



**DEPT. OF ELECTRONICS AND TELECOMMUNICATION
TRIDENT ACADEMY OF TECHNOLOGY, BHUBANESWAR**

**LECTURE NOTES
ON
RADAR AND TV ENGINEERING
B. Tech-ETC
7th Sem**

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7 th Semester	REC7D006	Radar and TV Engineering	L-T-P 3-0-0	3 Credits
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Module I

Radar : The Radar equation-Pulse Radar-CW Radar-CW Radar with non zero IF, equation for Doppler frequency- FM-CW Radar using sideband superhetrodyne receiver, MTI Radar-Delay line canceller, MTI Radar with power amplifier & power oscillator, Non coherent MTI Radar, Pulse Doppler Radar, Radar Transmitters. Radar Modulator-Block diagram. Radar receivers- noise figure, low noise front ends, Mixers – Different types of Displays – Duplexers- Branch type and balanced type. Navigation- Loop Antenna, Radio compass. Hyperbolic Systems of Navigation, LORAN – A. Distance Measuring Equipment . Instrument Landing System – Localizer, Glide Slope, Marker beacons.

Module II

Television: Scanning, Blanking and synchronisation, Picture signal - composite video signal Vestigial sideband transmission-Principle of CCD Camera - Monochrome picture tube- Monochrome TV receivers- RF tuner ,VHF tuner- Video amplifier, IF section, Vestigial sideband correction- Video detectors, Sound signal separation, AGC, sync separation, horizontal and vertical deflection circuits, EHT generation. Colour TV system: Principle of colour signal transmission and reception, PAL, NTSC, SECAM (block schematic description), Picture tube – delta gun.

Module III

Digital TV: Digitized Video, Source coding of Digitized Video – Compression of Frames – DCT based – (JPED), Compression of Moving Pictures (MPEG). Basic blocks of MPEG2 and MPE4. Digital Video Broadcasting (DVB) – Modulation: QAM – (DVB-S, DVB-C), OFDM for Terrestrial Digital TV (DVB –T). Reception of Digital TV Signals (Cable, Satellite and terrestrial). Digital TV over IP, Digital terrestrial TV for mobile. Display Technologies – basic working of Plasma, LCD and LED Displays.

Books:

1. Merrill I. Skolnik: Introduction to Radar Systems,3/e, Tata McGraw Hill,
2. N.S.Nagaraja: Elements of Electronic Navigation, 2/e, Tata McGraw Hill
3. R.R. Gulati: Monochrome and Colour Television. New Age international, 2008.
4. Herve Benoit, Digital Television Satellite, Cable, Terrestrial, IPTV, Mobile TV in the DVB Framework, 3/e, Focal Press, Elsevier, 2008
5. Shlomo Ovadia: Broadband Cable TV Access Networks, PH-PTR, 2001
6. Byron Edde: Radar Principles, Technology & Applications, Pearson Education.
7. Mark E Long: —The Digital Satlitte TV Hand Bookll, Butterworth-Heinemann.
8. K.R.Rao, J.O.Hwang, Techniques and standards for Image,Video and Audio coding,Prentice Hall,1996
9. John Arnold, Michael Frater, Mark Pickering,Digital Television Technology and Standards, John Wiley & Sons, Inc, 2007
10. Robert L. Hartwig,Basic TV Technology: Digital and Analog, 4/e, Focal Press, Elsevier, 2005

CHAPTER 1

INTRODUCTION TO RADAR SYSTEM

1.1 Introduction:-

Radar is an electromagnetic system for the detection and location of objects. It operates by transmitting a particular type of waveform, a pulse-modulated sine wave for example, and detects the nature of the echo signal. Radar is used to extend the capability of one's senses for observing the environment, especially the sense of vision.

An elementary form of radar consists of a transmitting antenna emitting electromagnetic radiation generated by an oscillator of some sort, a receiving antenna, and an energy-detecting device, or receiver. A portion of the transmitted signal is intercepted by a reflecting object (target) and is reradiated in all directions. It is the energy reradiated in the back direction that is of prime interest to the radar. The receiving antenna collects the returned energy and delivers it to a receiver, where it is processed to detect the presence of the target and to extract its location and relative velocity.

The distance to the target is determined by measuring the time taken for the radar signal to travel to the target and back. The direction, or angular position, of the target may be determined from the direction of arrival of the reflected wave- front. The usual method of measuring the direction of arrival is with narrow antenna beams. If relative motion exists between target and radar, the shift in the carrier frequency of the reflected wave (Doppler Effect) is a measure of the target's relative (radial) velocity and may be used to distinguish moving targets from stationary objects. In radars which continuously track the movement of a target, a continuous indication of the rate of change of target position is also available.

1.2 History Background

James Clerk Maxwell (1831 –1879) - predicted the existence of radio waves in his theory of electromagnetism. In 1886, Hertz experimentally tested the theories of Maxwell and demonstrated the similarity between radio and light waves. Hertz showed that radio waves could be reflected itself. Heinrich Hertz, in 1886, experimentally tested the theories of Maxwell and demonstrated the similarity between radio and light waves. Hertz showed that radio waves could be reflected by metallic and dielectric bodies. Due to these reflections occurred through metallic bodies given a start to the development of radar systems.

In 1903 a German engineer by the name of Hülsmeyer experimented with the detection of radio waves reflected from ships. He obtained a patent in 1904 in several countries for an radio waves reflected from ships as shown in fig.1.



(a)



(b)

Fig. 1 (a) Detection of wooden ship in 1904 **(b)** Hülsmeyer 1904, who detected the first object through radar

In the autumn of 1922 A. H. Taylor and L. C. Young of the Naval Research Laboratory detected a wooden ship using a CW wave-interference radar with separated receiver and transmitter. The wavelength was 5 m. The first application of the pulse technique to the measurement of distance was in the basic scientific investigation by Breit and Tuve in 1925 for measuring the height of the ionosphere. However, more than a decade was to elapse before the detection of aircraft by pulse radar was demonstrated.

