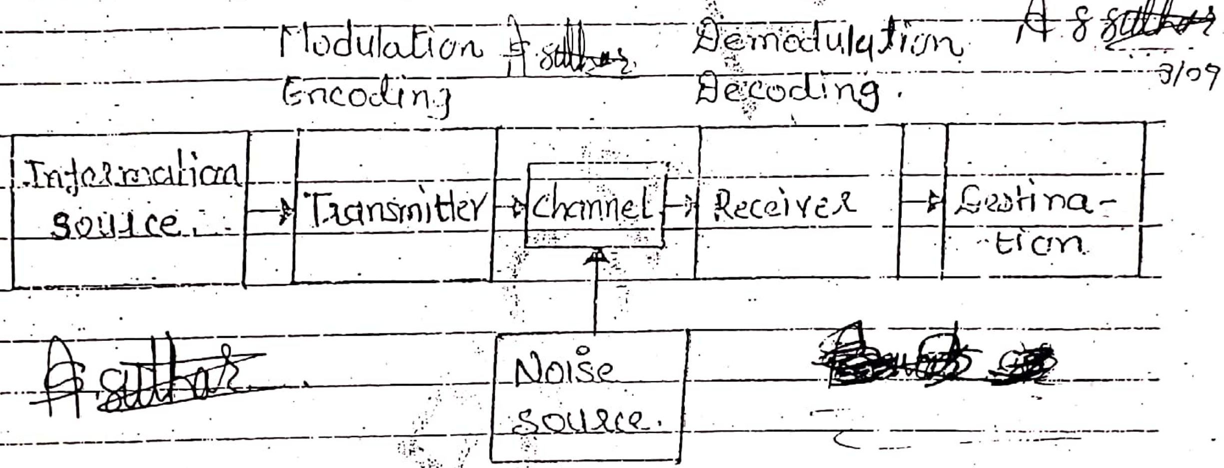
207 Principles of Communication

Basic Constituents of Communication System.

Electronics communication is the transmission, reception and processing of information between two or more locations by electronic means.

Block diagram of communication system.



* **Information :-** The information can be in the analog form such as voice, music or video signal, or in the digital form such as binary-coded numbers or alphanumeric codes.

Any communication system serves to communicate a message or information. This message originates in the information source. Out of these messages only the desired message is selected and conveyed.

All forms of information sources must be converted to electric energy before being processed and communicated. Suitable transducers like microphone or cameras are required for the conversion.

of information in to electric energy.

* **The Transmitter :-**

The transmitter is a collection of one or more electronic devices or circuits that converts the original information to a signal that is more suitable for transmission over a given transmission medium.

In a transmitter, the information modulates the carrier, and information is superimposed on high frequency sine wave. There may be amplitude modulation, frequency modulation or phase modulation of the carrier wave depending on the requirements.

* **The Channel and the Noise Source :-**

With reference to the block diagram, the term channel implies the medium through which the message travels from transmitter to the receiver. The channel may be made up of metallic wires, optical fiber cables with LASER source or the radio waves propagation through atmosphere.

During the process of transmission and reception the signal gets deteriorated due to distortion in the system and noise introduced in the system.

Noise is an unwanted energy present in a transmission system due to many causes. Since it is received with the desired signal, it places a limitation on the transmission system as a whole.

* The Receiver :-

The receiver is a collection of electronic devices and circuits that receives the signals transmitted by the transmitter and converts them in to ~~the~~ their original form.

The receivers may be of widely different varieties. One piezo-electric quartz crystal and headphones is the simplest radio receiver. ~~or~~ while most complex receiver is the radar receiver with complicated antenna system, visual display system and synchronizing circuit.

Whatever the receiver is, its most important function is demodulation / decoding. It is the process of recovering the message from the high frequency carrier voltage.

The output of a receiver may be feed to a loud speaker, video display, tele-typewriter, printer, picture tubes or computer.

Classification of RF Spectrum :-

When using radio channels for the communications, the message or information modulates the carrier, which usually a high frequency signal. The frequency of carrier signal depens on the service ~~required~~ required and band width of the message signal. Table-1 gives the classification of RF spectrum used for radio communication.

	Carrier frequency	class.	Applications.
1).	10 - 30 KHz	Very low Freq (VLF)	Long distance point to point communication.
2).	30 - 300 KHz	Low Freq. (LF)	Long distance point to point communication Navigation.
3)	300 - 3000 KHz	Medium Freq (MF)	Broad casting, ship to shore communication.
4)	3 - 30 MHz	High Freq. (HF)	National and International Broadcasting, point to point telephone, telegraph, Aviation.
5)	30 - 300 MHz	Very High Freq (VHF)	Radar, Television, FM Broadcast, Short distance communication.
6)	300 - 3000 MHz	Ultra High freq. (UHF)	Facsimile, Television, Air navigation.
7)	3 GHz - 30 GHz	Super High freq (SHF)	Radar navigation Radio Relay.

Need for using High carrier frequency :-

The term carrier is used for the signal which carries the information signal from the transmitter to the receiver.

There are several factors such as size of antenna, range of communication and selection of radio signals etc depends on the carrier frequency.

The efficiency of antenna depends on its size, which should be comparable with half wave length of carrier signal. The size of antenna should be

$$l_a = \lambda/2 \text{ or more!}$$

Where λ is wave length and can be calculated as

$$\lambda = c/f$$

Therefore the size of antenna is inversely proportional to the frequency. Higher the carrier frequency, smaller the size of antenna.

Further the effective distance travelled by the signal before it dies is more when the frequency of the signal is high. Higher the carrier frequency for given power more is the distance travelled by the signal and hence more range of communication.

Further the selection of the signal

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is better at higher frequencies than at the lower frequencies.

From the above considerations, higher carrier frequencies are preferred.

Bandwidth Requirements :-

In a practical communication system the information signal is made up of several sinusoidal voltages having frequency from low to high. For example the frequency range of audio signal is from 20 Hz to 20 KHz. This is rather a wastefully large band width.

Hence in practice, it is pruned to range of

- 0 – 3 KHz for telegraph,
- 0 – 3 KHz for telephony.
- 0 – 5 KHz for AM Broadcast.
- 0 – 15 KHz for FM Broadcast.

The band width of the communication system depends on the bandwidth of the information signal. Therefore to accomodate or to establish more no of channels the band width of the information signal is restricted to a reasonably low level, while for faster and high quality communication the band width should be high.

In practice requirement of speed and quality of signal decides the bandwidth of the communication system.

Mod

Modulation :-

Modulation is defined as the process by which some characteristics, usually amplitude, frequency or phase, of a carrier voltage is varied in accordance with the instantaneous value of modulating voltage.

The term carrier is used for the signal whose ~~charestics~~ characteristic is varied and the term modulating voltage is used for the signal in accordance with which the variation is made.

The carrier voltage v_c may be represented by the expression,

$$v_c = V_c \cos(\omega_c t + \theta_c)$$

where v_c = Instantaneous value of carrier.
V_c = Peak amplitude of carrier.
ω_c = Angular frequency of carrier.
θ_c = Phase angle of carrier.

Any of the three quantities namely amplitude, phase or frequency of carrier can be varied in accordance with the modulating voltage.

→ The process of modulation is performed in a transmitter in a section / circuit called "modulator."

* Demodulation is the reverse process of modulation and it is performed in the section / circuit called "demodulator" or detector."

Need for Modulation :-

There are two reason why the modulation is necessary in electronic communication system.

1). It is extremely difficult to radiate the low frequency signal.

For an efficient radiation of electromagnetic energy, the length of the transmitting antenna should be comparable to the λ/4 of the frequency.

This means that 15,000 meter long antenna is required for radiation of 5KHz signal and only 75 meter long antenna is required for 1MHz signal.

A vertical antenna of height 15,000 meter is unthinkable.

2) Another reason for modulation is it converts the low frequency signal information in to high frequency signal. If each transmitting station convert the information in to different frequency then their signals never interfears with each other.

The radiation efficiency of the antennas also depends on the carrier frequency. More the frequency more the efficiency.

Hence by using modulation process the ~~sto~~ information signal is converted in to high frequency signal, which reduces the length of antenna increases radiation efficiency and signals never get interfeared.

Types of Modulation :-

Modulation is defined as the process by which some characteristics, usually amplitude, frequency or phase of the carrier voltage is varied in accordance with the instantaneous value of modulating voltage.

Let the carrier voltage be represented by the expression,

$$v_c = V_c \cos(\omega_c t + \theta_c)$$

where V_c = peak amplitude of carrier

$\omega_c = 2\pi f_c$

f_c = carrier frequency

θ_c = Phase angle

f_m

The modulation process may then consist in varying one of the following three quantities

f_c

(1) Amplitude (V_c)

(2) Frequency (f_c)

(3) Phase (θ_c)

of the carrier voltage, in accordance with some function of the instantaneous value of modulating voltage.

Accordingly modulation process may be classified as

(1) Amplitude Modulation (AM)

(2) Frequency Modulation (FM)

(3) Phase Modulation (PM)

It is possible to produce simultaneously amplitude, frequency and phase modulation but in commercial transmitters, care is taken to produce only one at a time.

