LECTURE NOTES OF

ANALOG AND DIGITAL COMMUNICATION

5TH SEMESTER ETC

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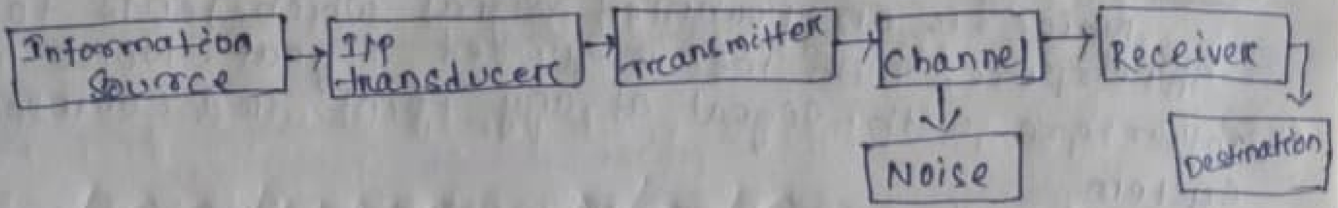
Unit - 1 Elements of Communication System

1.1. Communication Process

Communication is a process of establishing connection or link between two point for information exchange.

Elements of Communication :-



(Block diagram of a Communication System)

Information Source :-

The function of the information sources is to produce required Message signal which has to be transmitted. There can be various messages in the form of words, groups of words, code, symbols, sound signal etc.

Input Transducer :-

A transducer is a device which converts one form of energy into another form. The Message from the information source may or may not be electrical in nature. So input transducer converts non-electrical signal to electrical signal.

Transmitter :-

The function of the transmitter is to process the electrical signal from different aspects. Inside the transmitter, signal processing such as restriction of range of audio frequencies, amplification and Modulation are achieved.

Channel :-

A function of the channel is to provide a physical connection between the transmitter & receiver.

→ There are two types of channel

(I) point to point channel

(II) Broad cast channel

(I) Point to point channel :-
wire lines, Microwave links and optical fiber.

(II) Broadcast channel :-
It provided a capability where several receiving station can be reach simultaneously from a single transmitter.

Noise
Noise is an unwanted signal which tends to interfere with the required signal. Noise may interfere with signal at any point in a communication system.

Receiver
The main function of receiver is to reproduce the message signal in electrical form from the distorted received signal. This reproduction of the original signal is accomplished by a process known as the demodulation.

Destination
Destination is the final stage which is used to convert an electrical message signal into its original form.

1.2 Source of Information & Communication channels

Source of information
Some of the important source of information in the communication environment given below:
(I) Speech
(II) Picture
(III) Computer data

Communication channel
The medium over which the information is passed from the transmitter to the receiver is called as a communication channel. Depending on the mode of transmission the communication channels classified into two categories. Such as
(I) Guided medium
(II) Unguided medium

Communication channels

- Channels based on guided propagation
  - Telephone channels
  - Coaxial cable
  - Optical fiber
- Channel based on free propagation
  - Wireless broadcast channels
  - Satellite channels
  - Mobile radio channels

1.3 Classification of communication system

Regarding the made off propagation communication may be divided into 2 forms. such as

(I) Line communication.

(II) Radio or wireless communication.

(I) Line communication:-

The line communication where the transmitter or receiver are connected through a wire line.

→ However the installation and maintenance of transmission wires is costly & complex.

→ Its message transmission capability is limited.

(II) Radio or wireless communication:-

→ A message is transmitted through open space by Electromagnetic waves called as Radio waves.

→ The radio waves are transmitted from the transmitter in open space through a device it called antenna.

→ The advantages of radio communication are

(I) cost effectiveness

(II) possible long distance communication

(III) simplicity.

1.4 Modulation Process, Need of Modulation & classify Modulation Process

Modulation:-

The process of changing some characteristic such as Amplitude, frequency, Phase of the carrier signal according to the Message signal is known as Modulation.

Need of Modulation:-

(I) To remove interference
(II) Reduction of noise
(III) Multiplexing

→ Simultaneously transmission of Multiple Message signal over a single channel is known as Multiplexing.
→ If it transmits without modulation, the different Message signal over a single channel will interfere with one other.
→ Multiplexing helps in transmitting number of Message signal simultaneously over a single channel & therefore a number of channel needed will be less.

Classify Modulation Process

Modulation are of three types. These are

(I) Amplitude Modulation
(II) frequency Modulation
(III) Phase Modulation

(I) **Amplitude Modulation**

The process by which the amplitude of a carrier wave is varied in accordance with the original signal.

(II) frequency Modulation

The process by which the frequency of a carrier wave is varied in accordance with the original signal.

(III) Phase Modulation

The process by which the phase of a carrier wave is varied in accordance with the original signal.

1.5 Analog and Digital Signals & its conversion

Analog signal:-

The signal which is continous in nature that means the amplitude is change in every time is known as Analog signal.

Digital signal:-

The signal which is discrete in nature that means for a particular time period the amplitude is constant is known as Digital signal.

Conversion of Analog signal to Digital signal:-

There are three steps for conversion process

1. The signal is sampled.
2. The sampled signal is quantized.
3. The quantized signal is digitally coded.

Sampling

Sampling can be defined as the process of taking samples from the continuous time function $x(t)$.

Sampling Theorem

It state that the sampling frequency must be always greater than or equal to twice the highest frequency.

→ sampling is done with a Sample-And-Hold circuit.

Quantization

The process of taking a continous voltage signal and mapping it to a discrete number of voltage levels. The number of quantization levels is usually a power of 2 i.e

$N = 2^n$

where n is the number of quantization bit.
N is the number of quantization level.

Encoding

The process of converting the quantized signal into digital representation is known as Encoding.

→ The encoding is performed by giving each quantization level.

Eg:- If four bits are used
the lower bit level is 0000
next highest level is 0001

1.6 Basic concept of signal & signals Classification:

A signal is a physical quantity which varies with respect to time, space and contains some information from source to destination.

Signals are classified into following categories

(I) Even & Odd signal.
(II) Energy & Power signal.
(III) Periodic & aperiodic signal.
(IV) Real & imaginary signal.
(V) Continuous & Discrete Time signal.
(VI) Deterministic & Non Deterministic signals.

(I) **Even & Odd Signal:-**

A signal is said to be even signal when it satisfies the condition $x(t) = x(-t)$

A signal is said to be odd signal when it satisfies the condition $x(-t) = -x(t)$

(II) **Energy & Power signal:-**

A signal is said to be energy signal when it has finite energy and zero power.

A signal is said to be power signal when it has finite power and infinite energy.

(III) **Periodic & Aperiodic Signal:-**

A periodic signal is that type of signal which has a definite pattern & repeats that pattern values after a fixed length of time.

The signal which does not at the regular interval of time is known as an Aperiodic signal or non-periodic signal.

(IV) **Real & Imaginary Signal:-**

A signal $x(t)$ is a real signal if its values is a real number.

A signal $x(t)$ is a complex signal if its values is a complex no.

(V) **Continuous & Discrete Time Signal:-**

A signal is said to be continuous when it is defined for all instants of time.

A signal is said to be Discrete when it is defined at only discrete instants of time.

(vi) **Deterministic & Non-deterministic signals:-**

Signals which can be defined exactly by a Mathematical formula are known as deterministic signals.

Signal which cannot be described by a Mathematical equation is known as Non-deterministic signal.