The first detection of aircraft using the wave-interference effect was made in June, 1930, by L. A. Hyland of the Naval Research Laboratory. It was made accidentally while he was working with a direction-finding apparatus located in an aircraft on the ground. The transmitter at a frequency of 33 MHz was located 2 miles away, and the beam crossed an air lane from L. Hyland of the Naval Research Laboratory. It was made accidentally while he was working with a direction-finding apparatus located in an aircraft on the ground. The transmitter at a frequency of 33 MHz was located 2 miles away, and the beam crossed an air lane from a nearby airfield.

Before the advent of radar, the only practicable means of detection of aircraft was acoustic, and a network of acoustic detectors was built in the 1920s and 1930s around the south and east coast of the UK, some of which still remain. In calm air conditions, detection ranges of up to 25km were achievable.



(a)



(b)



(c)

Fig. 2 Different types of Acoustic Radars from 1920-1930

Radar Applications:-

In aviation, aircraft are equipped with radar devices that warn of aircraft or other obstacles in or approaching their path, display weather information, and give accurate altitude readings. The first commercial device fitted to aircraft was a 1938 Bell Lab unit on some United Air Lines aircraft. Such aircraft can land in fog at airports equipped with radar-assisted ground-controlled approach systems in which the plane's flight is observed on radar screens while operators radio landing directions to the pilot.

Marine radars are used to measure the bearing and distance of ships to prevent collision with other ships, to navigate, and to fix their position at sea when within range of shore or other fixed references such as islands, buoys, and lightships. In port or in harbour, vessel traffic service radar systems are used to monitor and regulate ship movements in busy waters.

Normal radar functions:

1. Range (from pulse delay)
2. Velocity (from Doppler frequency shift)
3. Angular direction (from antenna pointing)

Signature analysis and inverse scattering:

4. Target size (from magnitude of return)
5. Target shape and components (return as a function of direction)
6. Moving parts (modulation of the return)
7. Material composition

The complexity (cost & size) of the radar increases with the extent of the functions that the radar performs.

CHAPTER 2: BASIC PRINCIPLES OF RADAR

A radar system has a transmitter that emits radio waves called *radar signals* in moving or stationary target directions. When these come into contact with an object they are usually reflected or scattered in many directions. Radar signals are reflected especially well by materials of considerable electrical conductivity especially by most metals, by seawater and by wet ground. Some of these make the use of radar altimeters possible. The radar signals that are reflected back towards the transmitter are the desirable ones that make radar work. If the object is *moving* either toward or away from the transmitter, there is a slight equivalent change in the frequency of the radio waves, caused by the Doppler effect.

The basic principle of the radar is shown in fig. 2.1. A transmitter generates an electromagnetic signal that is radiated by the antenna into space. A portion of the transmitted electromagnetic energy is reflected back by the target towards the radar. Based on the received target echo signal the receiver made decision for the position, range and direction of the target. The term radar is a contraction of the words radio detection and ranging.

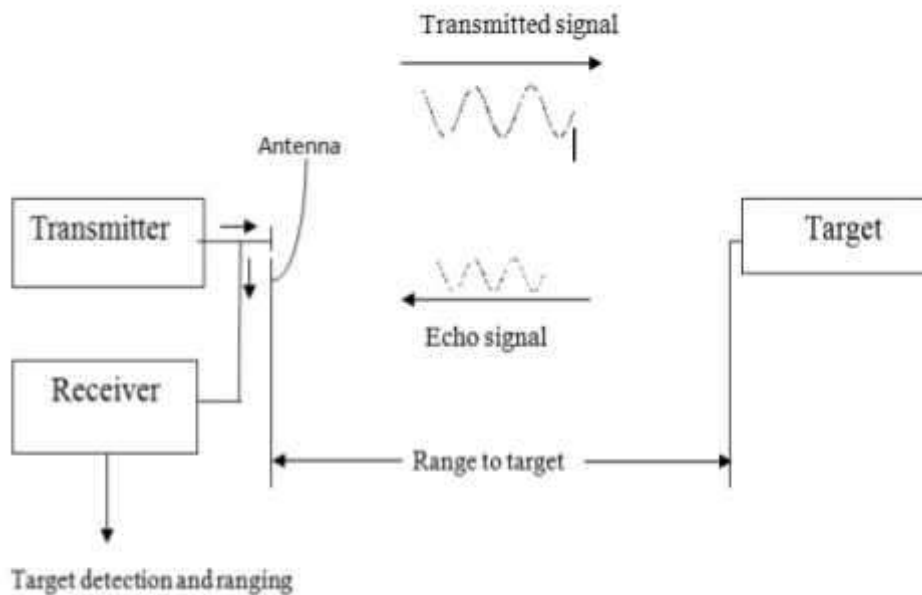


Fig. 2.1 Basic Principles of the Radar

The basic terminology used for radar is discussed as follows.

Range:- The range of the target is observed by measuring the time (T_R) it takes for the radar signal to travel to the target and return back to the radar. Thus the time for the signal to travel to

the target located at range (R) and the return back to the radar is $2R/C$. The range of the target can be given as:

$$R = \frac{cT_R}{2} \quad \dots (1)$$

with the range in kilometers or in nautical miles, and T in microseconds.

$$\begin{aligned} R(km) &= 0.15 T_R (\mu s) \\ R(nmi) &= 0.081 T_R (\mu s) \end{aligned} \quad \dots (2)$$

Maximum Unambiguous Range:- Once a signal is radiated into space by a radar, enough time must elapse to allow all echo signal to return to the radar before the transmission of next pulse. The rate at which the pulses are transmitted, is determined by the longest range of the target. If the time between pulses T_p is too short, an echo signal from the long range target might arrive after the transmission of the next pulse. The echo that arrives after the transmission of next pulse is called as *second-time-around-echo (or multiple-time-around-echo)*. Such an echo would appear to be at a closer range than actual, this range measurement will be misleading for range calculation, if it is not known that this is second time echo. The range beyond which the target appears as second-time-around-echoes is the *maximum unambiguous range*, R_{un} and is given by

$$\begin{aligned} R_{un} &= \frac{cT_p}{2} = \frac{c}{2f_p} \\ f_p &= \frac{1}{T_p} \\ \text{Duty cycle} &= \frac{\tau}{T_p} \end{aligned} \quad \dots (3)$$

Where T_p is the pulse repetition time and f_p is the pulse repetition frequency.

