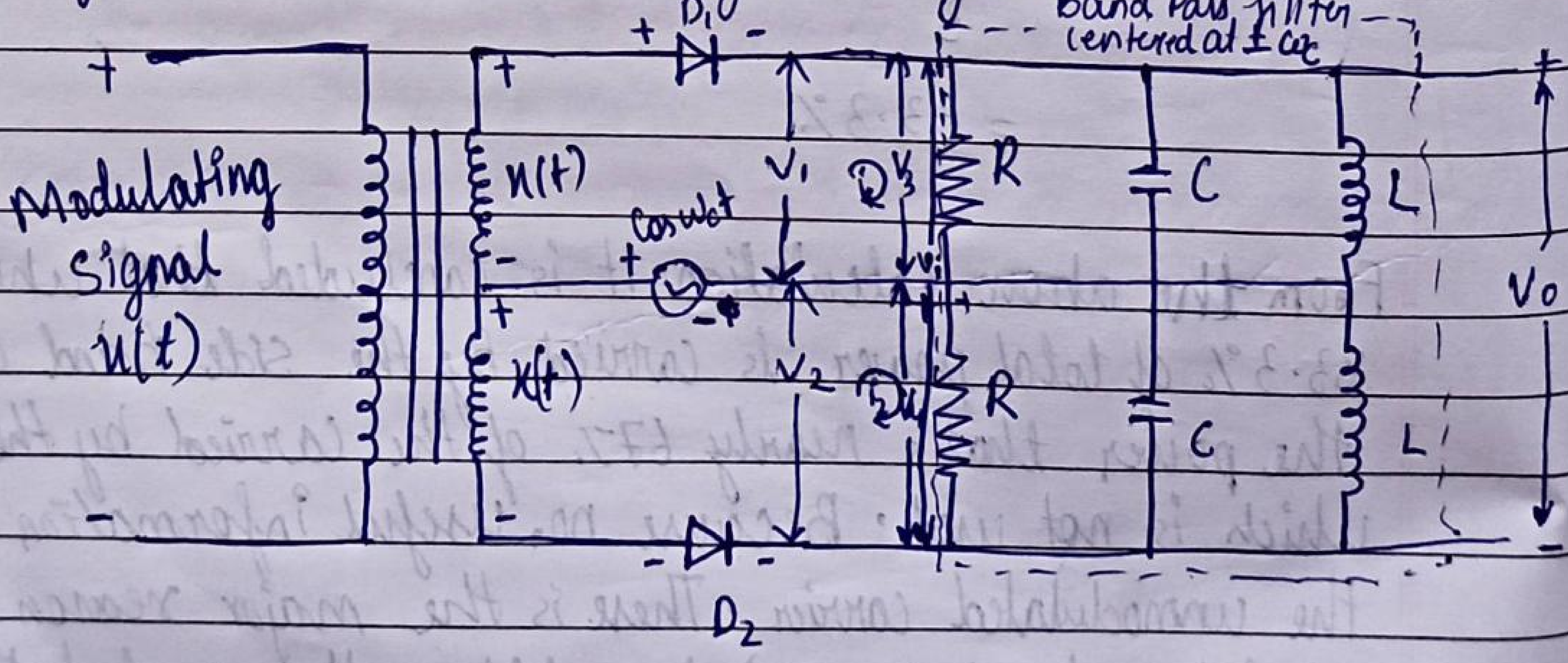
Generation of DSB-SC Signal -

$$S(t) = x(t) \cdot \cos\omega_c t$$

Where, $x(t)$ = Modulating signal
$\cos\omega_c t$ = Carrier signal

From the above expression we see that a DSB-SC signal is the product of modulating signal and the carrier signal. But a single device cannot generate DSB-SC signal. The circuit which generate DSB-SC signal is called a product modulator. Here we will discuss two types of product modulator. ① Balanced Modulator
② Ring Modulator

- Balanced Modulator - We know that a non-linear device may be used produce amplitude modulated signal that's one carrier and two non-linear devices are used in a balanced mode. So, that carrier can be supressed only by side band are left and DSB-SC AC signal is generated.



(Balanced Modulator using diodes)

∴ Rectifier - AC to DC

Filter - who ~~fitter the~~ gives the pure signal.

Balanced modulation is a type of product modulator which generate DSB-SC signal using two diodes. where the modulating signal $x(t)$ is applied to the diode through the ~~circuit~~ center taped transformer with the carrier signal $\cos\omega_c t$ the non-linear relationship between voltage and current is given by -

$$i = av + bv^2$$

In the above expression,

V is the input voltage to the diode & i is the current flowing through the diode.