AMPLITUDE MODULATION :-

[In Amplitude modulation process, the amplitude of carrier voltage varies in accordance with the instantaneous value of modulating voltage.]

Expression for AM voltage.

Let the modulating voltage or signal be given by the expression.

$$v_m = V_m \cos W_m t \quad \text{—— (1)}$$

where V_m is amplitude and W_m is angular frequency of modulating signal.

Let the carrier voltage be given by the expression,

$$v_c = V_c \cos W_c t \quad \text{—— (2)}$$

In expression (2), the phase angle θ_c has been taken as zero because it does not pay any part in the amplitude modulation process.

On modulation the amplitude of carrier no longer remains constant, but varies with the time. Hence the amplitude of AM voltage at any time may be expressed as

$$V(t) = V_c + K_a v_m$$
$$= V_c + K_a V_m \cos W_m t \quad \text{—— (3)}$$

where $K_a V_m \cos W_m t$ is the instantaneous change in amplitude.

The instantaneous value of modulated carrier voltag is given by

$$v = V_c \cos w_c t \quad \text{—— (4)}$$

substituting the value of $v(t)$ from eqⁿ (3) in eqⁿ (4). We get

$$v = (V_c + k_a V_m \cos\omega_m t)\cos\omega_c t$$

$$v = V_c\left[1 + \frac{k_a V_m}{V_c}\cos\omega_m t\right]\cos\omega_c t.$$

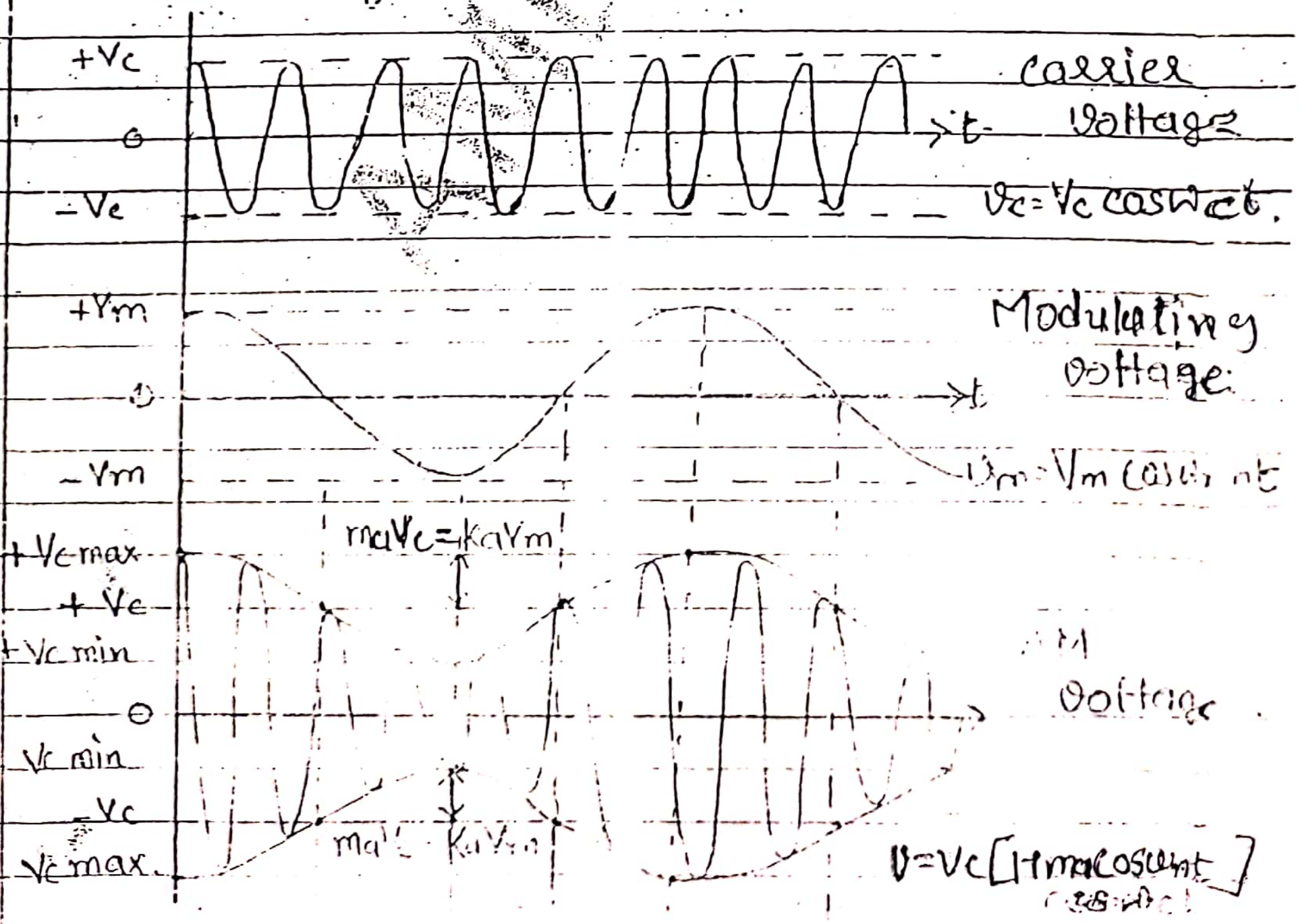
$$v = V_c(1 + m_a \cos\omega_m t)\cos\omega_c t \quad \text{—— (5)}$$

where $m_a = \dfrac{k_a V_m}{V_c}$ —— (6)

m_a is the modulation index or depth of modulation or modulation factor and percentage modulation can be calculated as

$$\% m_a = 100 \times m_a \quad \text{—— (7)}$$

Waveforms of AM Voltage.



Modulated Signal

5-6 Kv

From fig (1) we see that frequency of carrier remains unaltered but its amplitude varies in accordance with the variation of the modulating voltage V_m

It may be further seen that

$$V_{c\,max} = V_c + K_a V_m \quad \text{and} \qquad (8)$$

$$V_{c\,min} = V_c - K_a V_m \qquad (9)$$

On adding eqn (8) and (9) we get

$$V_{c\,max} + V_{c\,min} = 2V_c \qquad (10)$$

and on subtracting them we get

$$V_{c\,max} - V_{c\,min} = 2 K_a V_m \qquad (11)$$

On dividing eqn (11) by (10) we get

$$\frac{K_a V_m}{V_c} = \frac{V_{c\,max} - V_{c\,min}}{V_{c\,max} + V_{c\,min}}$$

$$\boxed{m_a = \frac{V_{c\,max} - V_{c\,min}}{V_{c\,max} + V_{c\,min}}} \qquad (12)$$

FREQUENCY MODULATION :-

[(In frequency modulation process the frequency of carrier voltage varies in accordance with the instantaneous value of the modulating voltage. In this process the Amplitude and phase angle of the carrier remains constant.)]

Since the amplitude of carrier remains constant, the effect of atmospheric and man-made disturbances can be easily eliminated and so the quality of the reproduced signal is relatively better in the FM process then AM process.

Expression for FM Voltage :-

Let the sinusoidal modulating voltage be given by expression

$v_m = V_m \cos \omega_m t$ ——— (1)

where V_m is amplitude and ω_m is angular frequency of modulating voltage.

Let the carrier voltage be given by

$v_c = V_c \sin(\omega_c t + \theta_c)$ ——— (2)

where V_c = amplitude of carrier

θ_c = Phase angle of carrier

and ω_c = angular frequency of carrier.

let $\phi = \omega_c t + \theta_c$ ——— (3)

ϕ = total instantaneous phase angle of carrier

so equation (2) may be put as

$v_c = V_c \sin \phi$ ——— (4)

The angular frequency ω and the total instantaneous phase angle are related by the relation,

$$\omega_c = \frac{d\phi}{dt} \quad (5)$$

On frequency modulation, the frequency of carrier no longer remains constant but varies with the time in accordance with the instantaneous value of the modulating voltage.

Thus the frequency of carrier voltage after frequency modulation is given by,

$$\omega = \omega_c + K_f v_m$$

$$\omega = \omega_c + K_f V_m \cos \omega_m t \quad (6)$$

where K_f is constant of proportionality.

Integrating eq^n (6), yields the phase angle of modulated carrier voltage

Thus we get

$$\phi = \int \omega \, dt$$

$$\phi = \int (\omega_c + K_f V_m \cos \omega_m t) \, dt$$

$$\phi = \omega_c t + \frac{K_f V_m}{\omega_m} \sin \omega_m t + \theta \quad (7)$$

where θ is the constant of integration and represents constant phase angle.