A problem with pulsed radars and range measurement is how to unambiguously determine the range to the target if the target returns a strong echo. This problem arises because of the fact that pulsed radars typically transmit a sequence of pulses. The radar receiver measures the time between the leading edges of the last transmitting pulse and the echo pulse. It is possible that an echo will be received from a long range target after the transmission of a second transmitting pulse.

In this case, the radar will determine the wrong time interval and therefore the wrong range. The measurement process assumes that the pulse is associated with the second transmitted pulse and declares a much reduced range for the target. This is called range ambiguity and occurs where there are strong targets at a range in excess of the pulse repetition time. The pulse repetition time defines a maximum unambiguous range. To increase the value of the unambiguous range, it is necessary to increase the PRT, this means: to reduce the PRF.

Echo signals arriving after the reception time are placed either into the transmit time where they remain unconsidered since the radar equipment isn't ready to receive during this time, or into the following reception time where they lead to measuring failures (ambiguous returns).

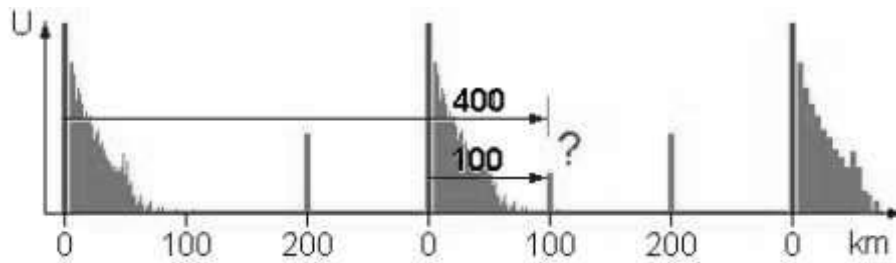


Fig. 2.2 a second-time-around echo in a distance of 400 km assumes a wrong range of 100 km

Pulse Repetition Frequency (PRF):- The rate at which the pulses are transmitted towards the target from the radar is called as the pulse repetition frequency, f_p .

$$f_p = \frac{1}{T_p} \quad \dots (4)$$

Pulse Repetition Period:- The time interval at which the pulses are periodically transmitted towards the target from the radar is called as the pulse repetition period, T_p is given by in terms of prf.

$$T_p = \frac{1}{f_p} \quad \dots (5)$$

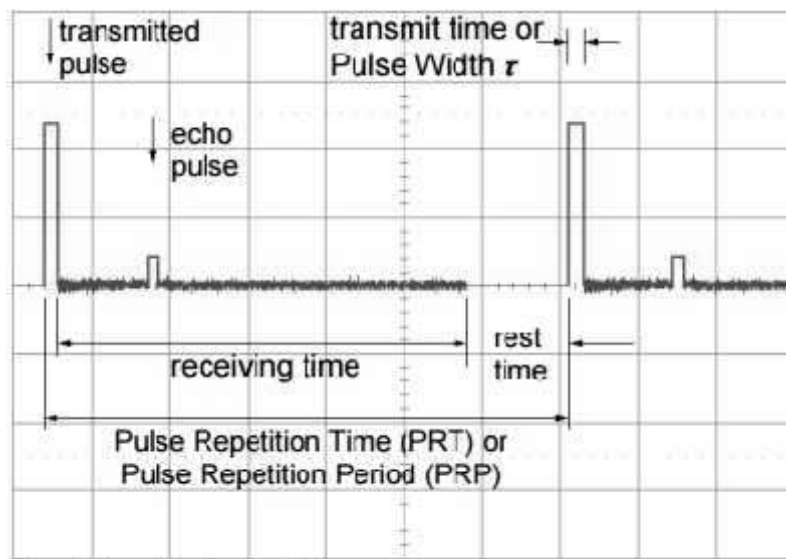


Fig. 2.3 A typical radar time line

Duty Cycle:- The duty cycle of the radar waveform is described as the ratio of the total time the radar is radiating to the total time it could have radiated.

$$Duty\ cycle = \frac{P_{av}}{P_T} \quad \dots (6)$$

$$Duty\ cycle = \frac{\tau}{T_p} = \tau f_p \quad \dots (7)$$

Where τ is pulse width of the transmitted pulse and T_p is the pulse repetition period.

Peak Power of the Radar:- The maximum power of the radar antenna, that can be transmitted for the maximum unambiguous range target detection in particular direction.

Average Power of the Radar:- The average power of the radar antenna, that can be transmitted for the maximum unambiguous range target detection in all the direction (for isotropic antenna).

Radar Wave forms:- Typical radar utilizes various waveforms for target detection.

- **Pulse waveform:-** A radar uses rectangular pulse wave form with pulse width of 1 microsecond, pulse repetition period 1 millisecond.
- **Continuous waveform:-** A very long continuous waveform are required for some long range radars to achieve sufficient energy for small target detection.