Here V_1 and V_2 are two input voltage across two diodes, expressed as -

$$V_1 = \cos\omega_c t + x(t)$$
$$V_2 = \cos\omega_c t - x(t)$$

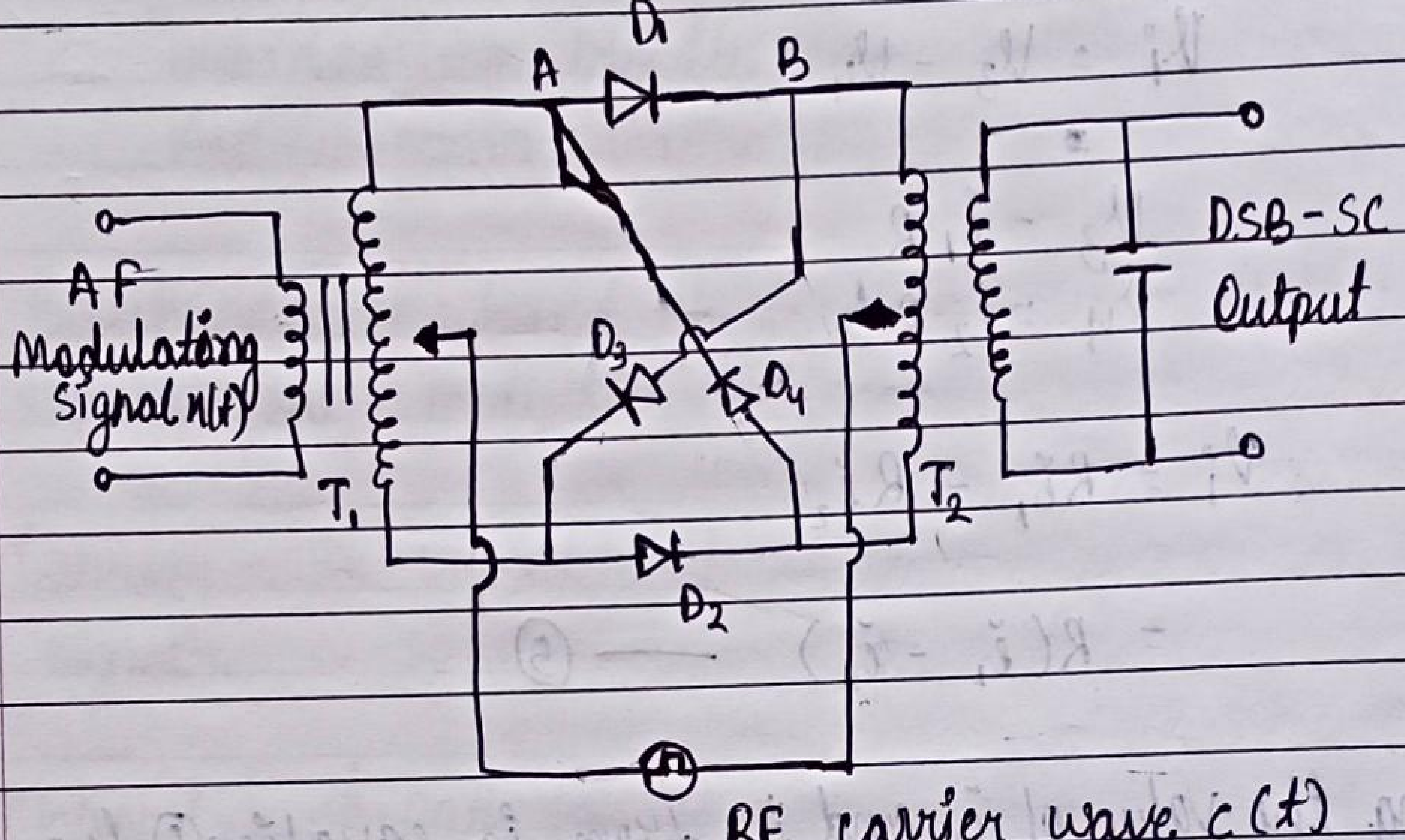
For diode D_1 the VI relationship is given by

$$i_1 = aV_1 + bV_1^2 \quad \text{——} \; (1)$$
$$= a[\cos\omega_c t + x(t)] + b[\cos\omega_c t + x(t)]^2$$
$$= a\cos\omega_c t + ax(t) + b[\cos^2\omega_c t + 2\cdot\cos\omega_c t\cdot x(t) + x(t)^2]$$
$$= a\cos\omega_c t + ax(t) + b\cos^2\omega_c t + 2b\cos\omega_c t\cdot x(t) + bx^2(t)$$
$$\rightarrow (3)$$

Similary for diode D_2 the non-linear VI relationship is

$$i_2 = aV_2 + bV_2^2 \quad \text{——} \; (2)$$
$$= a[\cos\omega_c t - x(t)] + b[\cos\omega_c t - x(t)]^2$$
$$= a\cos\omega_c t - ax(t) + b[\cos\omega_c t^2 + x(t)^2 - 2\times\cos\omega_c t \times x(t)]$$
$$= a\cos\omega_c t - ax(t) + b\cos\omega_c t^2 + bx(t)^2 - 2b\cos\omega_c t \times x(t) \longrightarrow (4)$$

Ring Modulator -



(A diode Ring modulator)

It consist of 4 diodes, an audio frequency transformer (T_1) and RF transformer (T_2). The carrier signal is assumed to be a square wave with frequency f_c and it is connected to a center tap of the 2 transformer. The DSB SC output is obtained at the secondary of the RF transformer T_2.

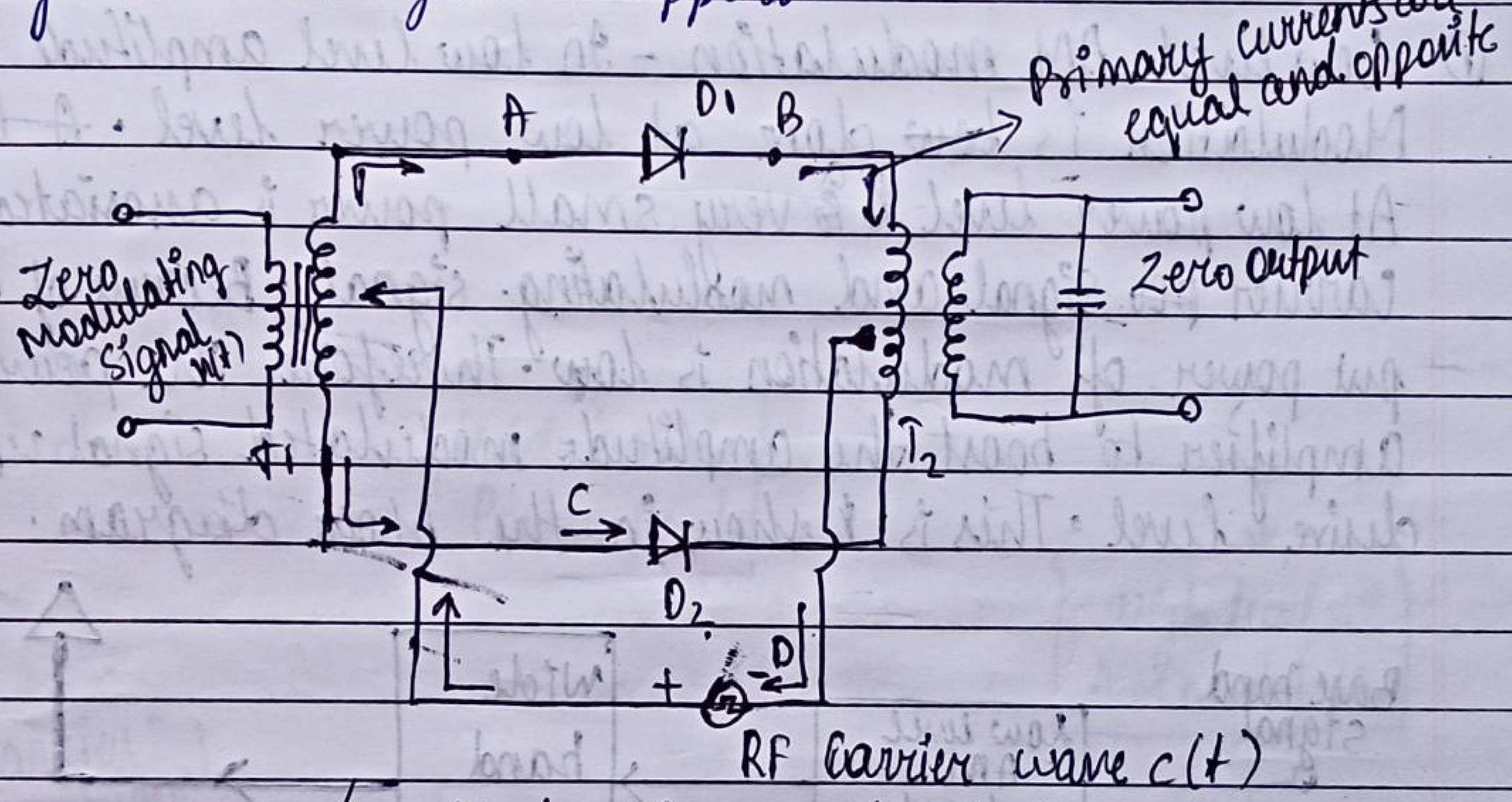
Working operation - The operation is explained with the assumption that the diodes act as perfect switches and they are switched ON and OFF by the RF carrier signal. This is because the amplitude and frequency of the carrier is higher than that of the modulating signal.