→ Non-deterministic signal is also known as random signal.

1.7 Bandwidth limitation

The bandwidth limitation is major limitation in communication system.

→ The frequency range is needed for a particular transmission is known as bandwidth.

→ This band of frequencies or bandwidth for a particular transmission is also called channel and it is always allocated by some international regulatory. This type of regulation is essential to avoid interference among the signals having same frequency.

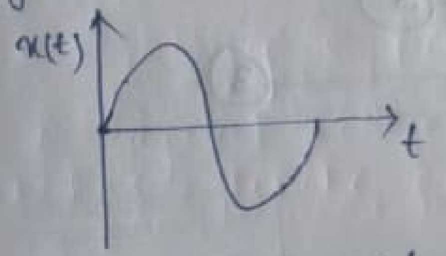
→ The Information Theory state that the greater is the transmission bandwidth of a communication system, the more is the information can be transmitted.

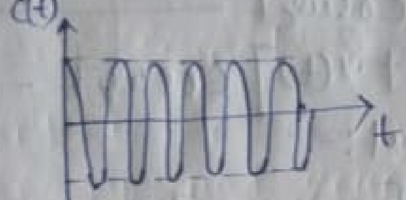
Unit - 2 Amplitude (Linear) Modulation system

2.1 Amplitude Modulation & derive the expression for AM, power relation in AM wave & find modulation index

Amplitude Modulation

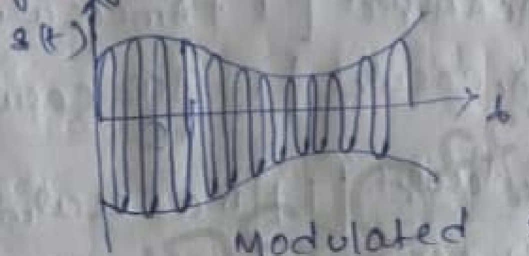
The process by which the amplitude of a carrier wave is varied in accordance with the modulating signal is called amplitude modulation.





Base band signal/ original signal/ Modulating signal

Carrier signal



Modulated signal

Let us consider a carrier wave

$c(t) = A\cos\omega t$

where A = Maximum Amplitude of the carrier

$x(t)$ = Message signal

$s(t) = x(t)\cos\omega t + A\cos\omega t$

$s(t) = [A + x(t)]\cos\omega t$

Modulating signal $x(t) = A_m \cos\omega_m t$

Carrier signal $c(t) = A_c \cos\omega_c t$

A_m = Maximum Amplitude of Modulating signal

A_c = Maximum Amplitude of carrier signal

ω_m = Angular frequency of Modulating signal

$\omega_m = 2\pi f_m$

$\Rightarrow f_m = \frac{\omega_m}{2\pi}$

ω_c = Angular frequency of carrier signal

$$\omega_c = 2\pi f_c$$

$$\Rightarrow f_c = \frac{\omega_c}{2\pi}$$

$$x(t) = A_m \cos\omega_m t \quad \text{--- (1)}$$

$$c(t) = A_c \cos\omega_c t \quad \text{--- (2)}$$

$$s(t) = [A + x(t)] \cos\omega_c t \quad \text{--- (3)}$$

Modulated signal:-

$$s(t) = [A_c + x(t)] \cos\omega_c t$$

$$= [A_c + A_m \cos\omega_m t] \cos\omega_c t$$

$$= A_c \cos\omega_c t + A_m \cos\omega_m t \cdot \cos\omega_c t$$

$$= A_c \cos\omega_c t \left[1 + A_m \cos\omega_m t\right]$$

$$= A_c \cos\omega_c t \left[1 + \frac{A_m}{A_c} \cos\omega_m t\right]$$

$$= A_c \cos\omega_c t \left[1 + m_a \cos\omega_m t\right] \quad \left(\because \frac{A_m}{A_c} = m_a\right)$$

$$= A_c \cos\omega_c t + m_a A_c \cos\omega_m t \cdot \cos\omega_c t$$

$$= A_c \cos\omega_c t + \frac{m_a A_c}{2} \times 2 (\cos\omega_c t \cdot \cos\omega_m t)$$

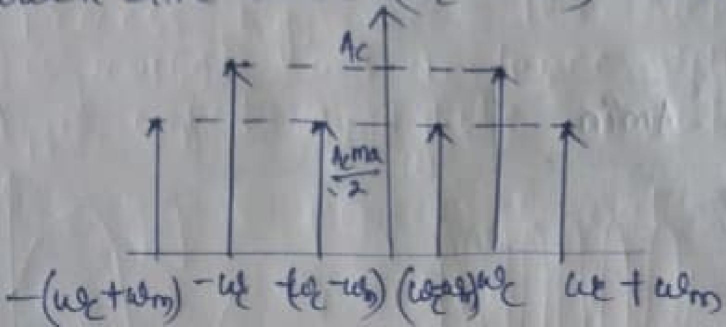
$$= A_c \cos\omega_c t + \frac{m_a A_c}{2} \cos(\omega_c + \omega_m)t + \frac{m_a A_c}{2} \cos(\omega_c - \omega_m)t$$

$$\because 2[\cos A \cdot \cos B] = [\cos(A+B) + \cos(A-B)]$$

$$\boxed{s(t) = A_c \cos\omega_c t + \frac{m_a A_c}{2} \cos(\omega_c + \omega_m)t + \frac{m_a A_c}{2} \cos(\omega_c - \omega_m)t}$$

It shows that Am signal has three components as follows.

(i) Carrier frequency (ω_c) having amplitude (A_c).
(ii) Upper side band ($\omega_c + \omega_m$) having amplitude $\frac{A_c m_a}{2}$
(iii) Lower side band ($\omega_c - \omega_m$) having amplitude $\frac{A_c m_a}{2}$



Bandwidth

width of higher side - width of lower side

$= \omega_c + \omega_m - (\omega_c - \omega_m)$

$= \omega_c + \omega_m - \omega_c + \omega_m$

$= 2\omega_m$

Modulation index

The ratio of amplitude of modulating signal to the amplitude of the carrier signal.

→ It is denoted by m_a.

→ Modulation index is also known as depth of modulation, degree of modulation.

$$\text{Modulation index} = \frac{\text{Maximum Amplitude of Modulating signal}}{\text{Maximum Amplitude of carrier signal}}$$

$$m_a = \frac{A_m}{A_c}$$

$A_{max} = A_c + A_m$

$A_{min} = A_c - A_m$

when $A_{max} + A_{min}$

$= A_c + A_m + A_c - A_m$

$= 2A_c$

$$\boxed{A_c = \frac{A_{max} + A_{min}}{2}}$$

when $A_{max} - A_{min}$

$= A_c + A_m - (A_c - A_m)$

$= A_c + A_m - A_c + A_m$

$= 2A_m$

$$\boxed{A_m = \frac{A_{max} - A_{min}}{2}}$$

$$m_a = \frac{A_m}{A_c}$$

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

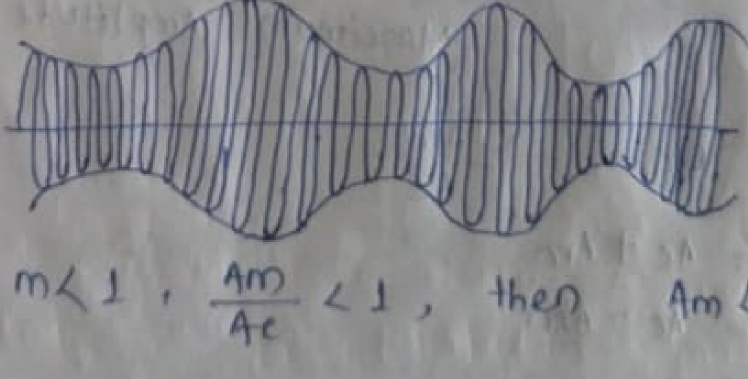
$$\boxed{m_a = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}}$$