Substituting the eq^n (7) in eq^n (1)

we get

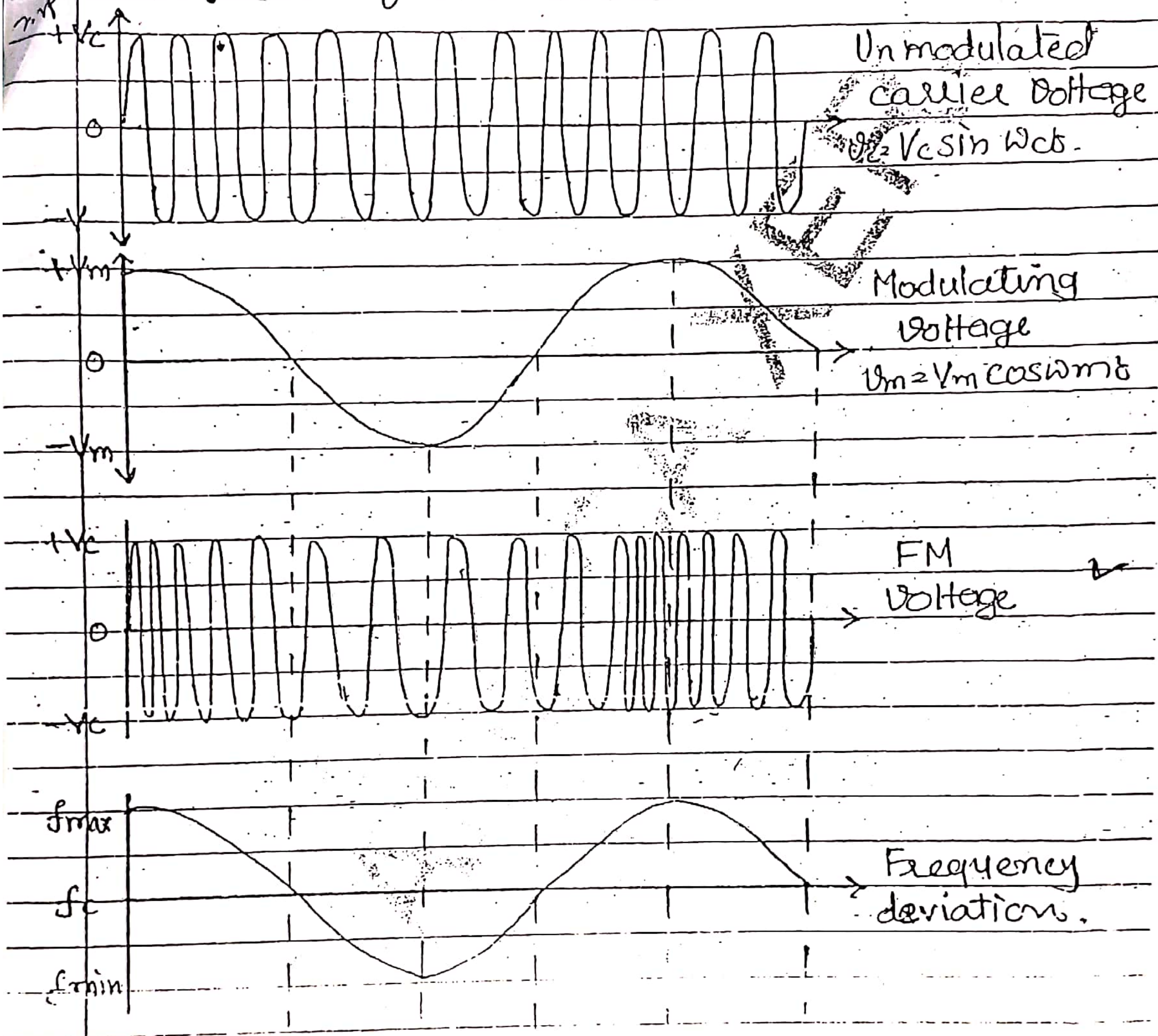
$$v = V_c \sin \left[\omega_c t + \frac{K_f V_m}{\omega_m} \sin \omega_m t + \theta\right]$$

$$v = V_c \sin (\omega_c t + m_f \sin \omega_m t + \theta) \quad (8)$$

where $$m_f = \frac{K_f V_m}{\omega_m} \quad (9)$$

m_f is modulation index or depth of modulation.

Waveforms of FM Voltage :-



Fig(1) shows the waveforms of the carrier, modulating and FM voltage. Variation of instantaneous carrier frequency with time is shown in fig(1)d. It may be seen that this frequency variation is identical to the modulating voltage.

It may be further seen that:

$\omega_{max} = \omega_c + k_f V_m$

m_a m_f

and $\omega_{min} = \omega_c - K_f V_m$

Thus the maximum and minimum frequency is given by

$$f_{max} = f_c + \frac{K_f V_m}{2\pi}$$

and $$f_{min} = f_c' - \frac{K_f V_m}{2\pi}$$

Thus the frequency deviation is given by

$$f_d = f_{max} - f_c = f_c - f_{min}$$
$$= \frac{K_f V_m}{2\pi}$$

The modulation index m_f is the ratio of frequency deviation to modulation freq^n.

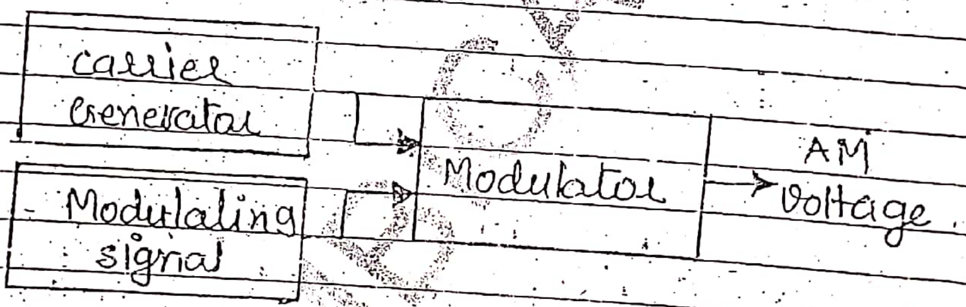
$$m_f = \frac{f_d}{f_m} = \frac{K_f V_m}{2\pi f_m} = \frac{K_f V_m}{\omega_m}.$$

AMPLITUDE MODULATION METHODS :-

Methods of amplitude modulation may be put in to following two categories :

(A) Linear Modulation methods :- These utilize the linear region of the current voltage characteristics of active device i.e. transistor, diode, FET, electron tubes etc.

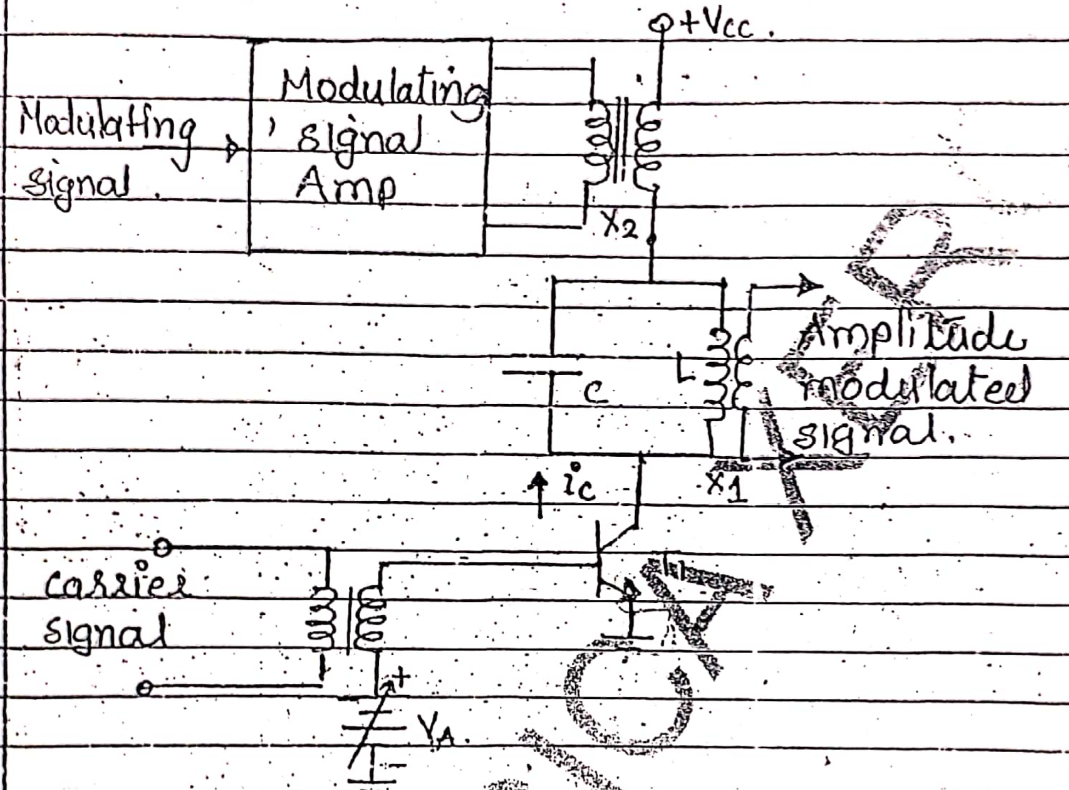
(B) Square law modulation methods :- These utilize the square law or non-linear region of the current-voltage characteristic curves of the active devices.



Fig(1) shows the constituents of AM signal generator. The carrier signal and modulating signal are fed to the modulator. where the amplitude modulation process occurs in active device and it gives out the AM voltage.