Mode-1 & Carrier Suppression -

Let us assume that the modulating signal is absent and only the carrier signal is applied. Hence, $x(t) = 0$.

OPERATION IN THE POSITIVE HALF CYCLE OF CARRIER –

In this mode let us assume that the modulating signal is 0 and only the carrier signal is applied

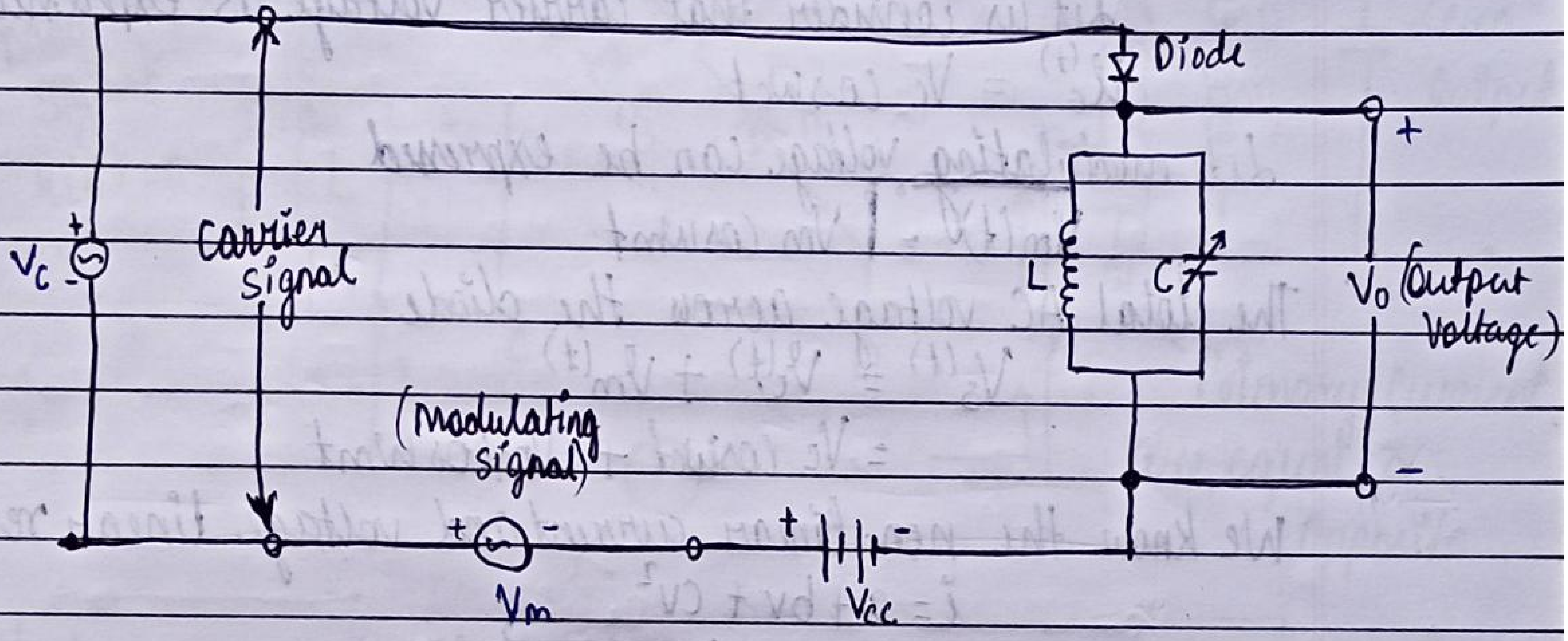


(A diode Ring modulator)

In this mode the diodes D_1 and D_2 are forward bias, Diode D_3 and D_4 are reversed bias. Let us observe the direction of currents flowing through the primary winding of output transformer T_2, & they are equal and opposite to each other. Therefore the magnetic feild produced by these currents are equal and opposite and cancle each other. Hence the induced voltage in the seconday winding is zero. Thus the carrier is supported in the positive half cycle.

↳ Extra at Pg. no. 37

Square law diode modulation -



Square-law diode modulation

Defination - Square law diode modulation circuit use non-linear current voltage characteristics of diode.

→ Circuit diagram (decription) -
Figure shows the circuit diagram of square law diode modulation.

Working -
Here carrier and modulating signals are applied across the diode.

→ A DC Battery Vcc is connected across the diode to get fix operating point on the VI characteristic of diode.

→ When carrier and ~~fre~~ modulating frequency are applied at the input of diode different frequency ~~turns~~ terms appear at the output of the diode.

→ These different frequency ~~turns~~ terms are applied across a tuned circuit which is tuned to the carrier frequency and just pass two side band and reject other frequency.

Mathematical analysis –

Let us consider that carrier voltage is expressed as

$$v_c(t) = V_c \cos w_c t$$

Let modulating voltage can be expressed

$$v_m(t) = V_m \cos w_m t$$

The total AC voltage across the diode

$$V_s(t) = v_c(t) + v_m(t)$$
$$= V_c \cos w_c t + V_m \cos w_m t$$

We know the non-linear current and voltage linear relationship –

$$i = a + bv + cv^2$$
$$= a + bV_s(t) + cV_s(t)^2$$

From the above ~~a~~ equation –

$$i = a + b(V_c \cos w_c t + V_m \cos w_m t) + c(V_c \cos w_c t + V_m \cos w_m t)^2$$

$$\cancel{= a + b(V_c}$$

$$= a + bV_c \cos w_c t + bV_m \cos w_m t + cV_c^2 \cos^2 w_c t + cV_m^2 \cos^2 w_m t + 2c \cdot V_m \cos w_c t \times V_m \cos w_m t$$

$$= a + bV_c \cos w_c t + bV_m \cos w_m t + \frac{cV_c^2}{2} \times 2\cos^2 w_c t + \frac{cV_m^2}{2} \times 2\cos^2 w_m t + cV_m V_c\, 2\cos w_c t \cos w_m t$$