There are three case of ma

Case - 1

when $A_m < A_c$, $m_a < 1$

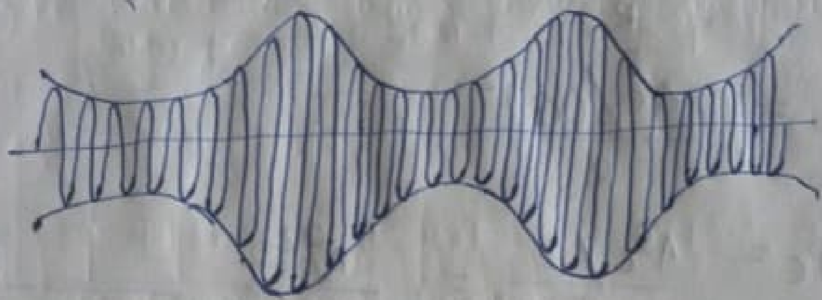
This condition is known as under modulation



when $m < 1$, $\frac{A_m}{A_c} < 1$, then $A_m < A_m$.

Case - II

when $m=1$, $\frac{Am}{Ac}=1$, $Am=Ac$, $ma=1$. This condition is known as exact modulation.



Case - III

when $m>1$, $\frac{Am}{Ac}>1$, $Am>Ac$, $ma>1$. This condition is known as over modulation.

Power relation in AM wave :-

we known total power of the AM wave is the sum of the carrier power & side band power.

Total power $(P_T) = P_C + P_{LSB} + P_{USB}$

$= P_C + P_S$

where

P_C = carrier power

P_{LSB} = Lower side band power

P_{USB} = upper side band power

P_S = side band power.

we known $P = \frac{V^2}{R}$

we take the rms value of V

$$P = \frac{(V_{rms})^2}{2}$$

$$= \frac{(V_m/\sqrt{2})^2}{2}$$

Then

$$P_c = \frac{(A_c/\sqrt{2})^2}{R}$$

$$= \frac{A_c^2/(\sqrt{2})^2}{R}$$

$$\Rightarrow P_c = \frac{A_c^2/2}{R} = \frac{A_c^2}{2R} \quad \text{—— (I)}$$

$$P_{USB} = \frac{(V_m/\sqrt{2})^2}{R}$$

$$= \frac{\left(\frac{m_a A_c}{2\sqrt{2}}\right)^2}{R}$$

$$= \frac{m_a^2 A_c^2/4\times 2}{R} = \frac{\frac{m_a^2 A_c^2}{8}}{R}$$

$$\Rightarrow P_{USB} = \frac{m_a^2 A_c^2}{8R} \quad \text{—— (II)}$$

$$P_{LSB} = \frac{(V_m/\sqrt{2})^2}{R}$$

$$= \frac{(m_a A_c/2\sqrt{2})^2}{R}$$

$$= \frac{m_a^2 A_c^2/4\times 2}{R} = \frac{m_a^2 A_c^2/8}{R}$$

$$\Rightarrow P_{LSB} = \frac{m_a^2 A_c^2}{8R} \quad \text{—— (III)}$$

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

$$= \frac{m_a^2 A_c^2}{8R} + \frac{m_a^2 A_c^2}{8R}$$

$$= 2\cdot\frac{m_a^2 A_c^2}{8R} = \frac{m_a^2 A_c^2}{4R}$$

$$P_T = P_c + P_s$$

$$= \frac{A_c^2}{2R} + \frac{m_a^2 A_c^2}{4R}$$

$$= \frac{A_c^2}{2R}\left[1 + \frac{m_a^2}{2R}\right]$$

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

$$\boxed{P_T = P_c\left[1 + \frac{m_a^2}{2R}\right]}$$

<u>Current Relation</u> :-

$$P = I^2 R$$

$$P_T = P_c\left[1 + \frac{m_a^2}{2R}\right]$$

$$\Rightarrow I_t^2 R = I_c^2 R\left[1 + \frac{m_a^2}{2}\right]$$

$$\Rightarrow \frac{I_t^2 R}{I_c^2 R} = \left[1 + \frac{m_a^2}{2}\right]$$

$$\Rightarrow \frac{I_t^2}{I_c^2} = \left[1 + \frac{m_a^2}{2}\right]$$

~~$\Rightarrow I_t^2 = I_c^2\left[1 + \frac{m_a^2}{2}\right]$~~

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

$$\Rightarrow \frac{I_t}{I_c} = \sqrt{1 + \frac{m_a^2}{2}}$$

$$\Rightarrow \boxed{I_t = I_c\sqrt{1 + \frac{m_a^2}{2}}}$$

* If there is Multiple Modulation index then

$$P_T = P_c\left[1 + \frac{ma_1^2}{2} + \frac{ma_2^2}{2} + \frac{ma_3^2}{2} + \cdots + \frac{ma_n^2}{2}\right]$$

$$\Rightarrow ma_T^2 = \left[ma_1^2 + ma_2^2 + ma_3^2 + \cdots + ma_n^2\right]$$

$$\Rightarrow \boxed{ma_T = \sqrt{ma_1^2 + ma_2^2 + ma_3^2 + \cdots + ma_n^2}}$$

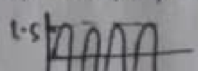
This is the expression for the total or net modulation index.

Q. 1)   find modulation index & modulated signal, percentage of Modulation.

Ans:- $ma = \frac{0.5}{1} = 0.5$

modulated signal $= 0.5 + 1 = 1.5$

% of Modulation index $= 0.5 \times 100 = 50\%$

2)   find modulation index and modulated signal, percentage of modulation ?

Ans:- $ma = \frac{1}{1.5} = 0.66$

modulated signal $= 1.5 + 1 = 2.5$

% of modulation index $= 0.66 \times 100 = 66\%$

3) what is the modulation index if $A_{max} = 5.9V$ & $A_{min} = 1.2V$

Ans:- $ma = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$

$= \frac{5.9 - 1.2}{5.9 + 1.2}$

$= \frac{4.7}{7.1}$

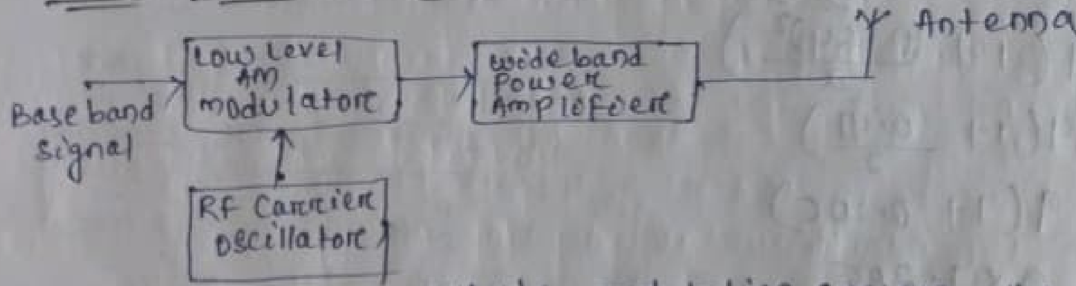
$= 0.6619$

Generation of AM wave

The device which is used to generate an amplitude modulation wave is known as amplitude modulator. The methods of amplitude modulation generation ~~may~~ be classified into two types such as