COLLECTOR MODULATION :-

Fig(2) shows the circuit of transistor as modulator. Here the linear portion of the characteristic curve is utilized. The linear class C amplifier in CE mode is used for modulation of carrier. In this method [illegible] carrier signal



is coupled to the base of transistor and modulating signal appears in series with the collector supply voltage Vcc. effective supply voltage to the amplifier is then given by

$$V = V_{cc} + V_m$$
$$V = V_{cc} + V_m \cos \omega_m t$$

The ~~modu~~ variation in modulating voltage changes instantaneous supply voltage to the circuit. Hence the peak current to the load circuit also varies with the instantaneous value of modulating voltage V_m.

Square law diode modulation :-

It utilizes the non-linear region of current-voltage dynamic characteristics of a diode. This dynamic characteristic is highly non-linear in the low voltage region.

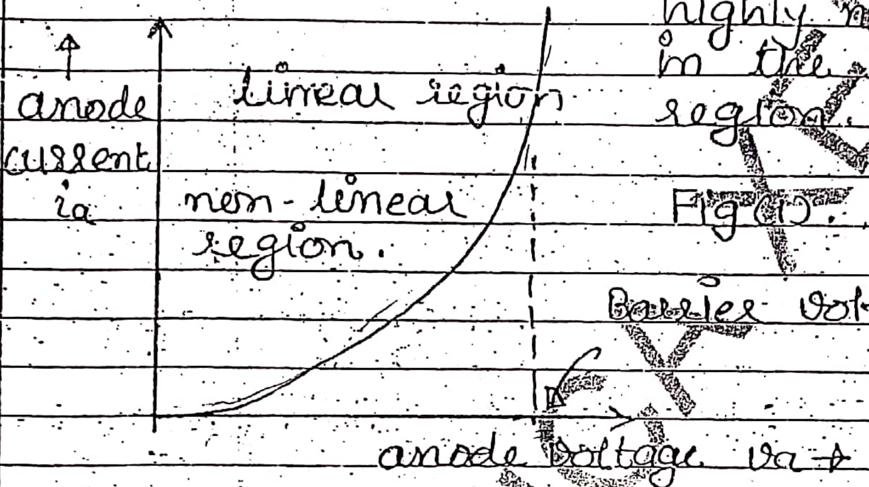


Fig (1).

The AC current in the non-linear region may then be expressed as function of ac voltage as given by the following Taylor series:

$$i_a = a_1 v_s + a_2 v_s^2 \quad \text{--- (1)}$$

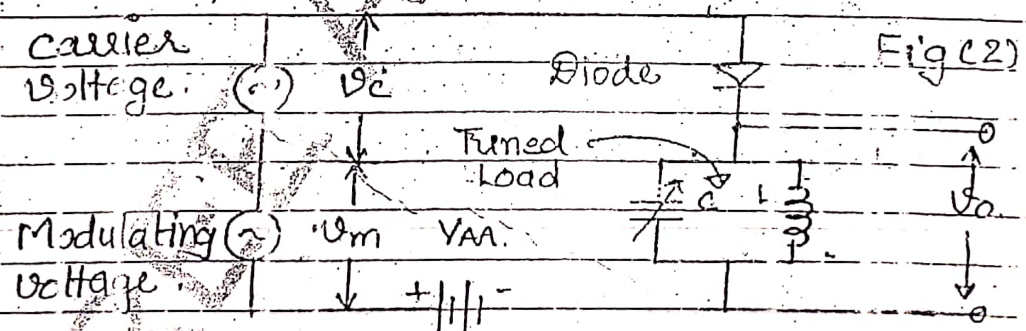


Fig (2).

Fig(2) shows the circuit arrangement of square law diode modulator.

Let the carrier voltage be given by

$$v_c = V_c \cos \omega_c t \quad \text{--- (1)}$$

Let the modulating voltage be given by

$$v_m = V_m \cos \omega_m t \quad (2)$$

Then the AC voltage at the anode of diode D is

$$v_s = v_c + v_m$$

$$v_s = V_c \cos \omega_c t + V_m \cos \omega_m t \quad (3)$$

Hence the resulting anode current is

$$i_a = a_1 v_s + a_2 v_s^2$$

$$= a_1 (V_c \cos \omega_c t + V_m \cos \omega_m t)$$

$$+ a_2 (V_c \cos \omega_c t + V_m \cos \omega_m t)^2$$

$$i_a = a_1 V_c \cos \omega_c t + a_1 V_m \cos \omega_m t$$

$$+ a_2 V_c^2 \cos^2 \omega_c t + a_2 V_m^2 \cos^2 \omega_m t$$

$$+ 2 a_2 V_c V_m \cos \omega_c t \cdot \cos \omega_m t \quad (4)$$

The various frequency terms present in eqn (4) are

(i) $a_1 V_c \cos \omega_c t$ → carrier frequency component.

(ii) $a_1 V_m \cos \omega_m t$ → Modulating frequency component.

(iii) $a_2 V_c^2 \cos^2 \omega_c t = a_2 V_c^2 \left[\frac{1 + \cos 2\omega_c t}{2} \right]$

→ This term consist of dc term $\frac{a_2 V_c^2}{2}$ and an ac term with frequency $2\omega_c$.

(iv) $a_2 V_m^2 \cos^2 \omega_m t = a_2 V_m^2 \left[\frac{1 + \cos 2\omega_m t}{2} \right]$

→ This term consist of dc term $\frac{a_2 V_m^2}{2}$ and an ac term with frequency $2\omega_m$.

(v) $2 a_2 V_c V_m \cos \omega_m t \cdot \cos \omega_c t$

$$= 2 a_2 V_c V_m [\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$$

→ This term consist of frequencies $\omega_c + \omega_m$ and $\omega_c - \omega_m$.

These frequencies are known as the

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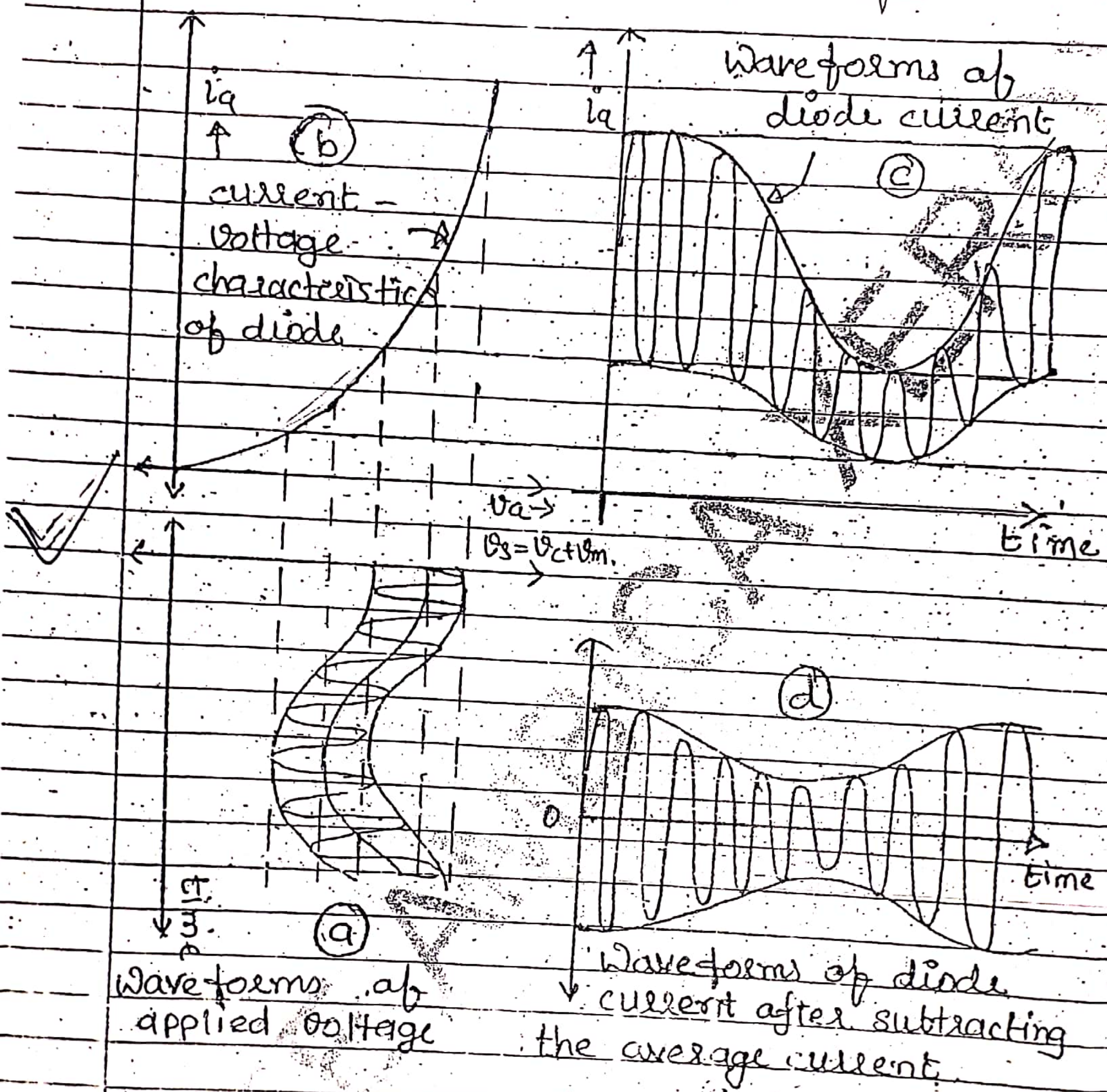
"upper side band" and "lower side band" terms.
Thus there are six different frequencies with the dc component.
The load impedance to the diode is tuned circuit, tuned to carrier frequency. thus it responds only to the carrier freq^n and frequencies close to it, i.e. $(\omega_c + \omega_m)$ and $(\omega_c - \omega_m)$. The remaining terms will not produce appreciable output voltage across the load.