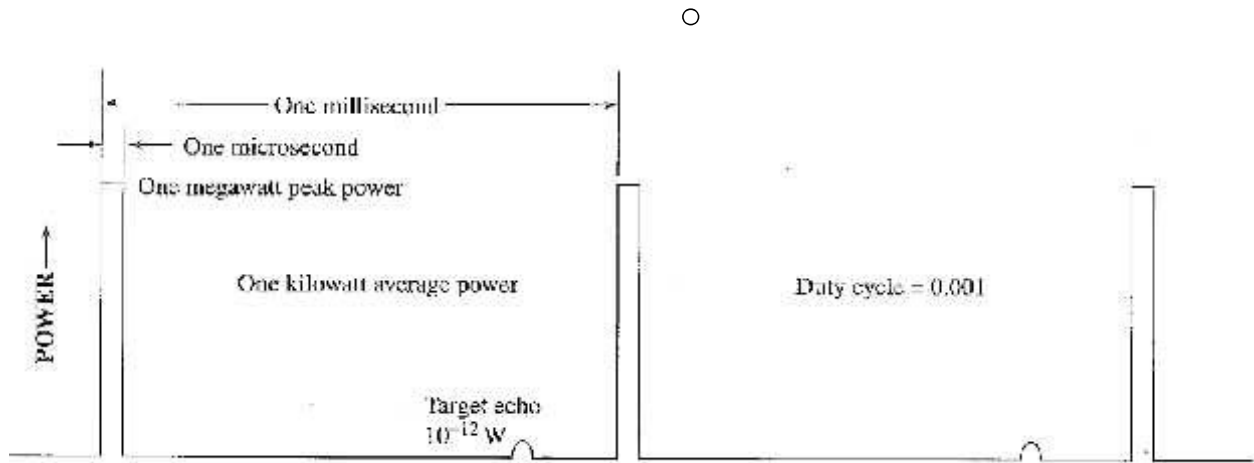


Fig.2.4 Example of typical pulse waveform for medium range air surveillance radar

CHAPTER: 3 RADAR RANGE EQUATION

3.1 Introduction:-

The radar range relates the radar range with the characteristics of transmitter, receiver antenna, target and environment. The radar range equation is useful to understand the maximum range of the radar that can be detected by the radar with their performance parameters. One of the simpler equations of radar theory is the radar range equation.

3.2 BASIC RADAR RANGE EQUATIONS

The transmitted power P_t is radiated by an isotropic antenna, the power density at distance R can be given as:

$$\text{Power density at range R from an isotropic antenna} = \frac{P_t}{4\pi R^2} \text{ (Watt/square meter)} \quad \dots (3.1)$$

The maximum gain of the antenna can be defined as:

$$G = \frac{\text{max power density radiated by an antenna}}{\text{power density radiated by a lossless isotropic antenna}} \quad \dots (3.2)$$

Thus the power density at target from a directive antenna can be given as:

$$\text{Power density at range R from a directive antenna} = \frac{P_t G}{4\pi R^2} \quad \dots (3.3)$$

The target receives a portion of the incident energy and reflected it in various directions. Thus the radar cross section of the target determines the power density returned back to the radar.

The reflected power from the target through its cross section (target cross section) can be given as:

$$\text{Reflected power from the target towards the radar} = \frac{P_t G}{4\pi R^2} \cdot \frac{\sigma}{4\pi R^2} \quad \dots (3.4)$$

The radar antenna receives a portion of the reflected power from the target cross section. the received power can be given as:

$$P_r = \frac{P_t G}{4\pi R^2} \cdot \frac{\sigma}{4\pi R^2} \cdot A_e \quad \dots (3.5)$$

$$A_e = \rho_a \bullet A \quad \dots (3.6)$$

Where A_e is the effective area of the receiving antenna, A is the physical antenna area and ρ_a is the antenna aperture efficiency. The maximum range of the radar (R_{\max}) can be defined as the maximum distance beyond which radar cannot detect the target. So the received signal power can be given as the minimum detectable signal.

$$S_{\min} = \frac{P_t G}{4\pi R^2} \bullet \frac{\sigma}{4\pi R_{\max}^2} \bullet A_e \quad \dots (3.7)$$

$$R_{\max} = \left[\frac{P_t G}{4\pi} \bullet \frac{\sigma}{4\pi} \bullet \frac{A_e}{S_{\min}} \right]^{1/4} \quad \dots (3.8)$$

This is the fundamental form of radar range equation. If the antenna is used for both the transmission and receiving purpose, then the transmitted gain (G) can be given in terms of the effective area (A_e).

$$G = \frac{4\pi A_e}{\lambda^2} \quad \dots (3.9)$$

Now the maximum radar range can be given as follows.

$$R_{\max} = \left[\frac{P_t G^2 \lambda}{(4\pi)^3} \bullet \sigma \bullet \frac{A_e}{S_{\min}} \right]^{1/4} \quad (\text{When } G \text{ is constant}) \quad \dots (3.10)$$

$$R_{\max} = \left[\frac{P_t}{(4\pi)^3} \bullet \sigma \bullet \frac{A_e^2}{S_{\min}} \right]^{1/4} \quad (\text{When } A_e \text{ is constant}) \quad \dots (3.11)$$

These three forms of radar range equations [2.8, 2.10 and 2.11] are based on the effective area (A_e) and transmitter antenna gain (G).

3.3 Radar Block Diagram

The operation of a typical pulse radar may be described with the aid of the block diagram shown in Fig. 1.2. The transmitter may be an oscillator, such as a magnetron, that is "pulsed" (turned on and off) by the modulator to generate a repetitive train of pulses. The magnetron has probably been the most widely used of the various microwave generators for radar. A typical radar for the detection of aircraft at ranges of 100 or 200 nmi might employ a peak power of the order of a megawatt, an average power of several kilowatts, a pulse width of several microseconds, and a

pulse repetition frequency of several hundred pulses per second. The waveform generated by the transmitter travels via a transmission line to the antenna.

where it is radiated into space.

A single antenna is generally used for both transmitting and receiving. The receiver must be protected from damage caused by the high power of the transmitter. This is the function of the duplexer. The receiver is usually of the superheterodyne type. The first stage might be a low-noise RF amplifier, such as a parametric amplifier or a low-noise transistor. However, it is not always desirable to employ a low-noise first stage in radar.