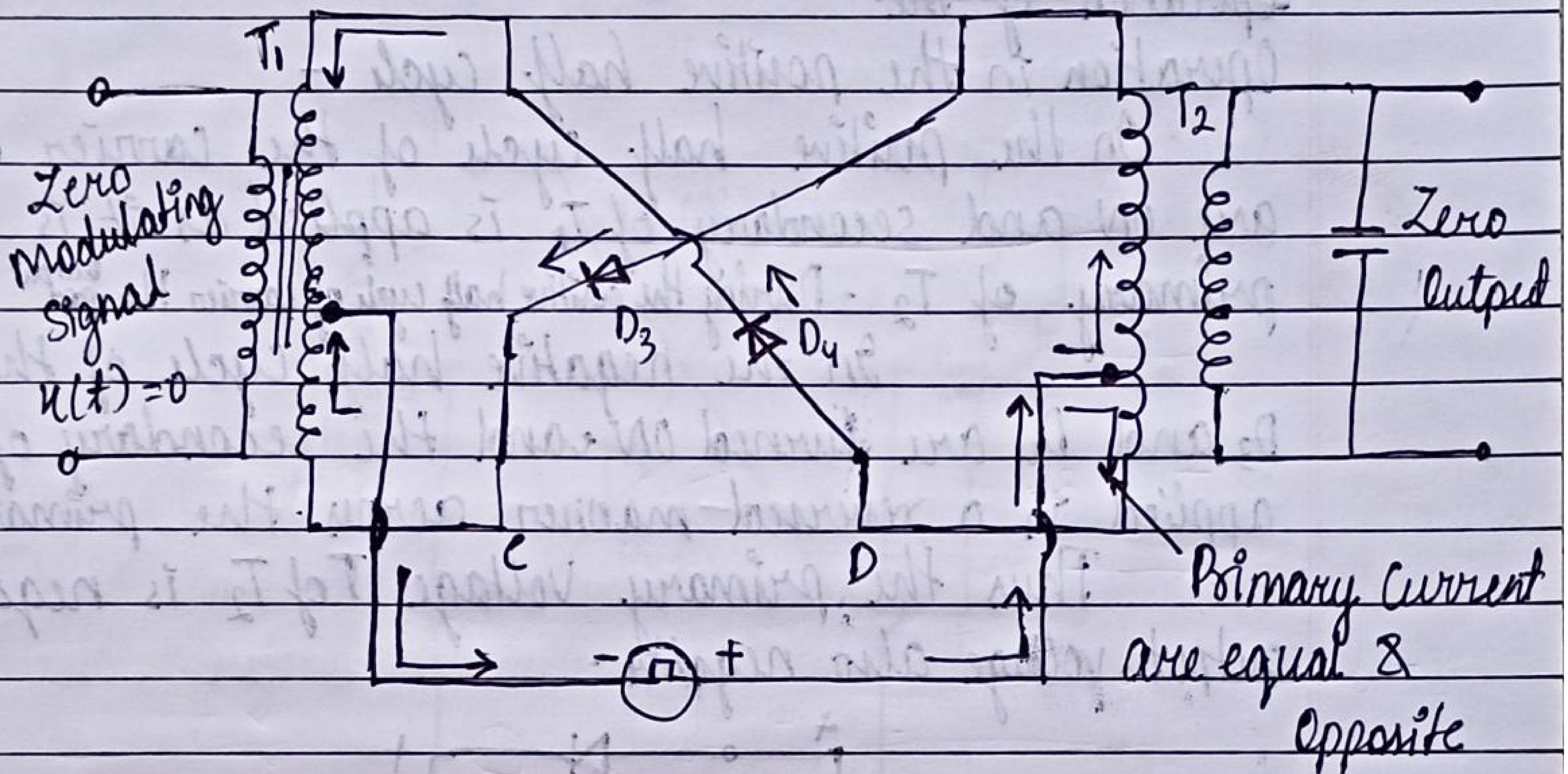
$$= a + bV_c \cos w_c t + bV_m \cos w_m t + \frac{cV_c^2}{2}(1 + \cos 2w_c t) + \frac{cV_m^2}{2}(1 + \cos 2w_m t) + cV_m V_c[\cos(w_c + w_m)t + \cos(w_c - w_m)t]$$

$$= a + \frac{cV_c^2}{2} + \frac{cV_m^2}{2} + bV_c \cos w_c t + bV_m \cos w_m t + \frac{cV_c^2}{2}\cos 2w_c t + \frac{cV_m^2}{2}\cos 2w_m t + cV_m V_c \cos(w_c + w_m)t + cV_m V_c \cos(w_c - w_m)t.$$

$$i_0 = bV_c \cos w_c t + cV_m V_c \cos(w_c + w_m)t + cV_m V_c \cos(w_c - w_m)t.$$

~~next step~~.

Operation of in nagative half cycle of the carrier -



Let us assume that the modulating signal is zero. In the negative half cycle of the carrier the diode D_3 and D_4 are forward biased and the diodes D_1 and D_2 are reversed biased. The currents flowing in the upper and lower half of the primary winding of T_2 are again equal and in opposite direction. These is going to cancle the magnetic feilds and the output voltage is zero. Thus the ~~output~~ carrier is supremed in the negative half cycle. The perfect cancellation of the carrier will takes place if and only if the characterisitc of the diodes are perfectly matched and the center tap is placed exactly at the centre of the primary of tranformer of T_2.

Mode-2

Operation of in presence of modulating signals -

when RF carrier and modulaiting signals both are applied.