1) Low Level AM modulation
2) High level AM modulation

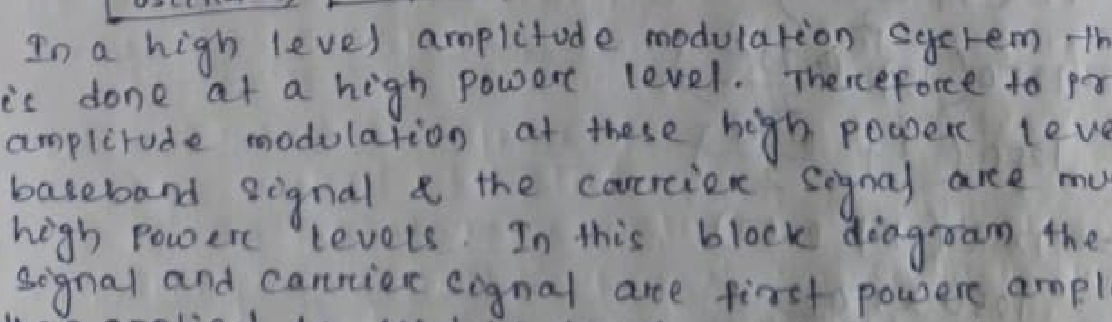
1. Low Level AM modulation



In a low level amplitude modulation system, the modulation is done at low power level. At low power level a very small power is associated with the carrier signal and the modulating signal. Because of this output power of modulation is low. Therefore power amplifiers are required to boost the amplitude. A wide band power amplifier is used to preserve the sidebands of the modulated signal.

Ex:- Square law diode modulation, switching modulation

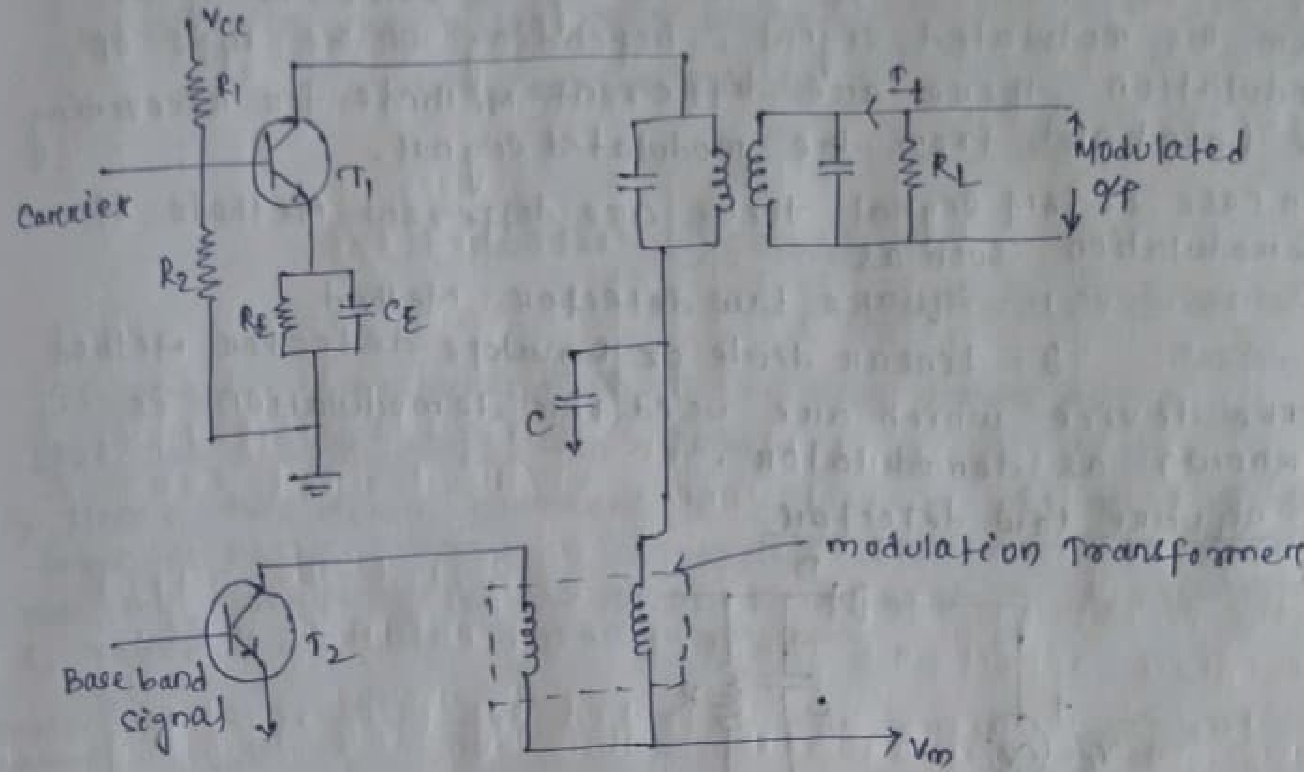
2. High level Amplitude modulation



In a high level amplitude modulation system the modulation is done at a high power level. Therefore to produce amplitude modulation at these high power levels the baseband signal & the carrier signal are must be at high power levels. In this block diagram the modulating signal and carrier signal are first power amplified and then applied to AM high level modulator. for modulating signal the wide band power amplifier is required just to preserve all the frequency components present in modulating signal. On the other hand for carrier signal narrowband power amplifier is required because it is a fixed frequency signal.

Ex:- Collector modulation method.

Collector Modulation (linear level AM Modulation)



Collector modulation is a linear modulator. The circuit consists of two transistors T_1 and T_2. The transistor T_1 makes a radio frequency class-C amplifier. At the Base of the T_1 carrier signal is applied.

→ The transistor T_2 makes a class B amplifier which is used to amplify the modulating signal appears across the modulation transformer.

→ Vcc is used to power supply. R_1, R_E emitter resistance, collector resistance is used to provide proper Biasing.

→ Transistor 2 is used for Baseband signal supply. capacitor is used for low impedance path for which carrier signal generate high frequency and the distortion occurs in carrier signal are prevent.

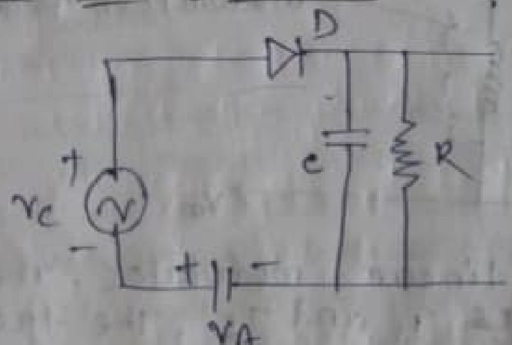
→ Tuned circuit combine carrier & modulating signal provide modulated signal through R_L. Particular frequency tuned for fixed the signal.