If the average current is subtracted from the diode anode current, the resulting current is shown in fig(3)d.
The resulting current is approximately the waveforms of an amplitude modulated current.

AMPLITUDE DEMODULATION :→

The process of demodulation or de detection is recovering the original modulating voltage from the carrier voltage.

Thus the detection process is a reverse of the modulation. Modulation process transfers the low frequency information in to high frequency signal while the demodulation process reinstates them back to their original position in the low frequency side of spectrum.

classification of Detection Methods :-

Detectors may be of two types.

(a) Square law diode detector :

Square law diode detector utilizes the non-linear portion of dynamic current-voltage characteristic of diode.

(b) Linear diode detector :

Linear diode detector uses the rectification property of a diode.

Square law Diode Detector :-

It utilizes the non-linear portion of the dynamic current-voltage characteristics of the diode. In this circuit the amplitude of applied voltage is kept so small that the operation of the diode is restricted to the excessively non-linear portion of characteristics curves.

Fig(1) gives the basic circuit of the square law diode detector.

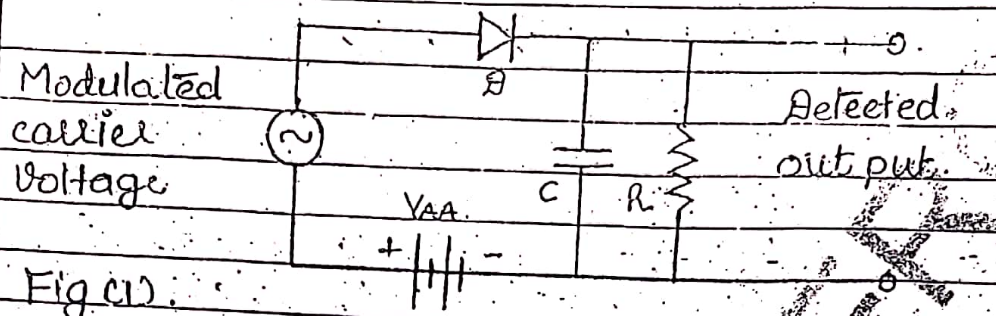


Fig (1).

The diode is positely biased by the bettery VAA to shift the zero signal operating point on the excessively non-linear part of the characteristic. The capacitor - Resistance shunt combination constitutes the load for the diode.

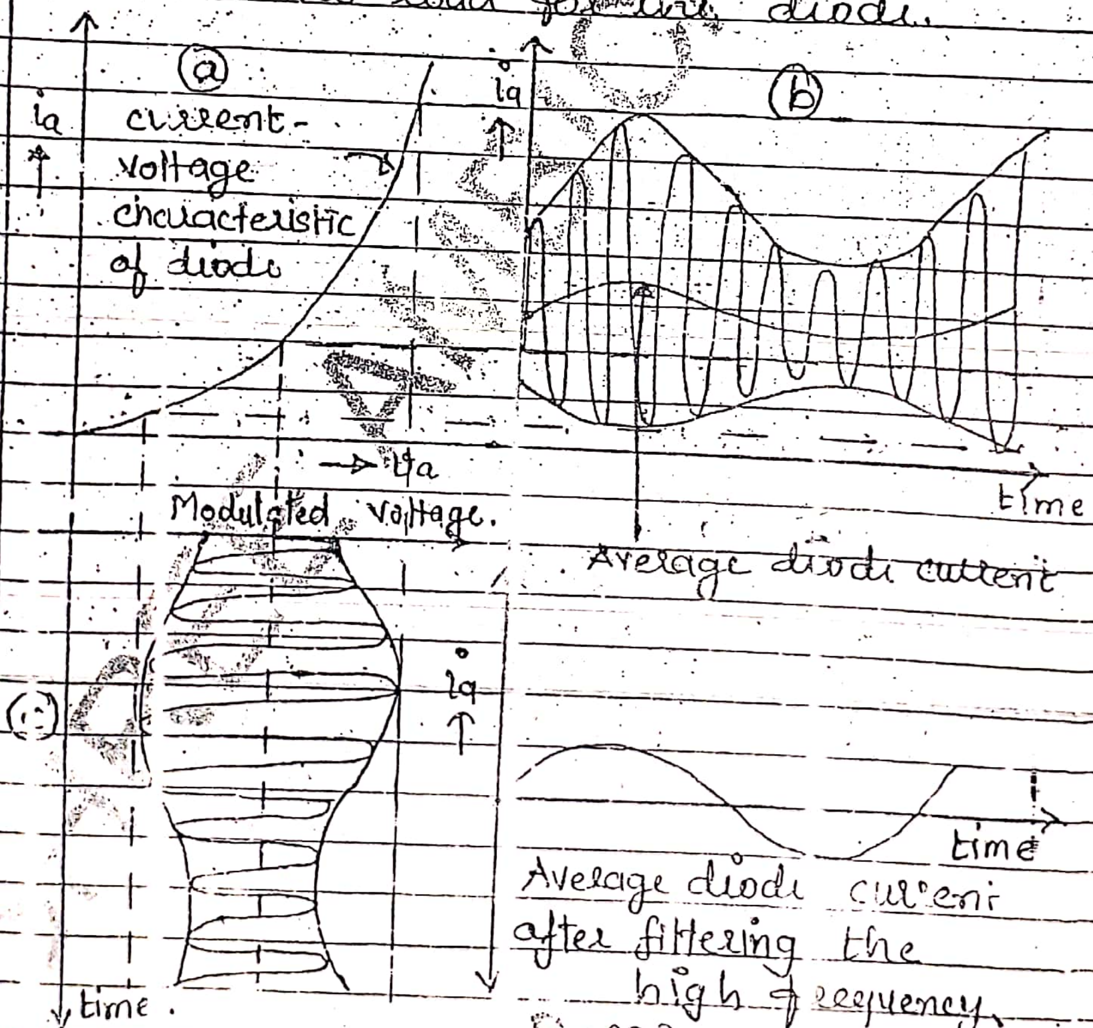


Fig (2)

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Fig (2) a gives the dynamic current-voltage characteristic of diode. Superposition of modulated carrier voltage fig(2)c results in the anode current as shown in fig(2) b.

Since the operation takes place on the non linear portion of characteristic, the current waveform in positive half cycle is expanded and that in negative half cycle is compressed. This results in average current as shown in fig(2) b.

The shunt capacitor at the load circuit bypasses the radio frequency component leaving only the average component at the detector output, which is shown in fig (2) d.

The relation between anode current i_a and voltage V_a in the non linear region portion of curve is given by,

$$i_a = a_1 V_a + a_2 V_a^2$$

and ac anode voltage is modulated voltage, which is expressed by

$$V_a = V_c[1 + m_a \cos \omega_m t] \cos \omega_c t$$

The resulting anode current contains the frequency terms ω_c, ω_m, $2\omega_c$, $2\omega_m$ $(\omega_c + \omega_m)$, $(\omega_c - \omega_m)$ and dc components.

All the high frequency terms are bypassed by the capacitor leaving only dc component with ω_m and $2\omega_m$ as signal component. The term with angular frequency ω_m is the original signal and $2\omega_m$ is the distortion in output.

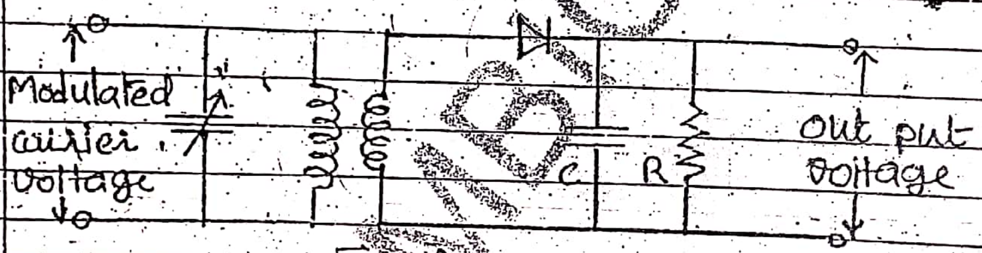
Linear diode detector :-

Linear diode detectors are widely used in radio receivers.

In this circuit the amplitude of AM voltage is 5 volts or more, so the diode operates in the linear region of its characteristic curve and effect of the barrier potential can be neglected.

∴ Linear diode detector utilizes the rectification property of the diode.

Fig(1) gives the basic circuit of the linear diode detector.



Fig(1)

The modulated carrier voltage is applied to the diode, the load circuit is shunt combination of resistor R and capacitor C.