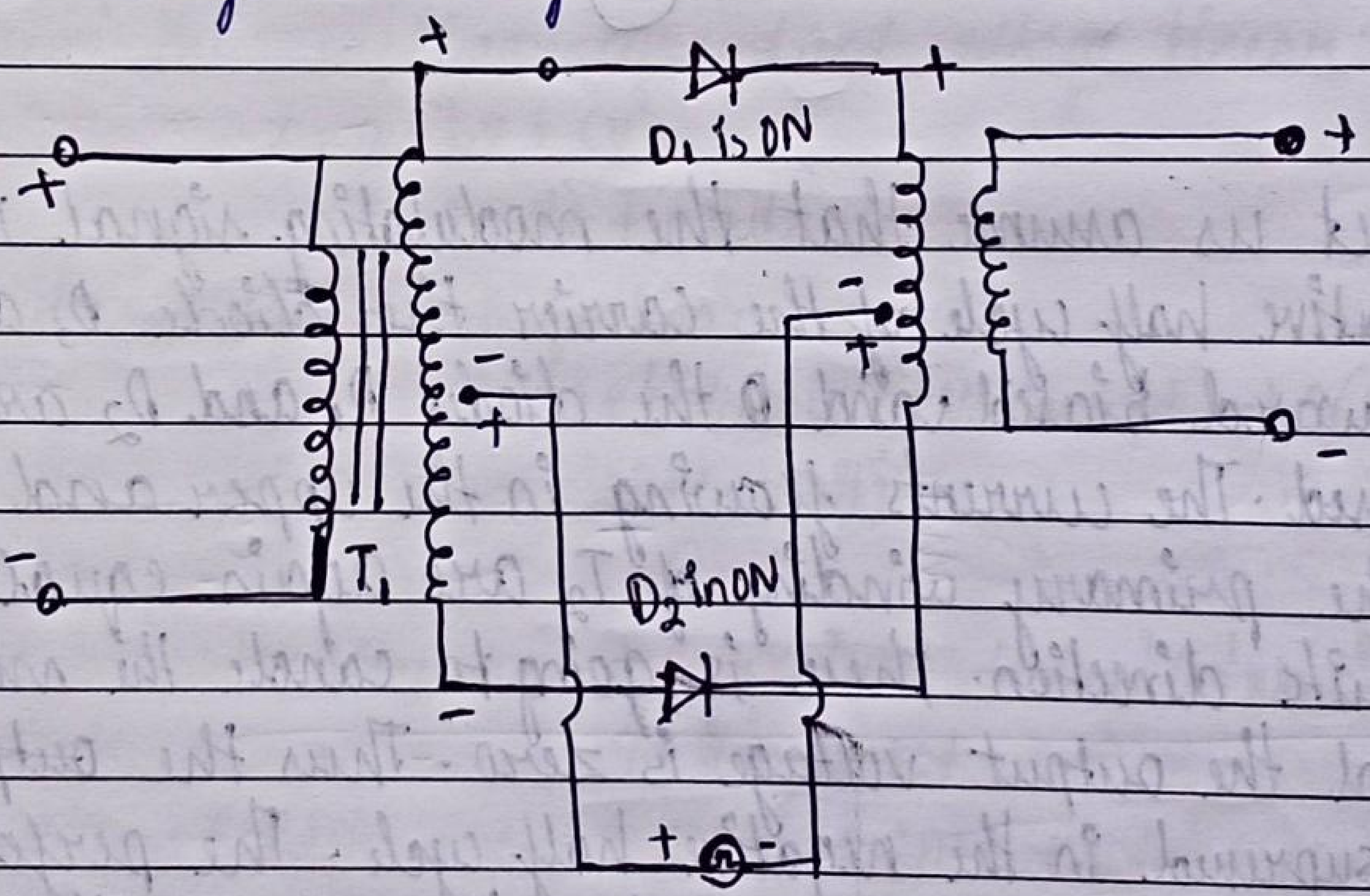
~~Operation of the~~

Operation in the positive half cycle –

In the positive half cycle of the carrier D_1 and D_2 are ON and secondary of T_1 is applied as it is across the primary of T_2. During the positive half cycle of carrier the output of T_2 is positive.

In the negative half cycle of the carrier D_3 and D_4 are turned ON and the secondary of T_1 is applied in a reversed manner across the primary of T_2.

Thus the primary voltage of T_2 is negative and output voltage also negative.



Equivalent circuit in the positive half cycle of modulating signal with carrier wave.

Operation in the negative half cycle of modulating signal – when modulating signal reverses the polarities the operation of the circuit is same as that in positive half cycle. Now, the only difference is that the diode pair D_3, D_4 will produce a positive output voltage where as D_1 ~~and~~ D_2 will produce a negative output voltage.

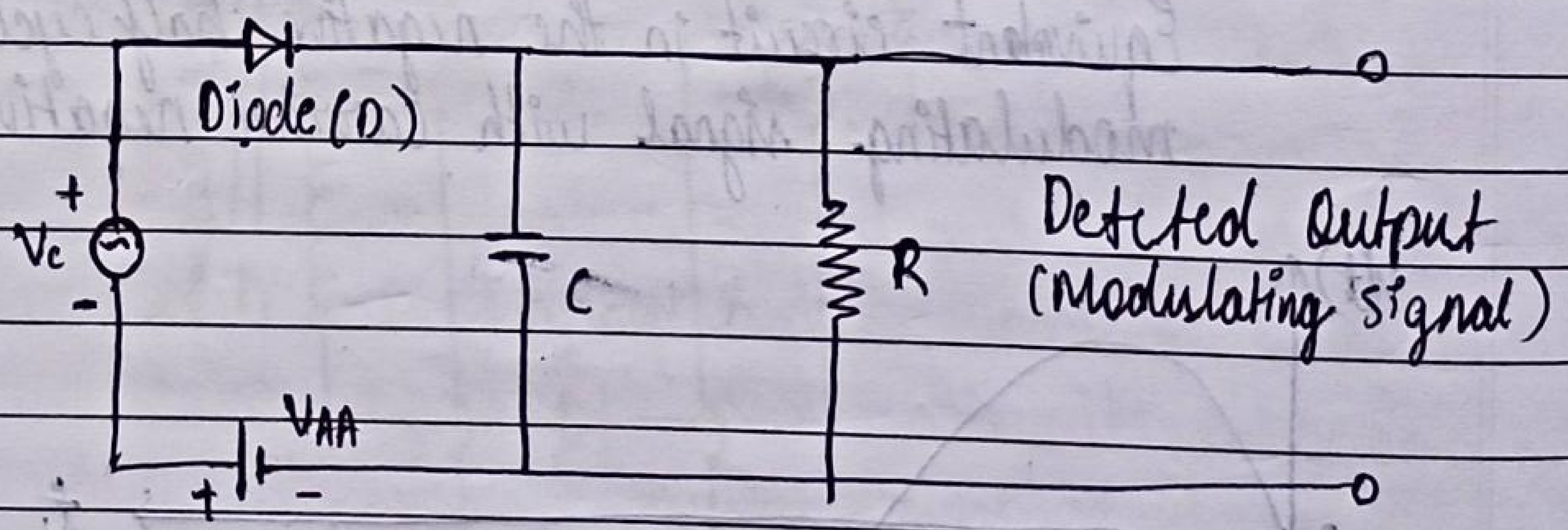
Demodulation of AM wave - The process of extracting modulating signal from the modulated signal is called demodulator or ~~de~~ ~~dede~~ detection.

The are two type of following ways -

1) Square law detector
2) Envelop law detector

Square law detector - The square law detector circuit is used for detecting modulator signal of small amplitude so that operating region restricted to the non-linear VI characteristic.

Circuit diagram -



Basic circuit of square law diode detector.