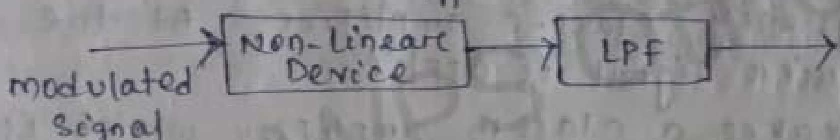
Demodulation

It is the process of recovering the baseband signal from the modulated signal. Depending on the type of modulation there are different methods for recovering the baseband from the modulated signal.

- In case of AM signal there are different methods of demodulation such as
  1. Square law detector Method
  2. Linear diode or Envalope detector Method
- The device which are used for demodulation is known as demodulator.

1. **Square law detector**





- The square law detector circuit is used for detecting modulated signal of small magnitude i.e below 1 volt.
- Square law detector is a non-linear detector. It is operates in the non-linear region to detect the original baseband signal.
- In this circuit the dc supply voltage V_A is used to get the fixed operating point in the non-linear portion of diode V-I characteristic.
- Since the operation is limited to the non-linear region of the diode characteristic the lower half of the modulated wave form is compressed. This produces envelope applied distortion.
- Due to this the average values of the diode current is no longer constant rather it varies with time.

The distorted output diode current is expressed by

$$I = av + bv^2$$

where V = i/p modulated voltage

Am wave is expressed as

$$V = A(1 + m_a \cos w_m t) \cos w_c t$$

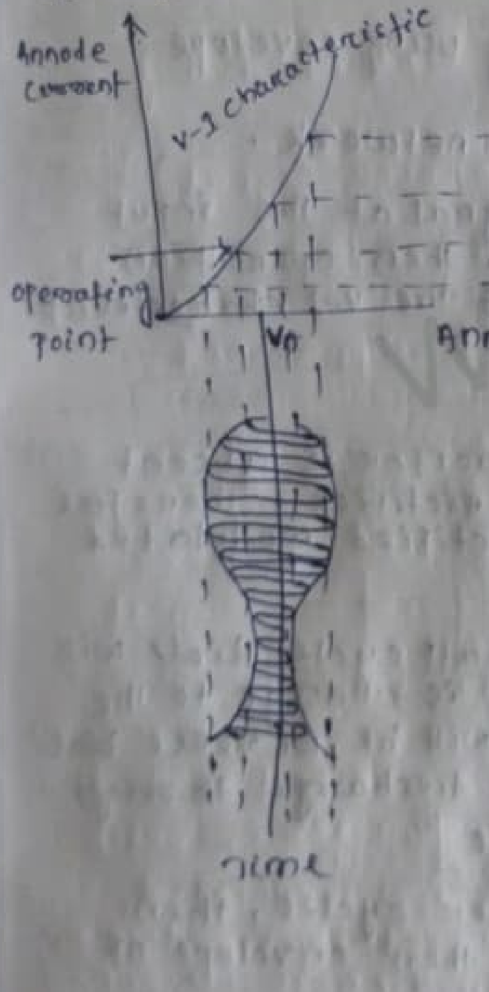
substituting the value of V we get

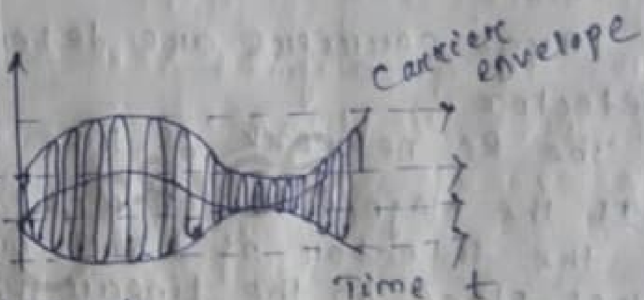
$$I = a[A(1 + m_a \cos w_m t) \cos w_c t] + \dots b[A(1 + m_a \cos w_m t) \cos w_c t]^2$$

$$= a[A(1 + m_a \cos w_m t) \cos w_c t] + b[A^2(1 + m_a^2 \cos^2 w_c t + 2m_a \cos w_m t) \cos^2 w_c t]$$

If above is expanded then we get term of frequencies like $2w_c$, $2(w_c \mp w_m)$, w_m, $2w_m$.

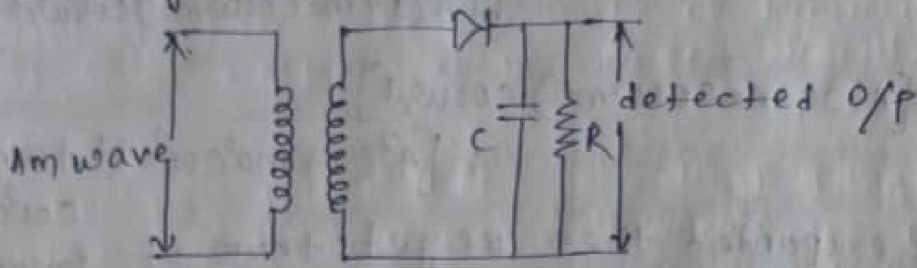
→ Hence this diode current "I" containing all these frequencies term is passes through a low pass filter which allows to pass the frequency below or upto modulating frequency w_m & reject the other higher frequency.





2. Linear diode detector

It is the process of recovering the base band signal from the AM signal using a diode operating in the linear region.



→ The input portion of the ckt is tuned transformer which provides perfect tuning at the desired carrier frequency.

→ The secondary side ~~bas~~ diode is connected the output is obtain across the parallel combination of R & C.

→ Large carriers are detected by using envelope detector.

→ The RC network is time constant network.

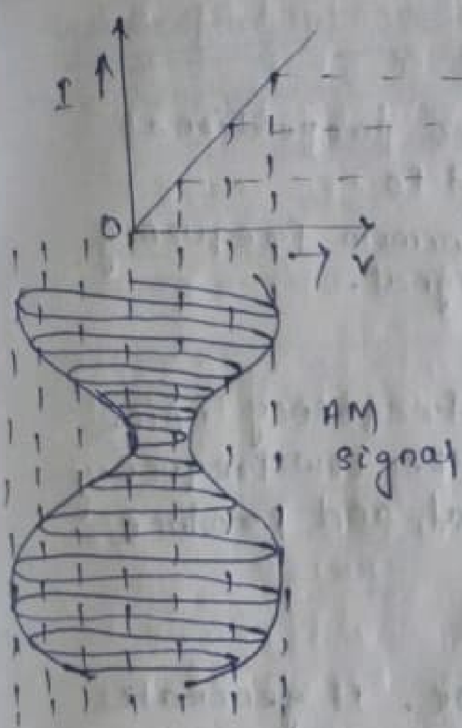
→ If the magnitude of modulated signal at the input of the detector is 1 volt or more, then operation takes place in the linear portion of the V-I characteristic of diode.

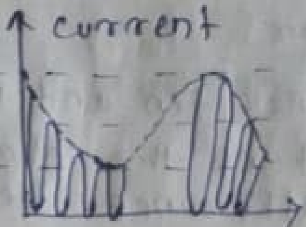
Working

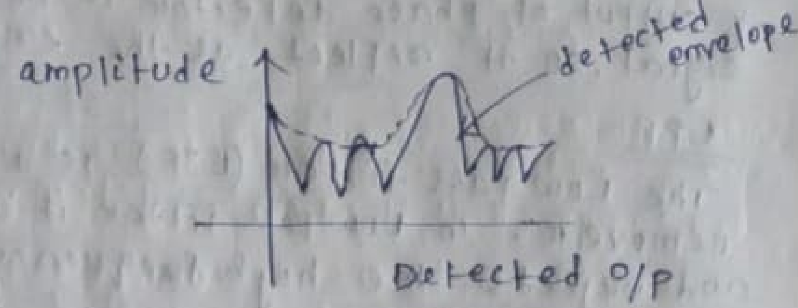
first let us assume that the capacitor is absent then the ckt is acts as a halfwave rectifier. Therefore O/P waveform would be a half ~~wave~~ rectified modulated signal.