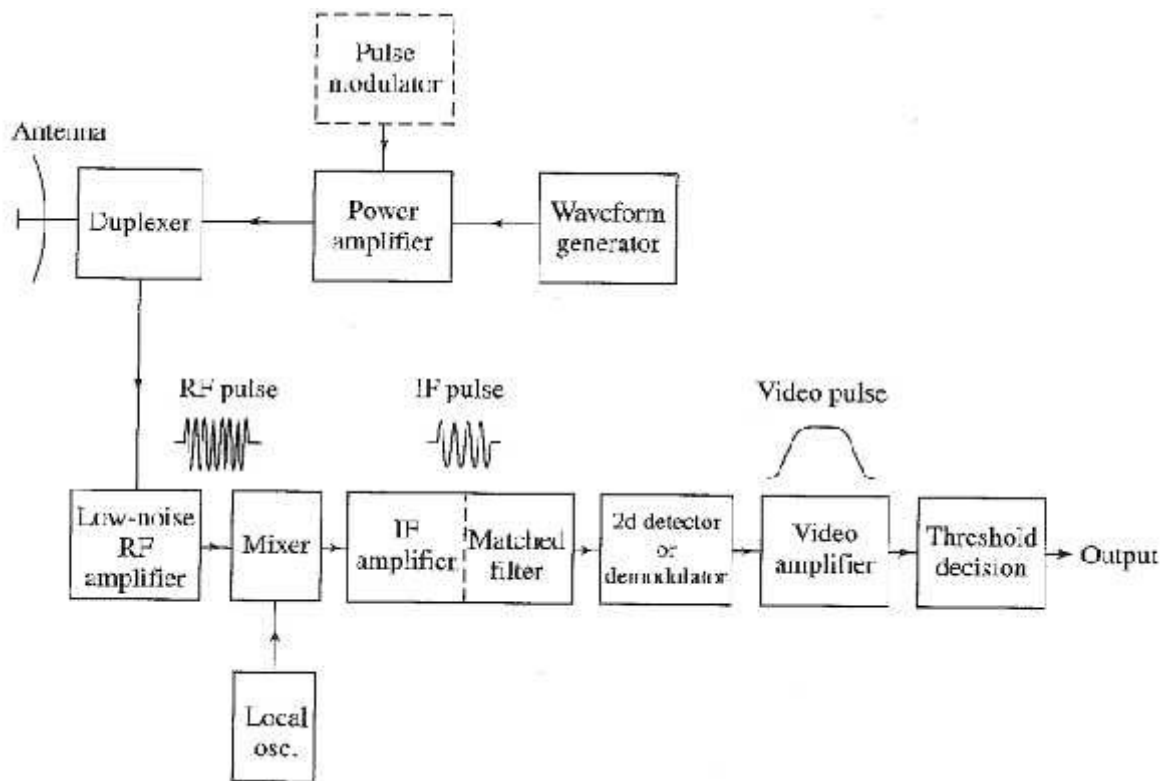


Fig. 3.1 Radar Block Diagram

The mixer and local oscillator (LO) convert the RF signal to an intermediate frequency (IF). A "typical" IF amplifier for an air-surveillance radar might have a center frequency of 30 or 60 MHz and a bandwidth of the order of one megahertz.

The IF amplifier should be designed as a matched filter; i.e., its frequency-response function $H(f)$ should maximize the peak-signal-to-mean-noise-power ratio at the output.

After maximizing the signal-to-noise ratio in the IF amplifier, the pulse modulation is extracted by the second detector and amplified by the video amplifier to a level where it can be properly displayed, usually on a cathode-ray tube (CRT). Timing signals are also supplied to the indicator to provide the range zero. Angle information is obtained from the pointing direction of the antenna.

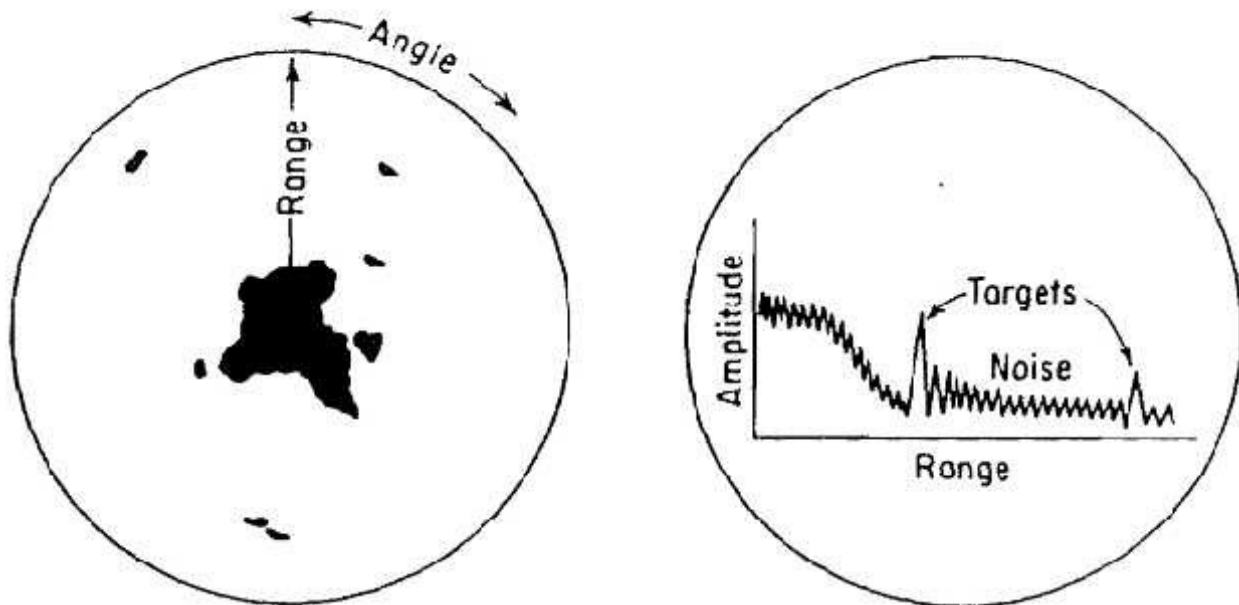


Fig. 3.2 (a) PPI presentation displaying range vs. angle (intensity modulation); (b) A scope presentation displaying amplitude vs. range (deflection modulation).

A common form of radar antenna is a reflector with a parabolic shape, fed (illuminated) from a point source at its focus. The parabolic reflector focuses the energy into a narrow beam, just as does a searchlight or an automobile headlamp. The beam may be scanned in space by mechanical pointing of the antenna. Phased-array antennas have also been used for radar. In a phased array the beam is scanned by electronically varying the phase of the currents across the aperture.