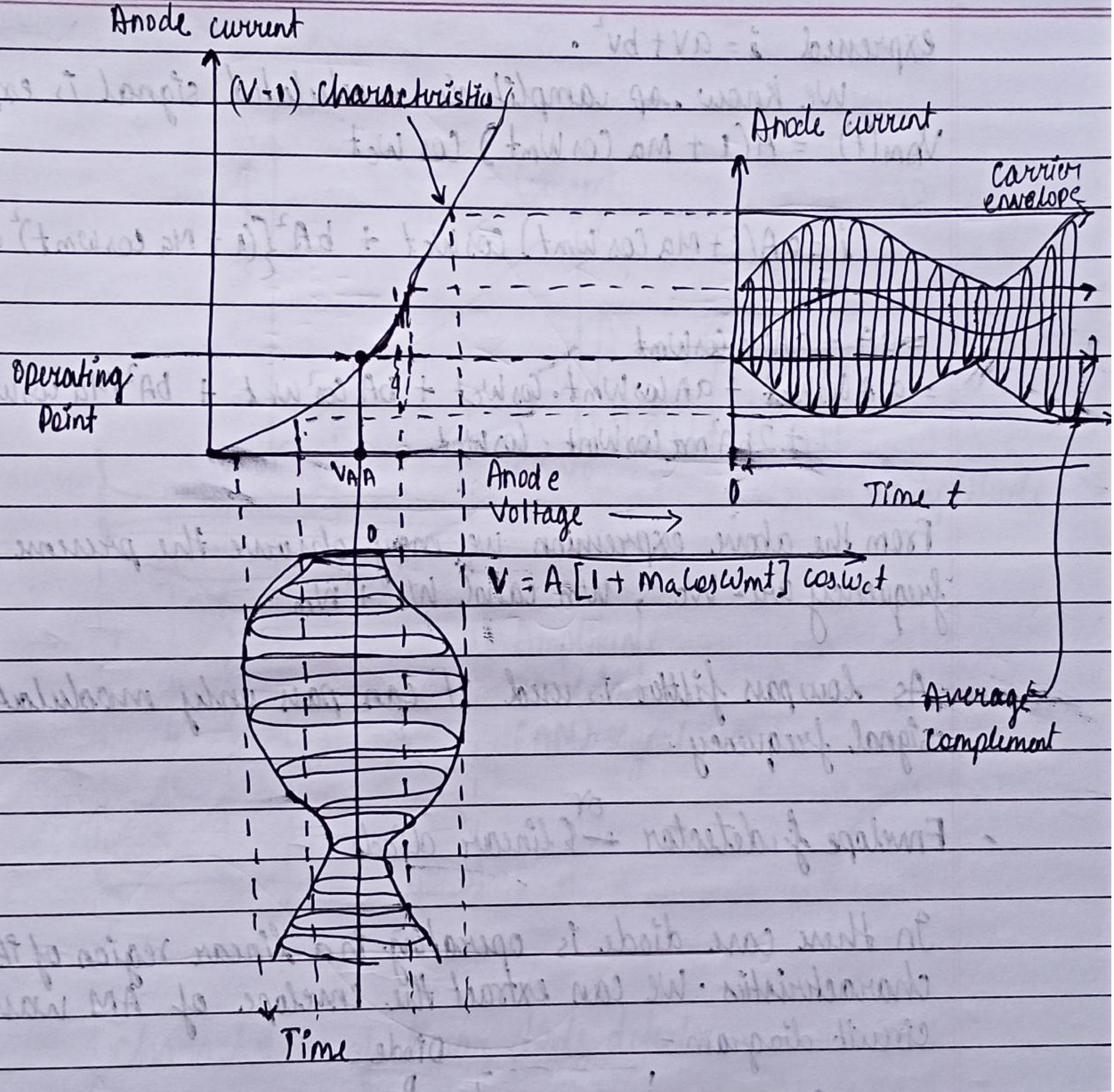


Figure shown above is the circuit diagram and VI characteristics of square law detector. In square law modulator the filter used is band pass filter where as in a square law a low pass filter is used. In these circuit, the DC supply voltage V_{AA} is used to get the fixed operating point in the non-linear portion of the diode VI characteristics. In these case the due to non-linear region the lower half portion of the modulated wave form is compressed.

The distorted output diode current is

Ch-3

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ANGLE MODULATION SYSTEM

Angle modulation ~~system~~ - Angle modulation may be defined as the process in which the total phase angle ~~ꟷ~~ of a carrier wave is varried in accodance with the instataneous value of the modulating signal while keeping the amplitude of the carrier constant

Mathematical Representation →

Let us consider that an unmodulated carrier signal is expressed as

$$c(t) = A\cos(W_c t + \theta_0) \quad \text{——} \quad (1)$$

where A = Amplitude of the carrier
W_c = Carrier frequency
θ_0 = Some phase angle

Substituting $W_c t + \theta_0 = \phi$, we get

$$c(t) = A\cos\phi \quad \text{——} \quad (2) \quad (3)$$

where $\phi = (W_c t + \theta_0)$ is the total phase angle of the carrier signal.

We may consider equation (2) as the real part of rotating phasor $Ae^{j\phi}$

Let us denote this rotating phasor by C. So that

$$C = Ae^{j\phi} \quad \text{——} \quad (4)$$

$$c(t) = Re(Ae^{j\phi})$$

$$c(t) = A \cdot Re(e^{j\phi}) = A\cos\phi \quad \text{——} \quad (5)$$

This phasor C rotates at a constant angular velocity W_c.

θ_0 is the phase angle of the unmodulated carrier at $t = 0$. ~~From~~

From equation C the constant velocity W_c of the phasor C is related to its total phase angle ~~too~~ ϕ as ~~the~~

$\phi = W_c t + \theta_0$.

Diffentiating both sides of these equation with respect to t we have,

$$W_c = \frac{d\phi}{dt} \quad \text{———} (6)$$

~~The derivative~~

~~The~~ For unmodulated carrier derivative $\frac{d\phi}{dt}$ is constant. However these derivative $\frac{d\phi}{dt}$ may not constant with time, These may vary ~~by~~ ~~A~~ with time. Therefore the angular velocity of the phasor C could also vary with time. Hence these time dependent angular ~~fre~~ velocity or angular frequency is known as ~~instata~~ instaneous angular velocity or instataneous angular frequency. These instaneous angular frequency is denoted by ~~Omega I~~ W_I. So $\frac{d\phi}{dt} = W_i$ ——— (7)

where angular frequency W_I is time dependent

From equation (4,7), we get

$$\phi = \int W_i \, dt$$

Again writing equation (4,1) of unmodulated carrier as

$c(t) = A \cos(W_c t + \theta_0)$

or, $c(t) = A \cos \phi$

where ϕ is the total phase angle of the unmodulated carrier expressed as

$$\phi = W_c t + \theta_0$$

Now, if this angle ϕ is varied according to the instantaneous value of the message or modulation signal, the carrier signal is then said to be angle modulated.