→ If capacitor is introdued then +ve half cycle diode will be forward bias it conduct capacitor is charge to the peak value. In -ve halfcycle diode will be reverse bias. It is a open ckt & capacitor starts discharge through resistance R. Then time constant $\tau = RC$

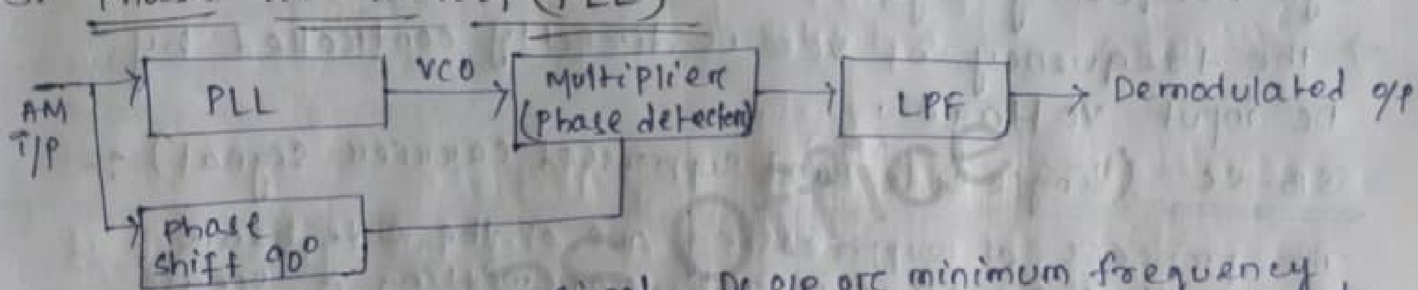
→ This process is repeat again for other cycles, then when the peaks are joined together then envelope of modulating signal obtained.

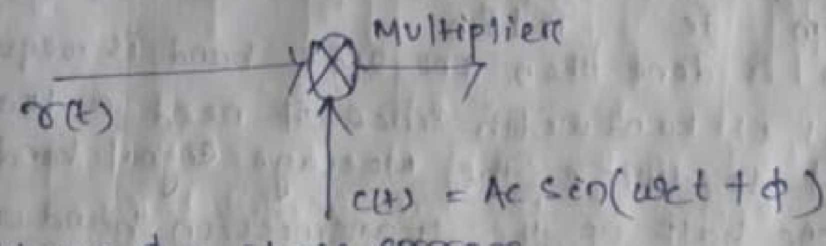






3. Phase locked loop (PLL)





where ϕ = phase error

→ A PLL is a non-linear feedback system that tracks the phase of input signal and minimized the phase error at local oscillator.

→ PLL is used for removing the phase error.

Phase detector

→ It compares fin and fo

→ The output of the phase detector is proportional to phase difference between fin and fo.

→ output of phase detector is DC or minimum frequency signal. so it reflect as the error signal.

LPF

The Low pass filter (LPF) is a High frequency noise remover. In Low pass filter it allows the low-frequency and rejects the high frequency signal and produce the DC signal.

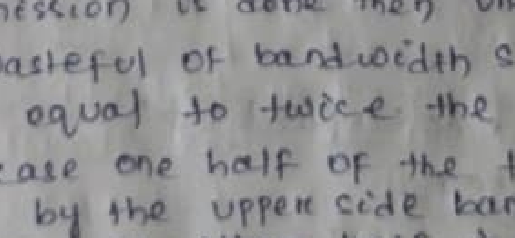
VCO

VCO stands for voltage control oscillator. It generates high frequency signal.

→ The frequency of VCO is directly controlled by DC input voltage.

SSB-SC (Single Side Band Suppressed Carrier Signal) :-

The process of suppressing one of the side bands along with the carrier and transmitting a single side band is known as single side band suppressed carrier system or SSB-SC signal.



→ If transmission is done then one side band is required.

→ AM are wasteful of bandwidth since it need a transmission bandwidth equal to twice the Message signal bandwidth.

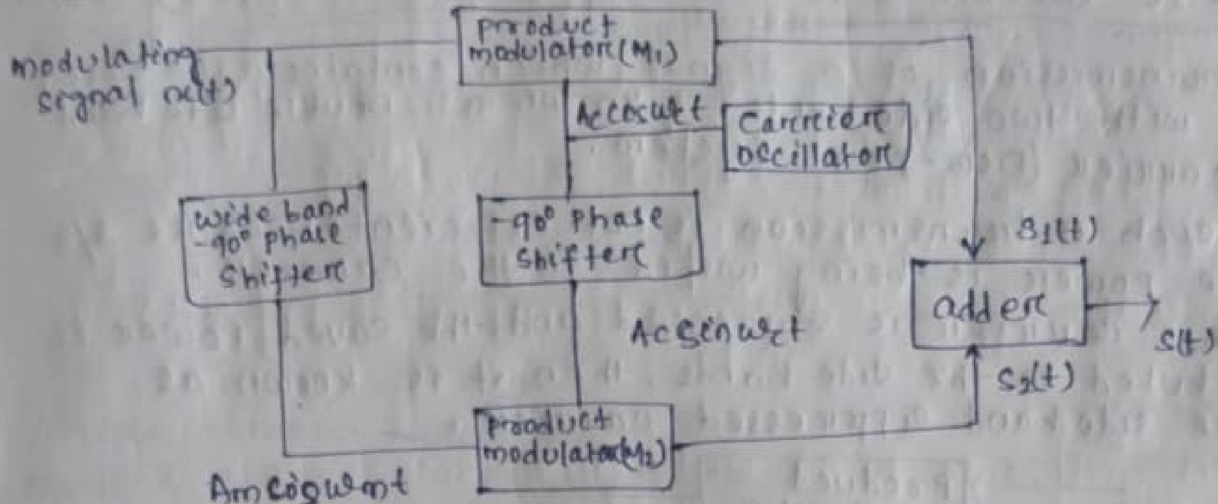
→ In either case one half of the transmission bandwidth is occupied by the upper side band of the modulated signal where as other half is occupied by the lower sideband. for transmission of information is concerned only one side band is necessary.

→ If the carrier and one of the two side band are suppressed at the transmitter no information is lost.

Generation of SSB-SC signal

The Generation of SSB-SC signal is two types such as
(i) frequency Discrimination.
(ii) phase shift Method.

Phase shift Method



→ Message signal is applied directly to the product modulator m_1 and it is applied the product modulator M_2 with the phase shift of $-90°$.

→ The function of product modulator is to Multiply the i/p signal & give the o/p.

→ $-90°$ phase shifter produce an o/p which has a phase lag of $90°$ with respect to the input.

→ Carrier oscillator used to generate carrier signal.

→ Adder produce the sum of the o/p which is either the sum of two inputs or the difference of two inputs based on the polarity of inputs..