3.3 Radar's Electromagnetic Spectrum

Conventional radars generally have been operated at frequencies extending from about 220 MHz to 35 GHz, a spread of more than seven octaves. These are not necessarily the limits, since radars

can be, and have been, operated at frequencies outside either end of this range. Skywave HF over-the-horizon (OTH) radar might be at frequencies as low as 4 or 5 MHz, and Groundwave HF radars as low as 2 MHz. At the other end of the spectrum, millimeter radars have operated at 94 GHz. Laser radars operate at even higher frequencies.

The place of radar frequencies in the electromagnetic spectrum is shown in Fig. 3.3. Some of the nomenclature employed to designate the various frequency regions is also shown. Early in the development of radar, a letter code such as S, X, L, etc., was employed to designate radar frequency bands. Although its original purpose was to guard military secrecy, the designations were maintained, probably out of habit as well as the need for some convenient short nomenclature. This usage has continued and is now an accepted practice of radar engineers.

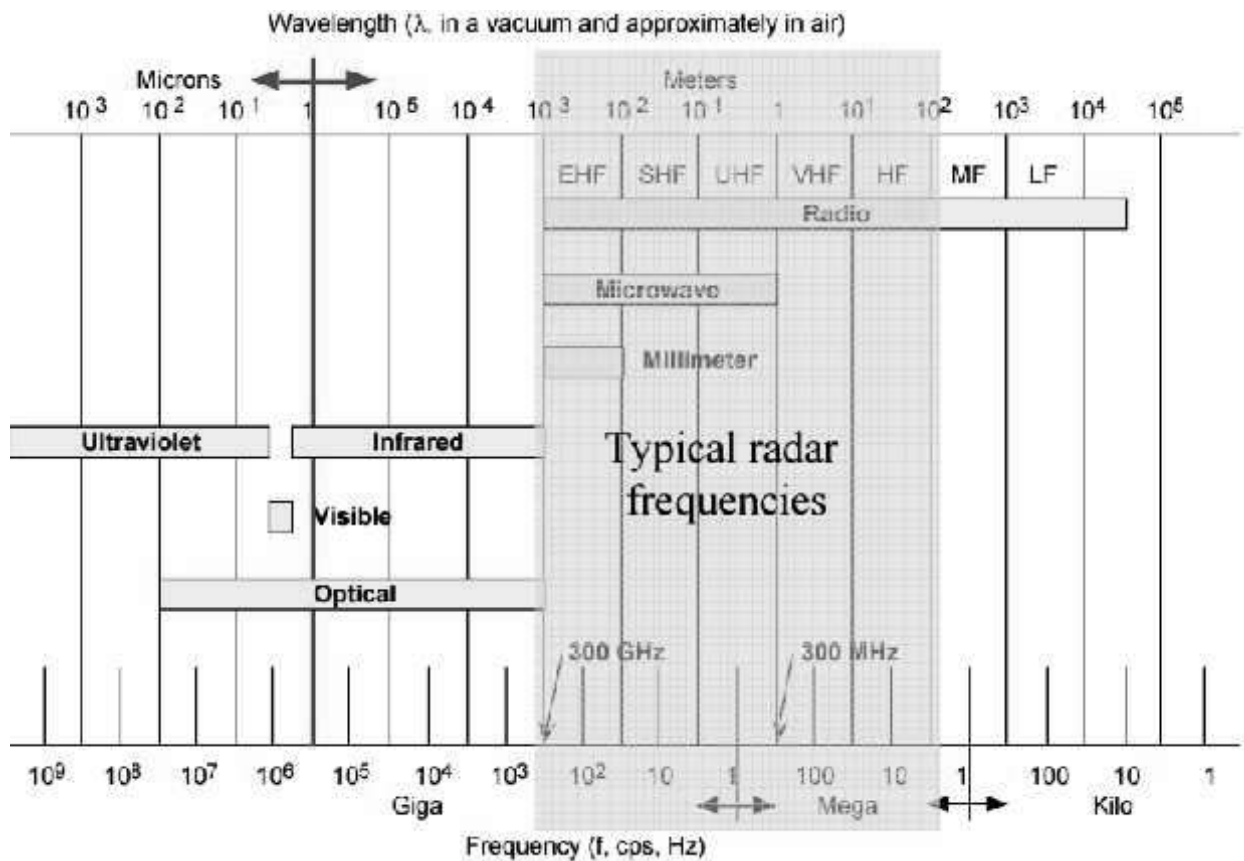


Fig. 3.3 Frequency spectrum for radar frequencies

Table 3.1 lists the radar-frequency letter-band nomenclature adopted by the IEEE. These are related to the specific bands assigned by the International Telecommunications Union for radar. For example, although the nominal frequency range for L band is 1000 to 2000 MHz, an L-band

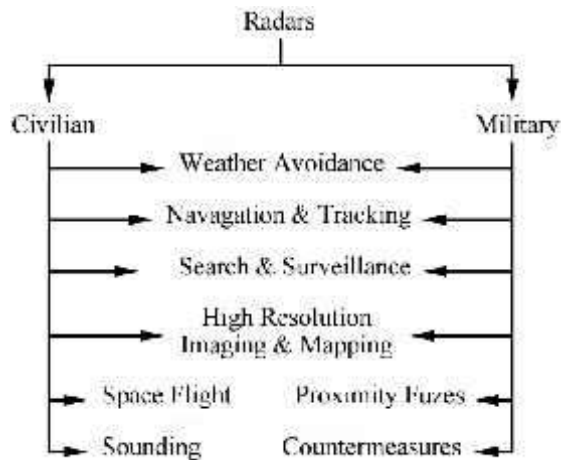
radar is thought of as being confined within the region from 1215 to 1400 MHz since that is the extent of the assigned band.