Since the applied voltage is large the barrier potential can be neglected.

Assuming capacitor C to be absent, the total impedance in the circuit is $(r_a + R)$ where r_a is anode resistance of diode. The current passes for the positive cycle of carrier voltage only and hence out put is in the form of pulses as shown in fig(2)C.

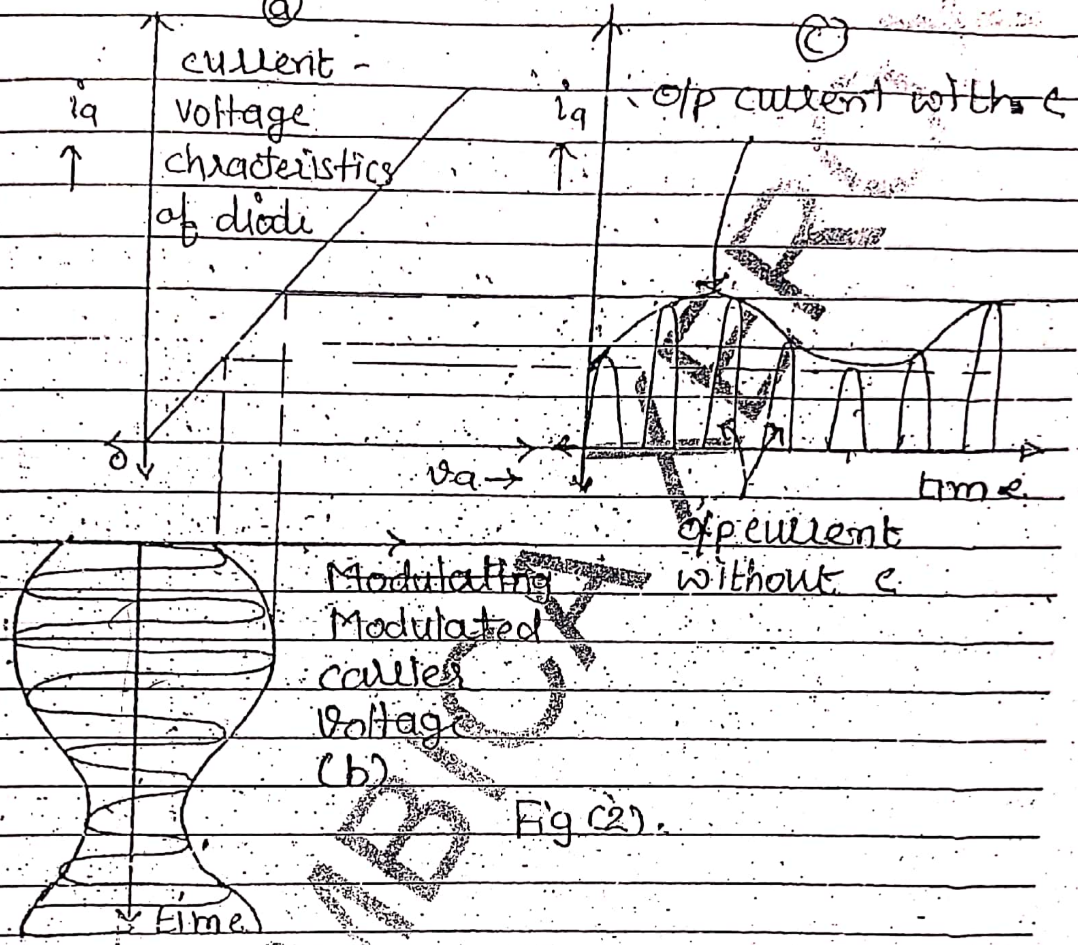


Fig (2).

The presence of the shunt capacitor modifies the out put. During the positive half cycle diode conducts and charges the capacitor to peak value of carrier voltage. During negative half cycle, the diode does not conduct and hence the capacitor c discharges through the resistor R and voltages are developed across the load R in the negative cycle also. The nature of out put voltage depends on the value of R and C.

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Frequency Modulation Methods :-

Following are the typical methods of producing frequency modulation.

1) Reactance tube modulation.
2) Reactance FET modulation.
3) Reactance BJT modulation.
4) Varactor diode modulation.
5) Armstrong method of modulation.

* Reactance Tube modulation :-

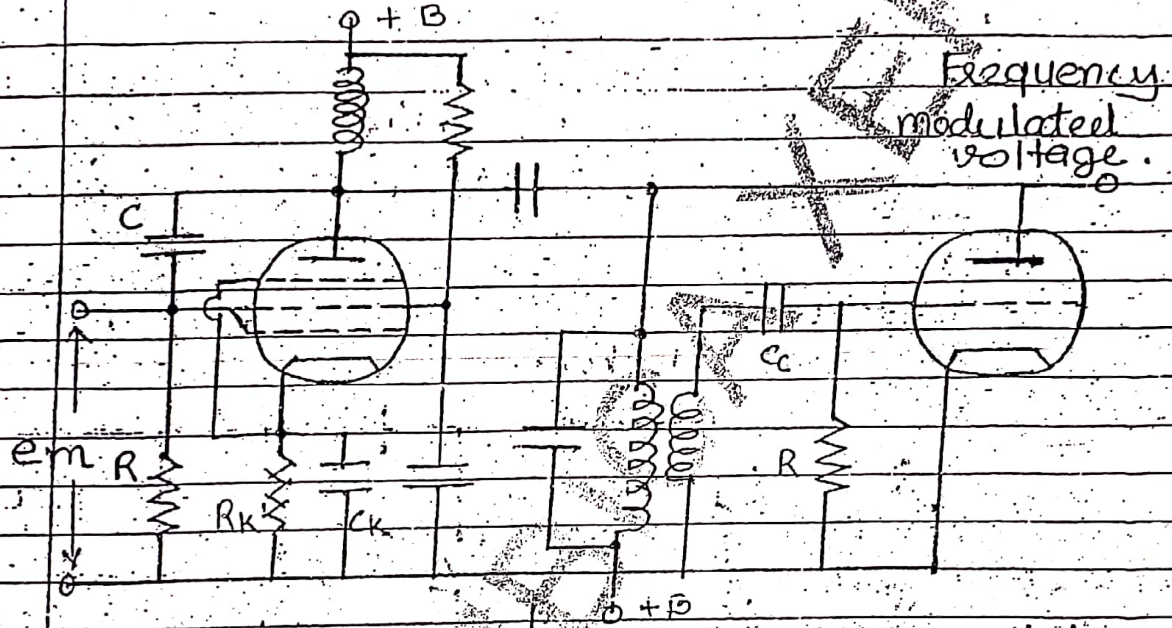
Before the advent of semiconductor devices, this method was most popularly used. However today it has been largely replaced by the varactor diode method.

This method uses a reactance tube whose reactance varies in accordance with the modulating voltage applied between its control grid and cathode.

The reactance tube is placed in shunt with the tuned circuit of an oscillator, This oscillator frequency then varies in accordance with the modulating voltage resulting in frequency modulation. By proper adjustment of circuit parameters, linear relationship may be obtained between modulating voltage and frequency deviation of carrier freq^n.

The reactance tube may be either capacitive reactance or an inductive reactance tube depending upon whether it offers capacitive reactance or inductive reactance across its plate and cathode terminals.

Fig(1) shows the basic circuit of capacitive reactance tube modulated oscillator.



Reactance Tube ← → Tuned plate Oscillator.

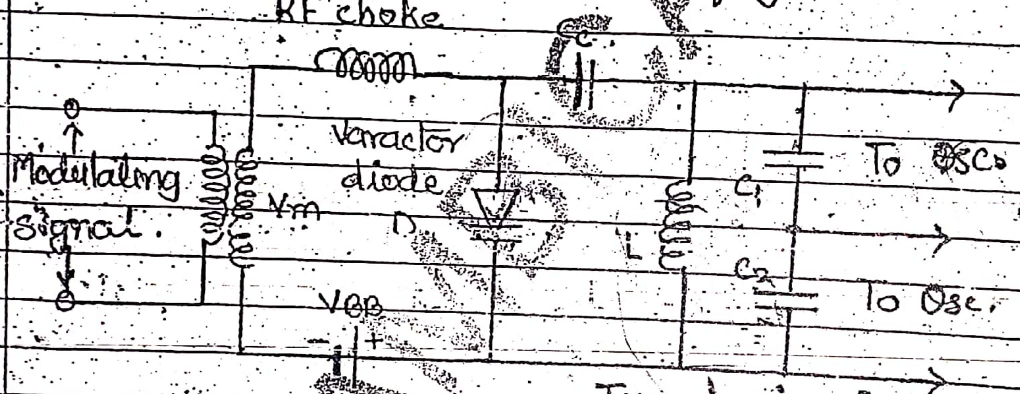
The mutual conductance (gm) of the tube varies in accordance with the modulating voltage. As the reactance tube is placed in shunt with the tuned circuit of the tuned plate oscillator, the frequency of oscillator also varies with the variation in modulating voltage.

Frequency Modulation using Varactor Diode:

Varactor diode is the pn junction diode with relatively large junction area and hence the junction capacitance of varactor diode in reverse bias is also large compared to the rectifier diode.