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Types of angle modulation -
There are 2 types of angle modulation -
1) Phase modulation
2) Frequency modulation

Application -
Angle modulation is been used for the following applicati
1) Radio broadcasting
2) Two way mobile radio
3) Microwave communication
4) TV sound transmission
5) Cellular Radio
6) Satelite communication

Phase modulation -
Phase modulation is that type of angle modulation in which phase angle ϕ is varried linearly with a base band of modulating signal $x(t)$ about an unmodulated phase angle $(\omega t + \phi_0)$.
The instanceous value of the phase angle is equal to the phase angle of the unmodulated carrier $(\omega_c t + \phi_0)$ pulse a time varries component which is propersonal to modulating signal $x(t)$.

Mathematical representation -
We know that unmodulated carrier signal is expressed as

$$c(t) = A\cos(\omega_c t + \theta)$$

$$\text{or } c(t) = A\cos\phi$$

where, $\phi = \omega_c t + \theta_0$

Neglecting θ_0, we get total phase angle of unmodulated carrier is $\phi = \omega_c t$.

Now, according to phase angle modulation, this phase angle 'ϕ' is varied linearly with a baseband or modulating signal $x(t)$.

Let the instantaneous value of phase angle be denoted by ϕ_i. Therefore,

$$\phi_i = \omega_c t + k_p x(t)$$

where k_p is the proportionality constant & known as phase sensitivity of the modulator. This is expressed in radian/volt.

Since, the expression for unmodulated carrier wave is $c(t) = A \cos\phi$.

Therefore, the expression for phase modulated wave will be $s(t) = A \cos\phi_i$. (4.11)

Putting the value of ϕ_i in equation from equation (4.10) we get $s(t) = A \cos[\omega_c t + k_p x(t)]$

which is required mathematical expression for as phase ~~a~~ modulated wave.

Frequency modulation -

Frequency modulation is that type of angle modulation in which the instantaneous frequency ω_i is varried linearly with a message or baseband signal $x(t)$ about an unmodulated carrier frequency ω_c.

→ The instantaneous value of the angular frequency ω_i will be equal to the carrier frequency ω_c plus a time varying component proportional to the base band signal $x(t)$.

Mathematical representation -

we know that the instantaneous frequency is given by

$$\omega_i = \omega_c + k_f \cdot x(t) \quad \text{—— (1)}$$

where RF is proportionally constant & is known as the frequency sensitivity of the modulator. This is expressed in Hz/volt.

Now, let the expression for unmodulated carrier signal be

$$C(t) = A\cos(\omega_c t) + \theta_0) \text{ ——— (ii)}$$

$$C(t) = A\cos\phi \text{ ——— (iii)}$$

$$\phi = \omega_c t + \theta_0 \text{ ——— (iv)}$$

where, ϕ is the total phase angle of the unmodulated carrier.

Let ϕ_i be the instantaneous phase angle of the modulated signal. From equation (4.15) the equation for unmodulated carrier is

$$C(t) = A\cos\phi$$

On frequency modulation amplitude 'A' must remain constant & only angle 'ϕ' will change.

Hence, the expression for frequency modulated wave will be

$$S(t) = A\cos\phi \text{ ——— (v)}$$

where ϕ_i = Instantaneous phase angle frequency equation (iii), we have

$$\phi = \omega_c t + \theta_0$$

On differentiation, we get

$$\frac{d\phi}{dt} = \omega_c$$

or

$$\phi = \int \omega_c dt \text{ ——— (vi)}$$

Base on equation (vi), we may write the expression on ~~equation~~ instantaneous phase angle ϕ_i as

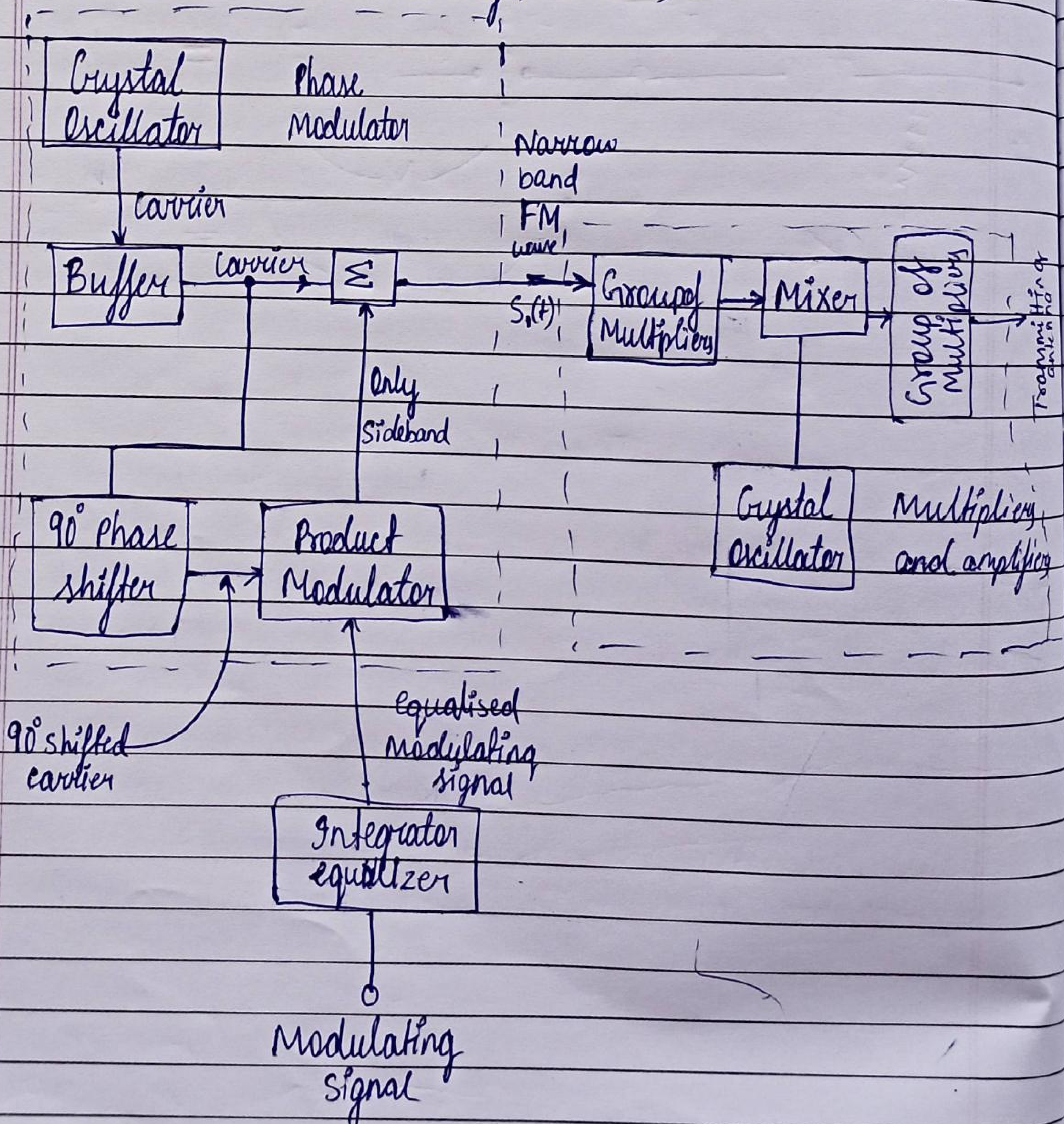
$$\phi_i = \int \omega_i dt \text{ ——— (vii)}$$