Table 3.1 Radar Bands and their Usage

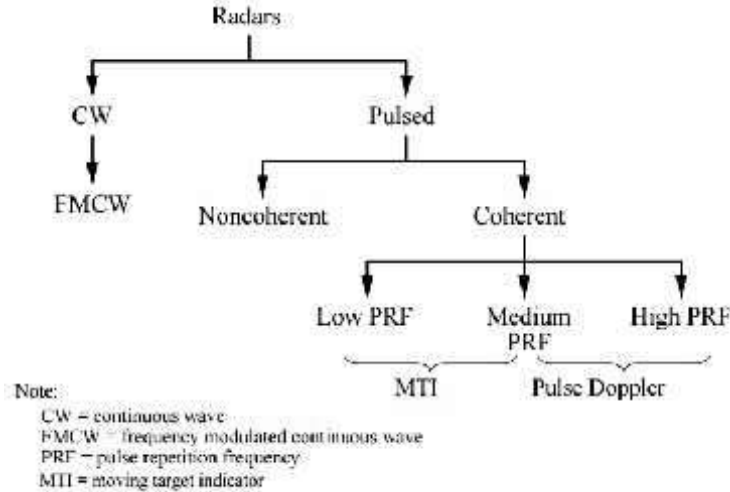
Band Designation	Frequency Range	Usage
HF	3–30 MHz	OTH surveillance
VHF	30–300 MHz	Very-long-range surveillance
UHF	300–1.000 MHz	Very-long-range surveillance
L	1–2 GHz	Long-range surveillance En route traffic control
S	2–4 GHz	Moderate-range surveillance Terminal traffic control Long-range weather
C	4–8 GHz	Long-range tracking Airborne weather detection
X	8–12 GHz	Short-range tracking Missile guidance Mapping, marine radar Airborne intercept
K _u	12–18 GHz	High-resolution mapping Satellite altimetry
K	18–27 GHz	Little use (water vapor)
K _a	27–40 GHz	Very-high-resolution mapping Airport surveillance
millimeter	40–100+ GHz	Experimental

3.4 Radar classification

Radar can be classified based on the function and the waveforms



(a)



(b)

Fig. 3.3 Radar can be classified based on the (a) function and (b) waveforms

In practice, however, the simple radar equation does not predict the range performance of actual radar equipments to a satisfactory degree of accuracy. The predicted values of radar range are usually optimistic. In some cases the actual range might be only half that predicted. Part of this discrepancy is due to the failure of Eq. (3.10) to explicitly include the various losses that can occur throughout the system or the loss in performance usually experienced when electronic equipment is operated in the field rather than under laboratory-type conditions & another important factor that must be considered in the radar equation is the statistical or unpredictable nature of several of the parameters. The minimum detectable signal S_{min} and the target cross section (σ) are both statistical in nature and must be expressed in statistical terms.

3.5 MINIMUM DETECTABLE SIGNAL

The ability of a radar receiver to detect a weak echo signal is limited by the noise energy that occupies the same portion of the frequency spectrum as does the signal energy. The weakest signal the receiver can detect is called the minimum detectable signal. The specification of the minimum detectable signal is sometimes difficult because of its statistical nature and because the criterion for deciding whether a target is present or not may not be too well defined.

Detection is based on establishing a threshold level at the output of the receiver. If the Receiver output exceeds the threshold, a signal is assumed to be present. This is called threshold detection.

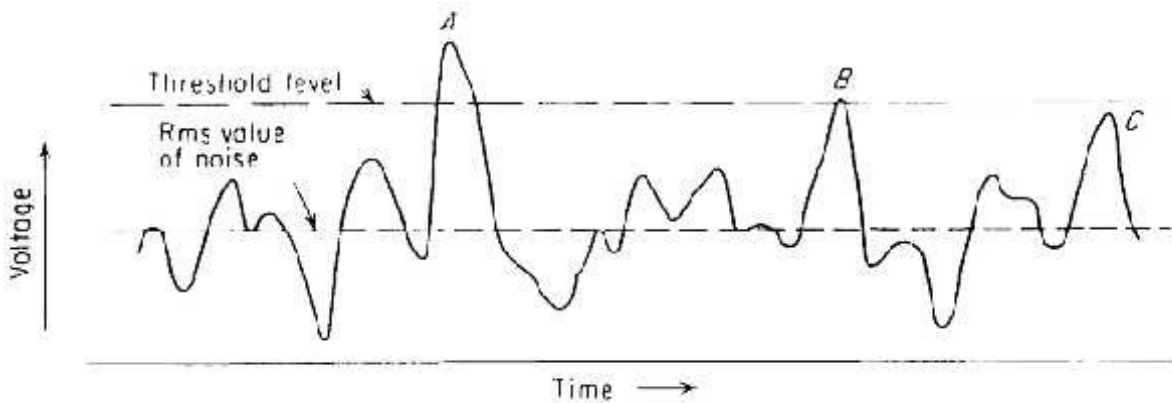


Fig. 3.4 Typical envelope of the radar receiver output as a function of time. A, and B, and C represent signal plus noise. A and B would be valid detections, but C is a missed detection.

A target is said to be detected if the envelope crosses the threshold. If the signal is large such as at A, it is not difficult to decide that a target is present. But consider the two signals at B and C, representing target echoes of equal amplitude. The noise voltage accompanying the signal at B is large enough so that the combination of signal plus noise exceeds the threshold.

Weak signals such as C would not be lost if the threshold level were lower. But too low a threshold increases the likelihood that noise alone will rise above the threshold and be taken for a real signal. Such an occurrence is called a false alarm.

CHAPTER 4: CONTINUOUS WAVE AND FREQUENCY MODULATED RADAR

4.1 THE DOPPLER EFFECT

It is well known in the fields of optics and acoustics that if either the source of oscillation or the observer of the oscillation is in motion, an apparent shift in frequency will result. This is the doppler effect and is the basis of CW radar.

If R is the distance from the radar to target, the total number of wavelengths (λ) contained in the two-way path between the radar and the target is $2R/\lambda$. The distance R and the wavelength (λ), are assumed to be measured in the same units. Since one wavelength corresponds to an angular excursion of 2π radians, the total angular excursion ϕ made by the electromagnetic wave during its transit to and from the target is $4\pi R / \lambda$.