The junction capacitance of the varactor diode can be made varied with respect to the audio modulating voltage by suitable circuit arrangement.

Frequency modulation may be achieved using the junction capacitance of reverse biased varactor diode placed across the tuned circuit of an oscillator as shown in fig (i).



Tuned circuit of oscillator.

Let the modulating voltage be V_m, Then the entire voltage applied to the varactor diode is given by

$$V = V_{BB} + V_m.$$

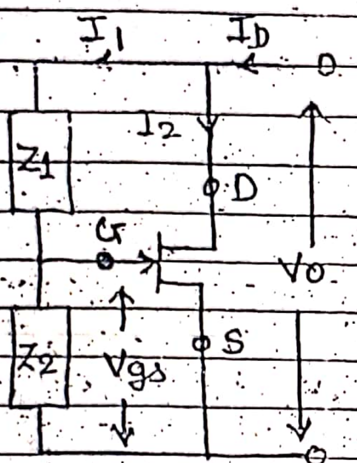
Where V_{BB} is reverse bias battery voltage. The capacitance of the varactor junction varies as $K \cdot \sqrt{V_m}$ where K is constant. The frequency of oscillation is given by

$$f = \frac{1}{2\pi \sqrt{L(C + K\sqrt{V_m})}}$$

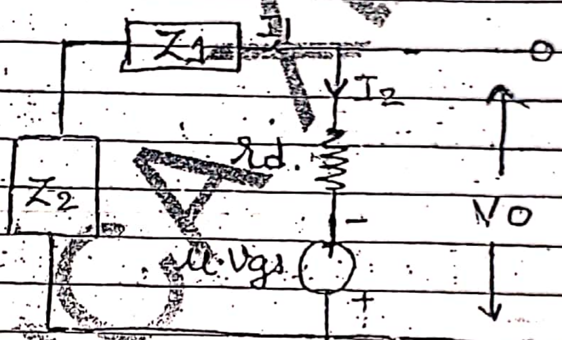
Where L is tuned circuit inductance and C is equivalent cap. of tuned circuit.

Reactance FET :-

Fig (1) gives the basic circuit of the reactance FET and fig(2) gives its equivalent circuit.



Fig(1) Basic circuit of reactance FET.



Fig(2). ac equivalent circuit of reactance FET.

The FET may be made to behave as capacitance or an inductance depending on the nature of circuit elements Z_1 & Z_2. Table 1 shows reactance offered by the FET for the various combination of the impedances Z_1 & Z_2.

	Circuit arrangement	Z_1	Z_2	Condition required	Reactance & its formula.
1	RC-circuit	C	R	$X_C >> R$	Capacitive $C_e = g_m RC$
2	RC-circuit	R	C	$R >> X_C$	Inductive $L_e = RC/g_m$
3	RL-circuit	R	L	$R >> X_L$	Capacitive $C_e = g_m L/R$
4	RL-circuit	L	R	$X_L >> R$	Inductive $L_e = L/g_m R$

Any of the four combination may be used to obtain reactance.

The basic pre-requisites for FET to behave as almost pure reactance is that in each case the drain current must be much greater then the bias network current.

Because of simplicity in construction and operation mostly RC-circuit is used in practice.

With reference to equivalent circuit voltage V_o is applied to the drain and source terminals of FET whose output impedance is Z_o.

Let I_o be the current drawn by the reactance FET from the source voltage V_o, then.

$$I_o = I_1 + I_2 \quad \text{---} (1)$$

$$I_1 = \frac{V_o}{Z_1 + Z_2} \quad \text{---} (2)$$

$$I_2 = \frac{V_o + \mu V_{gs}}{r_d} \quad \text{---} (3)$$

$$V_{gs} = \frac{Z_2}{Z_1 + Z_2} \times V_o \quad \text{---} (4)$$

where μ is amplification factor, g_m is transconductance and r_d is the drain resistanc

Hence:

$$I_o = \frac{V_o}{Z_1 + Z_2} + \frac{V_o + \mu V_{gs}}{r_d}$$

$$= \frac{V_o}{Z_1 + Z_2} + \frac{V_o}{r_d} + \frac{\mu V_{gs}}{r_d}.$$

$$Y_o = \frac{1}{\frac{1}{g_m}\left[1+\frac{1}{jWCR}\right]} \quad (8)$$

Thus $$Z_o = \frac{1}{g_m}\left[1+\frac{1}{jWCR}\right] \quad (9)$$

$$Z_o = \frac{1}{g_m} + \frac{1}{jWg_mCR}$$

$$Z_o = \frac{1}{g_m} - \frac{jX_C}{g_mR}$$

$$Z_o = \frac{1}{g_m}\left[\frac{R-jX_C}{R}\right] \quad (10)$$

if $X_C >> R$ then eqn (10) reduces to

$$Z_o = \frac{-jX_C}{g_mR} \quad (11)$$

Thus the impedance offered by the FET is

$$\boxed{C_e = g_mCR} \quad (12)$$

Above equation shows that

1) The equivalent capacitance C_e depends on the device transconductance g_m and may be ~~biased~~ varied with the bias voltage of device.

2) The C_e also depends on the value of components R and C, which can be easily varied to have variation in the value of equivalent capacitance C_e.

$$I_o = \frac{V_o}{Z_1+Z_2} + \frac{V_o}{r_d} + g_m V_{gs} \quad [\because \mu = g_m \cdot r_d]$$

$$I_o = \frac{V_o}{Z_1+Z_2} + \frac{V_o}{r_d} + \frac{g_m V_o Z_2}{Z_1+Z_2}$$

$$I_o = V_o\left[\frac{1}{Z_1+Z_2} + \frac{1}{r_d} + \frac{g_m Z_2}{Z_1+Z_2}\right] \quad \text{—} \; (5)$$

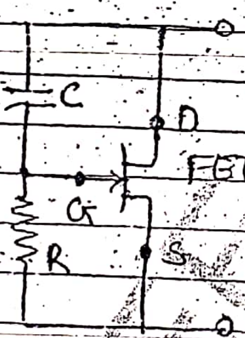
Hence the output admittance may be

$$Y_o = \frac{I_o}{V_o} = \frac{1}{Z_1+Z_2} + \frac{1}{r_d} + \frac{1}{\left(\frac{1}{g_m}\right)\left(\frac{Z_1}{Z_2}+1\right)} \quad (6)$$

Equation (6) forms the general form of admittance of reactance FET.

* For capacitive reactance FET

$Z_1 = \frac{1}{j\omega C}$ and $Z_2 = R$.



~~substituting~~ substituting the values of impedences Z_1 and Z_2 in equation (6) results in

$$Y_o = \frac{1}{R + 1/j\omega C} + \frac{1}{r_d} + \frac{1}{\frac{1}{g_m}\left[1+\left(\frac{1}{j\omega CR}\right)\right]} \quad (7)$$

Assuming that the bias network current I_1 is negligible compared to drain current I_2, Also dynamic drain resistance r_d is very large and hence may be neglected in the circuit.
Hence the expression for the admittance reduces to

Classification of FM detectors :-

The function of FM detector is to extract the original modulating voltage from the frequency modulated voltage.

FM detectors may be classified as follows,

i) single tuned / slope detector.

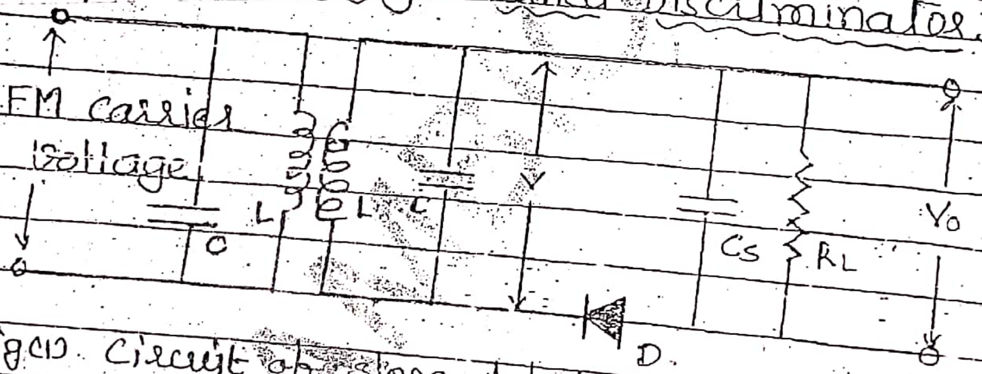
ii) Stagger tuned / Balanced slope detector.

iii) Phase difference discriminator

(a) Centre-tuned discriminator also known as Foster-seeley discriminator.

(b) Ratio detector.