O/P of the upper modulator M

$$s(t) = A_m A_c \cos(2\pi f_m t) \cos(2\pi f_c t)$$

$$\Rightarrow s_1(t) = \frac{A_m A_c}{2} \cos(2\pi(f_m + f_c)t) + \cos 2\pi(f_c - f_m)t)$$

O/P of the lower modulator

$$s_2(t) = A_m A_c \sin(2\pi f_m t) \sin(2\pi f_c t)$$

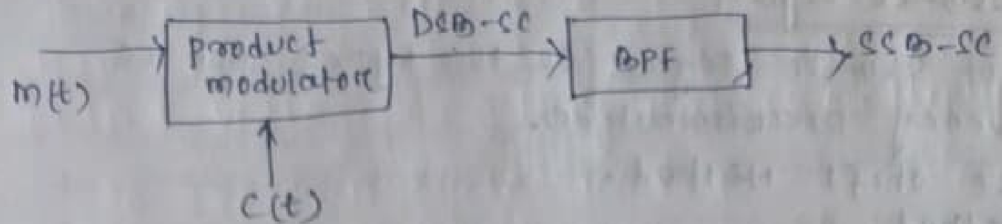
$$= \frac{A_m A_c}{2} \cos 2\pi(f_c - f_m)t - \cos 2\pi(f_c + f_m)t$$

$$s(t) = s_1(t) + s_2(t)$$

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

Upper side band $= s_1(t) - s_2(t)$

$$= A_m A_c \cos 2\pi(f_c + f_m)$$

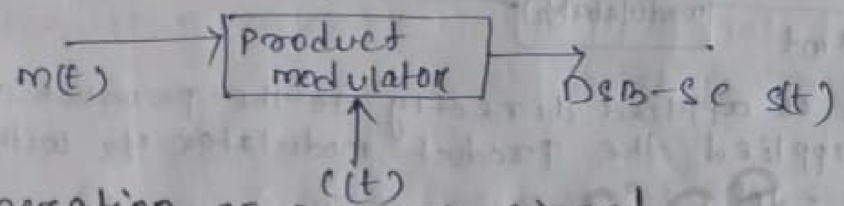


DSB-SC (Double side band suppressed carrier)

The transmission of a signal which contains a carrier along with two side bands is known as Double side band full carrier (DSB-FC) system.

→ But such a transmission is not efficient because 2/3 of the power is being wasted in the carrier.

→ If this carrier is supressed and the saved power is distributed to the side bands, then it is known as Double side band suppressed carrier.



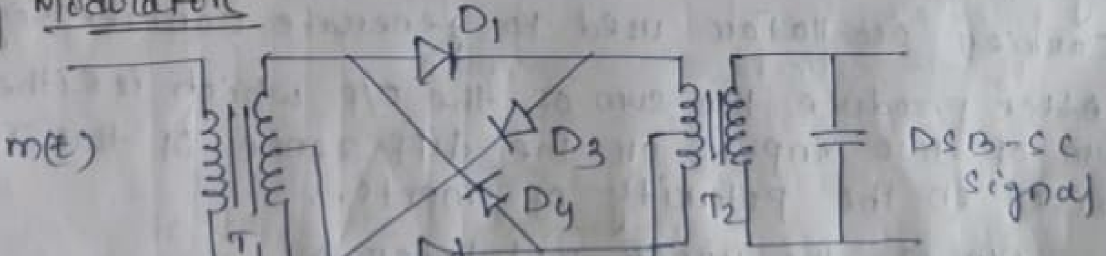
Generation of DSB-SC signal

Generation of DSB-SC signal is of two types, such as

(I) Balance modulator

(II) Ring modulator

Ring Modulator



four diode connected in the ring structure therefore this modulator is known as the ring modulator.

→ Two center tapped transformers are used such as T_1 which is used ~~for~~ as in audio frequency and T_2 is used in radio frequency.

→ message signal m(t) is applied at the i/p transformer T_1. carrier is applied between the T_1 & T_2 and output is taken secondary of T_2.

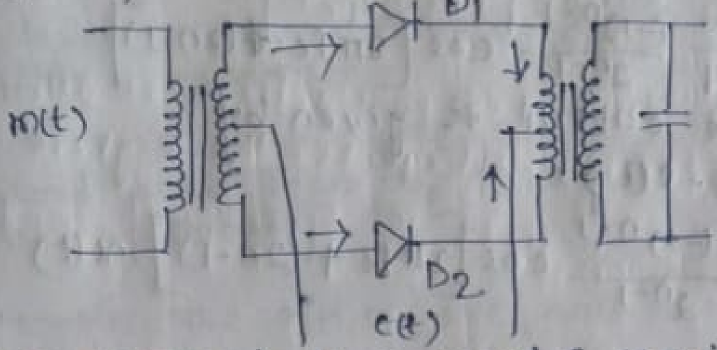
Working

There are two mode of operation

Mode -1

Let us assume that the modulating signal is absent and only the carrier is applied.

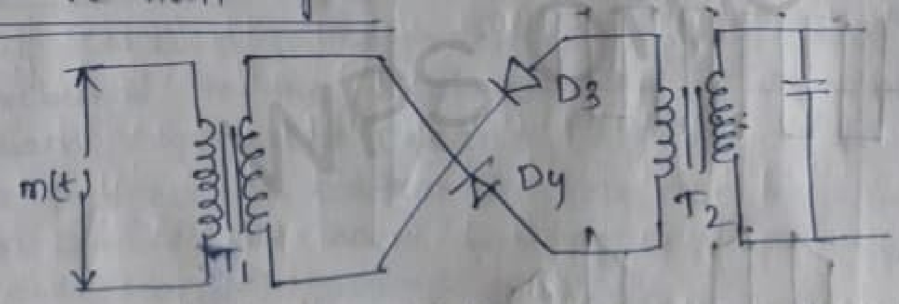
→ for +ve half cycle Diode D_1, D_2 is ~~tea~~ forward bias & D_3 & D_4 are reverse bias.



Here current flow equal & opposite, then magnetic field equal & opposite. It means ~~to~~ it cancel each other then induced voltage is 0.

→ Then the carrier is suppressed in the +ve half cycle.

for -ve half cycle



for -ve half cycle Diode D_3, D_4 is forward bias & D_2, D_1 are reverse bias. Here current flow equal & opposite, then magnetic field equal & opposite. It means it cancel each other then induced voltage is 0. Then the carrier is suppressed in the -ve half cycle.

Mode -2

In ~~+ve half cycle~~ mode-2 carrier and modulating signal both are applied.

→ In +ve half cycle Diode D_1 & D_2 is conducting, ~~so what~~ and the process is same as mode-1 operation but as modulating signal is applied wheatever we get the output it is Multiply by 1.

→ During -ve half cycle D_3, D_4 are conducting. We have assume modulating signal is present then what ever output voltage we getting that is multiply by -1.