where ω_i = instantaneous frequency modulation wave. Putting this value of ω_i in equation (vt) we get the expression for frequency modulated wave will be.

$$S(t) = A\cos[\omega_c t + RF\int x(t)\,dt] \text{ ——— (viii)}$$

Method of FM generation -
There are two types of method -
① Direct method
② Indirect method

Indirect method (Armstrong method)



Indirect method (Armstrong method) of FM generation.

The working operation of indirect method are divided into two parts.

Part 1 -

Generate a narrow band FM wave using ~~fr~~ phase modulator. ~~Use~~

Part 2 -

Use the frequency multiplers and mixers to obtain required values of frequency deviation carrier and modulation index.

Figure shown above is the indirect method of FM generation.

→ The crystal oscillator produces ~~an mod~~ a stable ~~an modu~~ unmodalated carrier which is apply 90° phase shift as well as combining network through a buffer.

→ The 90° phase shifter ~~carrier~~ produces a 90° phase shifted carrier.

→ It is applied to the ~~p~~ balanced modulator. Along with modulating signal.

→ Hence at the output of product modulator, we get DSD-SC signal.

→ The two side band and the orginal carrier without any phase shift are applied to a combining network.

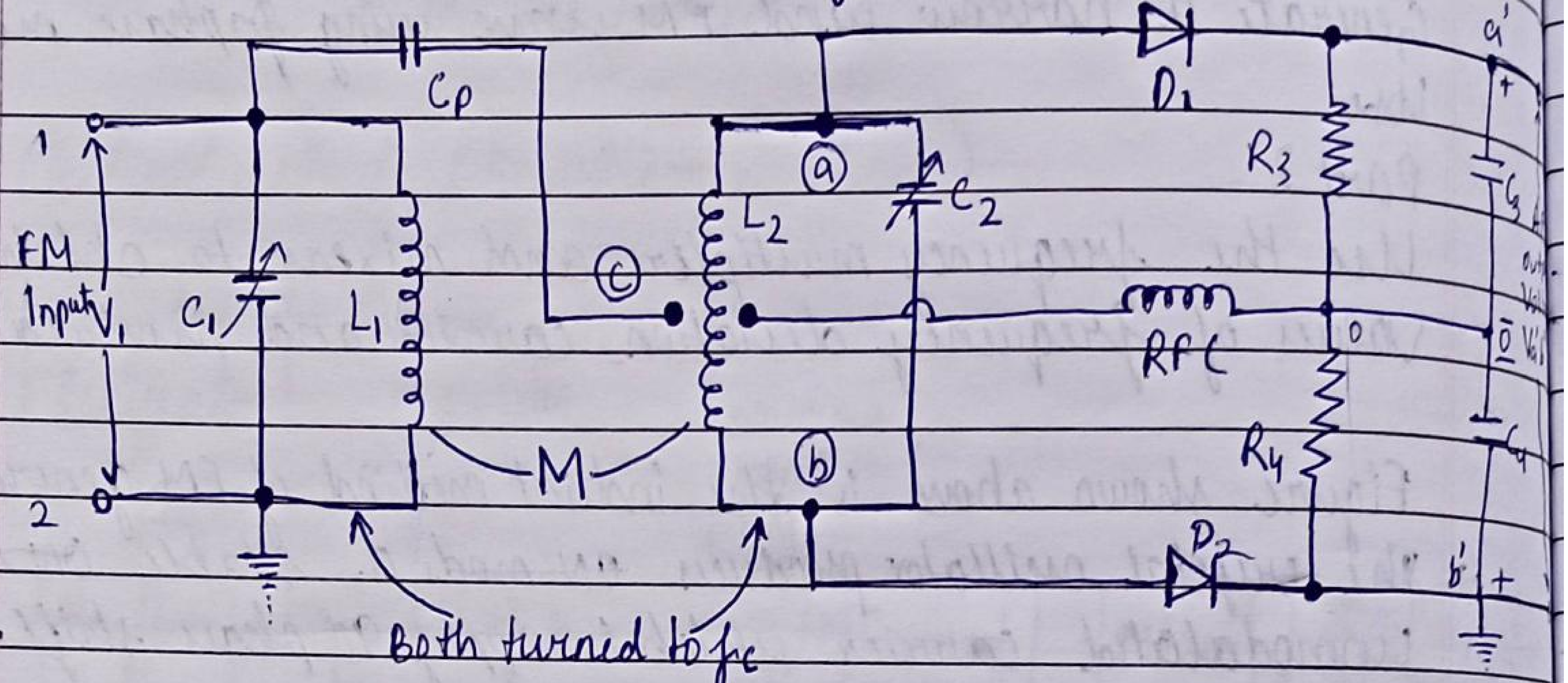
→ The FM signal produce at the output of phase modulator has low carrier frequency and low modulation index.

→ Therefore they are increased with the help of frequency multiplier and mixer.

Demodulation of FM wave -

Demodulation of FM wave -

Phase discrimator (Foster seeley) -



Phase discrimator

Operation - Here the primary and secondary tuned circuit are tuned to the same center frequency. The voltages apply to the two diodes D_1 and D_2 are not constant.

In these case varying of the voltage depend upon frequency of the input signal.

→ At input frequency (f_{in}) = f_c, the individual output voltages of the two diodes will be equal and opposites. The output voltage is zero.

$$V_0 = V_{01} - V_{02}$$

→ For $f_{in} > f_c$, the phase shift ~~the~~ between the primary and secondary winding is such that ~~the~~ output of D_1 is higher than D_2. Hence output voltage will be positive.