Slope Detector (Single Tuned Discriminator) :-



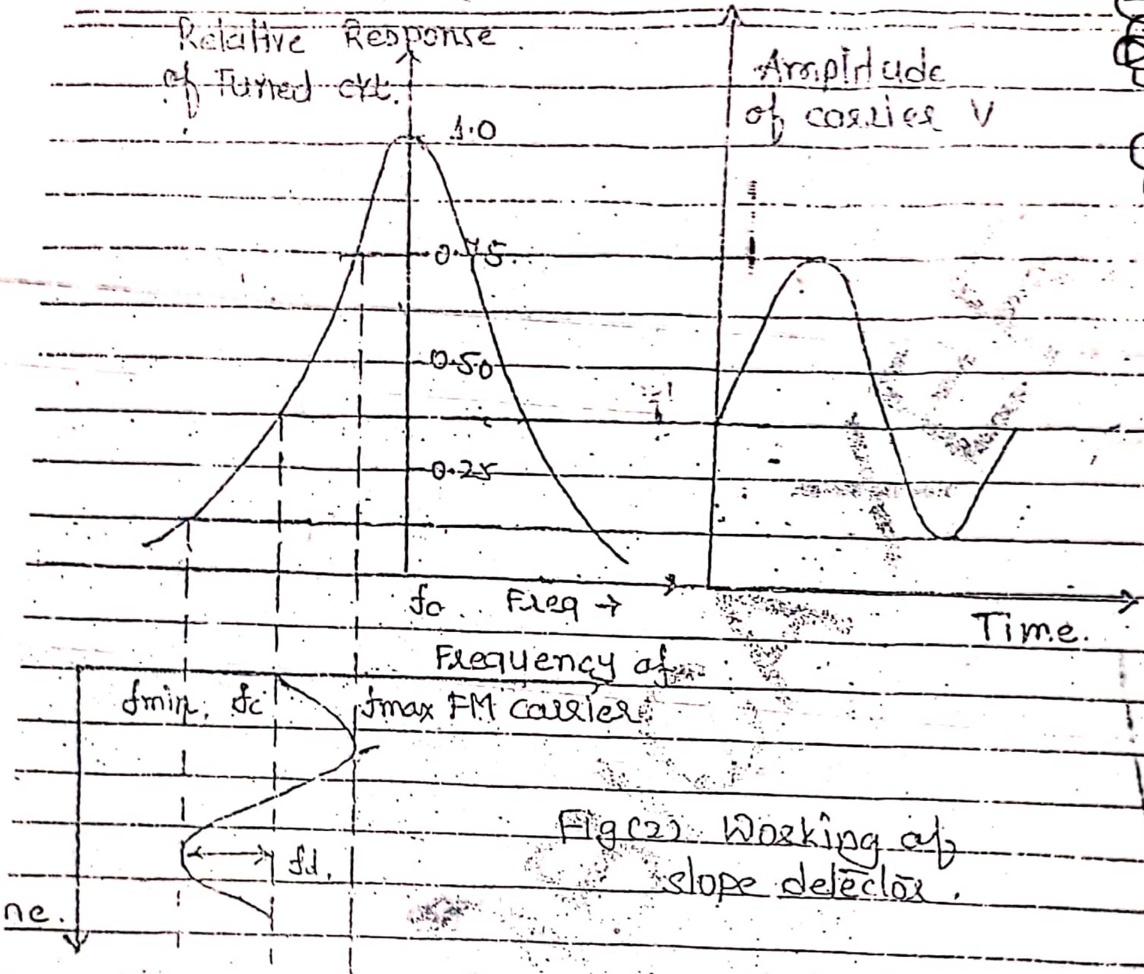
Fig(1). Circuit of slope detector.

The circuit of slope detector is shown in fig(1). It is made up of a tuned circuit, tuned to slightly different from the carrier frequency, and linear rectifier with filter section.

Fig(2) shows the action of slope detector. It converts the frequency modulated voltage into amplitude modulated voltage.

As the instantaneous carrier frequency varies the response of the tuned circuit varies accordingly. Hence the o/p voltage

Date:



Fig(2) Working of slope detector.

of the tuned circuit 'V' also varies. This amplitude modulated voltage may then be rectified in diode detector to get back the modulating voltage. If the response of the tuned circuit is straight line, then the o/p voltage "Vo" is identical with the original modulating voltage.

Limitations: ① As the response of practical tuned circuit is non-linear, the detected [illegible] distorted [illegible] it [illegible] the [illegible] ② Another drawback of this circuit is [illegible] does not reject the [illegible] variations and hence any noise present in [illegible] [illegible] detector [illegible]

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V.P. & R.P.T.P SCIENCE COLLEGE

INTERANAL EXAM

S.Y.B.Sc(SEM-III) ELECTRONICS

SUB: - Analog Communication SUB CODE: US03CELC22

DATE:-03/10/2019 TIME: 3:00 pm to 4:15 pm MARKS-25

Q-1 Choose correct answer [05]

1. The frequency of the carrier signal is normally kept_____.
   (A) zero (C) high
   (B) low (D) None of above
2. _________ Modulation process is used for high quality audio communication.
   (A) Phase (C) Frequency
   (B) Amplitude (D) None of above
3. _______frequency is known as UHF.
   (A) 3-30 MHz (C) 300-3000 MHz
   (B) 30-300 MHz (D) None of above
4. Height of the transmitting antenna depends on _____.
   (A) transmitted power (C) modulation signal frequency
   (B) carrier signal frequency (D) None of above
5. Varactor diode operates in _______ bias condition.
   (A) forward (C) reverse
   (B) zero (D) None of above

1.5 Q-2 Define amplitude modulation. Derive the expression for the amplitude modulated voltage with necessary diagram. [05]

OR

Q-2 Define frequency modulation. Derive the expression for the frequency modulated voltage with necessary diagram. [05]

2 Q-3 Discuss square law diode modulation method with necessary diagram. [05]

OR

Q-3 Discuss linear diode detector circuit with necessary diagram. [05]

2 Q-4 Draw a circuit diagram of reactance tube modulation method and discuss it. [05]

OR

Q-4 Describe frequency modulation method using varactor diode. [05]

2 Q-5 Explain the concept of ground wave propagation. [05]

OR

Q-5 Discuss surface wave propagation system. [05]

[60]

Seat No :________

No. of Printed Pages : 02

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Sardar Patel University
B.Sc. (semester-III) CBCS Examination 2019
28/11/2019, Thursday
Electronics & Communication
US03CELC22: Analog Communication
Time: 2:00 pm TO 5:00 pm

Maximum Marks: 70

Note: Figures to right indicates the full marks.

Q-1 Multiple Choice Questions. **(10)**

1. The very low frequency (VLF) range extends from ______.
   a) 10-30 KHz b) 15 KHz
   c) 25 KHz d) 50 KHz

2. Man made noise is produced by ______.
   a) solar eruption b) arc discharging in electrical machine
   c) lighting discharge d) distant stars

3. The super high frequency (SHF) range extends from______.
   a) 10-30 MHz b) 30-300MHz
   c) 300-3000MHz d) 3000-30000 MHz

4. In a linear diode detector negative peak clipping is the result of due to the ______.
   a) high value of the time constant RC b) Not effect on the time constant RC
   c) low value of the time constant RC d) none

5. ______amplifier is mainly used in collector modulation techniques.
   a)class A b)class B
   c)class C d) class AB

6. RC capacitive reactance tube behaves as capacitance of value ....
   a) CR b)1/gm
   c) CR/gm d) gmCR

7. Varactor diode operates in .... bias condition.
   a)reverse b)zero
   c)forward d) none

8. Surface wave propagation is mainly used for ______ signals.
   a) short wave b) long and medium wave
   c) very high frequency d) none

9. The length of the half wave antenna is ______.
   a) L=λ/4 b) L=5 λ
   c) L=λ/2 d) L=10 λ

10. If the antenna is vertical then waves are polarized _____.
    a) horizontal b) circular
    c) elliptical d) vertical

(P.T.O)

Q-2 **Answer in short. (Any ten)** **(20)**

1. Explain the term Frequency modulation .
2. Classify the external noise and explain any one.
3. Give the classification of RF spectrum
4. Draw the waveform of frequency modulated carrier voltage.
5. Why we preferred collector modulation then base modulation?
6. Draw the basic circuit of square law diode detector.
7. Draw the characteristics curve of square law diode detector
8. What is the difference between varactor diode and rectifier diode?
9. Mention the method of frequency modulation.
10. Explain radiation resistance.
11. What is the application of space wave propagation?
12. Which factor affects to the magnitude of the space wave and surface wave?

Q-3 Draw the block diagram of Modern electronics communication system and explain its function briefly. **(10)**

OR

Q-3 Define Amplitude modulation. Derive the mathematical expression for the amplitude modulated voltage with necessary diagram. **(10)**

Q-4 (a) Describe the working of square law diode modulation with proper circuit diagram. **(10)**

OR

Q-4 (b) Describe the working of Collector modulation with proper circuit diagram **(05)**

(c) Describe the working of linear diode detector with proper circuit diagram. **(05)**

Q-5 (a) Draw the circuit of Slope detector and explain its working. **(05)**

(b) Write a short note on: frequency Modulation using Varactor Diode **(05)**

OR

Q-5 (c) Explain method of frequency modulation, and draw the circuit of an R-C capacitive reactance FET and obtain expression for the effective capacitance Ce offered by FET between drain and source terminals. **(10)**

Q-6 Explain ground wave propagation with necessary diagrams. **(10)**

OR

Q-6 Explain function and process of antenna action with necessary diagrams. **(10)**

******X******