In +ve half cycle $m(t) \times 1$

In -ve half cycle $m(t) \times -1$

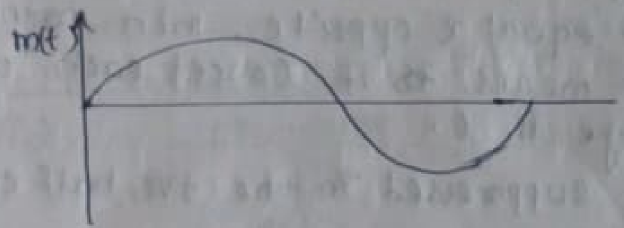
The square wave carrier can be represent by

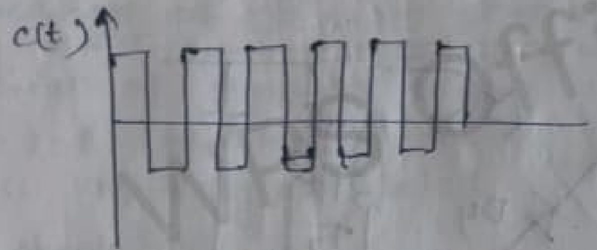
$$c(t) = \frac{4}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2^{n-1}} \cos\left[2\pi f_c t(2n-1)\right]$$

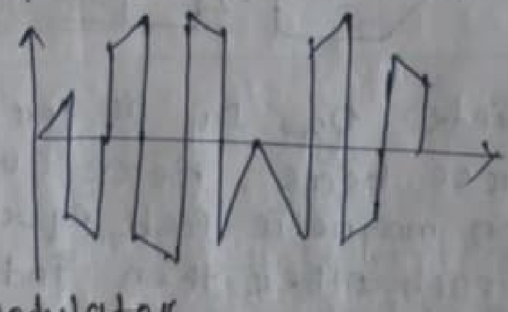
The ring modulator output is given by

$$s(t) = m(t) \cdot c(t)$$

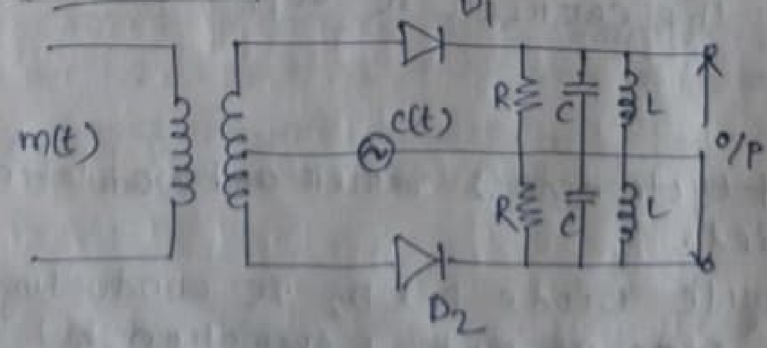
$$s(t) = \frac{4}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2^{n-1}} \cos\left[2\pi f_c + (2n-1)\right] x(t)$$







Balance Modulator



we use two non-linear device in Balance modulator for ~~one diode During~~ balance the circuit and produce a DSB-SC signal.

→ A modulating signal m(t) is applied to the diodes through a center tapped transformer with the carrier signal c(t).

→ During +ve half cycle Diode D_1 is forward bias and D_2 is Reverse bias so the diode D_1 conduct. Then current & voltage generate.

→ During -ve half cycle Diode D_1 is Reverse bias and D_2 forward bias. Then the current flow through D_2 and voltage generate.

→ ~~for +ve~~ The O/P of +ve & -ve half cycle goes to the band pass filter. The band pass filter allows a particular band and rejects the other frequency. Then at the output of the modulator the carrier signal is suppressed and we get the double side band output.

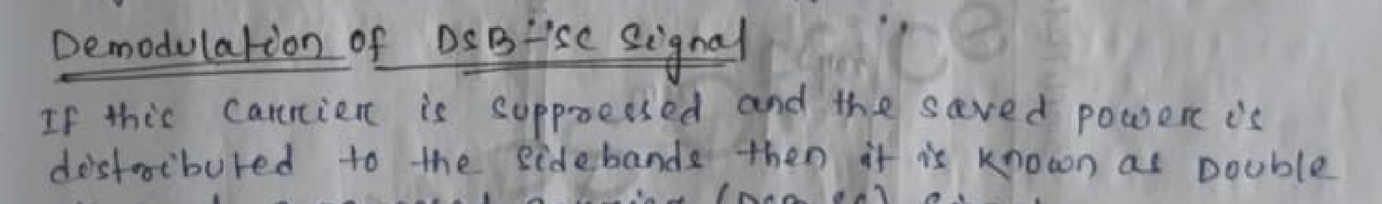
Demodulation of DSB-SC Signal

If this carrier is suppressed and the saved power is distributed to the sidebands then it is known as Double side band suppressed carrier (DSB-SC) signal.

→ The process of extracting an original message signal from Double side band Suppressed Carrier wave is known as detection of DSB-SC.

→ There are two methods of detection of DSB-SC signal such as (I) Synchronous Detection or Coherent Detection
(II) Costas Loop

(I) Synchronous Detection Method



In synchronous detection method the received modulated or DSB-SC signal is first multiplied with a locally generated carrier signal cos$\omega_c t$ and then passes through a low pass filter. At the output of a low pass filter, the original modulating signal is recovered.

Mathematically

$$x(t) = [m(t)\cos\omega_c t][\cos\omega_c t]$$

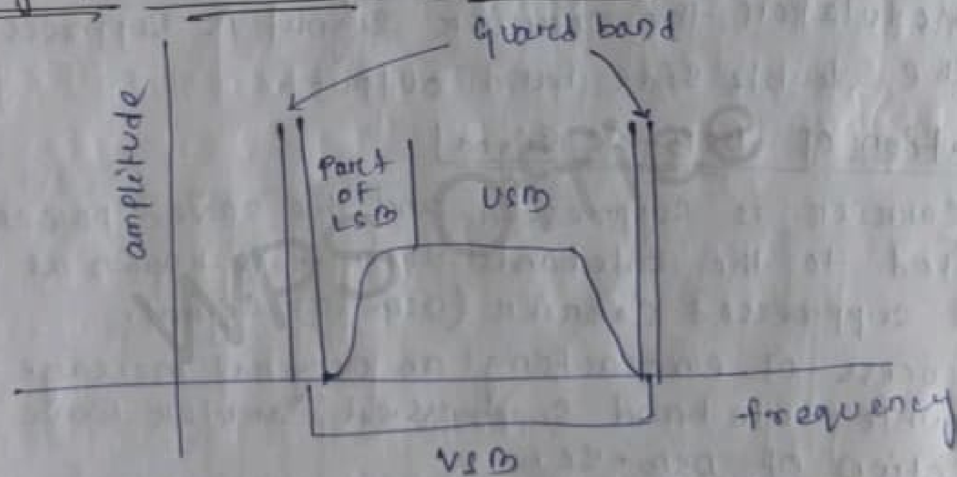
$$= m(t)\cos^2\omega_c t \qquad (\because \cos^2 A = 1 + \cos 2A)$$

$$= \frac{m(t)}{2}[1 + \cos 2\omega_c t]$$

$$= \frac{m(t)}{2} + \frac{m(t)}{2}[\cos 2\omega_c t]$$

when $x(t)$ is given to the Low pass filter it allows the lower band frequency and rejects the higher frequency that means it rejects $\frac{m(t)}{2}[\cos 2\omega_c t]$ and allows $\frac{m(t)}{2}$.

Vestigial side band Modulation



In case of SSB modulation when a side band is passed through the filters the band pass filter may not working perfectly in practice. As a result of which some of the information may get lost.

→ Hence to avoid this loss a technique is chosen a compromise between DSB-SC & SSB-SC called as vestigial side band (VSB). The word vestige which means "a part" from which the name is derive.

→ Both of the side bands are not required for the transmission as it is a waste. But a single band if transmitted leads to loss of information. Hence the technique has envolved.

→ VSB modulation is the process where a part of the signal is called vestige is modulated along with one side band.