If target is in motion the range R and phase ϕ is continually changing. Thus the change in phase with respect to time can be given as frequency.

$$\frac{d\phi}{dt} = \frac{4\pi}{\lambda} \frac{dR}{dt} \quad \dots (1)$$

Range with respect to time can be defined as the radial velocity of the target. Thus the Doppler angular frequency can be given as:

$$\omega_d = 2\pi f_d = \frac{4\pi}{\lambda} v_r \quad \dots (2)$$

Where f_d is Doppler frequency and v_r is the radial velocity of the target with respect to radar. The Doppler frequency can be related with transmitter frequency f_0 .

$$f_d = \frac{2v_r}{\lambda} = \frac{2v_r f_0}{c} \quad \dots (3)$$

When v_r is given in knots then the Doppler frequency can be given as:

$$f_d = \frac{1.03v_r (knots)}{\lambda(m)} \quad \dots (4)$$

The relative velocity may be written $v_r = v \cos\theta$ where v is the target speed and θ is the Angle made by the target trajectory and the line joining radar and target. When $\theta = 0$, the doppler frequency is maximum. The doppler is zero when the trajectory is perpendicular to the radar line of sight ($\theta = 90^\circ$).

A plot of doppler frequency shifts as a function of radial velocity and the radar frequency bands is given in fig. 4.2. This figure illustrates that as the target radial velocity get increases the Doppler frequency shifts get increases with higher radar frequencies.

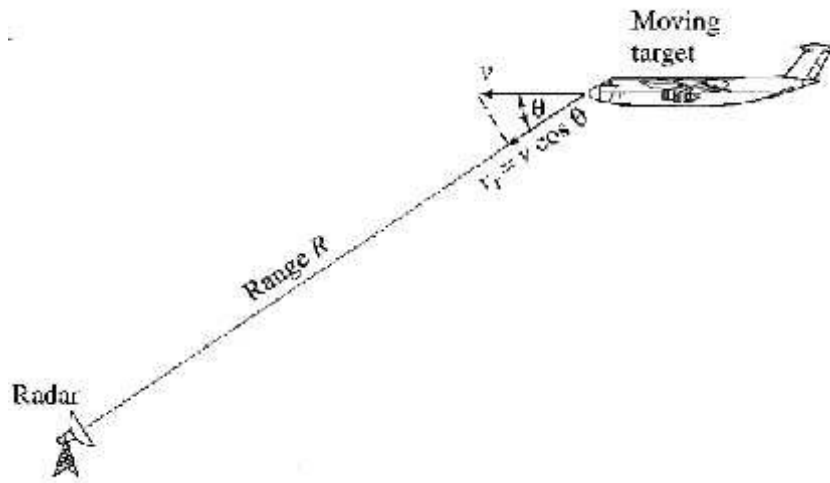


Fig. 4.1 Geometry of Radar and target in deriving the Doppler shifts

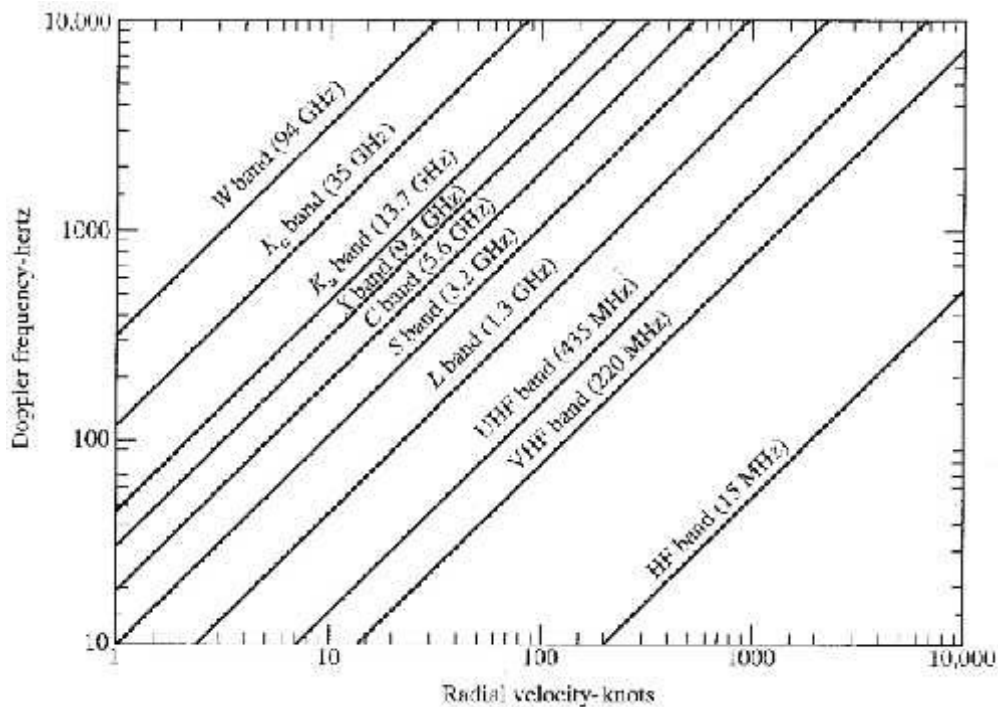


Fig. 4.2 Doppler frequency shifts for a moving target as a function of v_r and radar frequency band.

4.2 Continuous Wave Radar (CW Radar):-

A block diagram of simple CW radar is shown in Fig. 4.3. The transmitter generates a continuous (unmodulated) oscillation of frequency f_0 , which is radiated by the antenna. A portion of the radiated energy is intercepted by the target and is scattered, some of it in the direction of the radar, where it is collected by the receiving antenna.

If the target is in motion with a velocity v_r relative to the radar, the received signal will be shifted in frequency from the transmitted frequency f_0 by an amount $\pm f_d$ as given by Eq. (4).

- The plus sign associated with the doppler frequency applies if the distance between target and radar is decreasing (closing target), that is, when the received signal frequency is greater than the transmitted signal frequency.
- The minus sign applies if the distance is increasing (receding target).

The received echo signal at a frequency $f_0 \pm f_d$ enters the radar via the antenna and is heterodyned in the detector (mixer) with a portion of the transmitter signal/o to produce a doppler beat note of frequency f_d . The sign f_d is lost in this process.

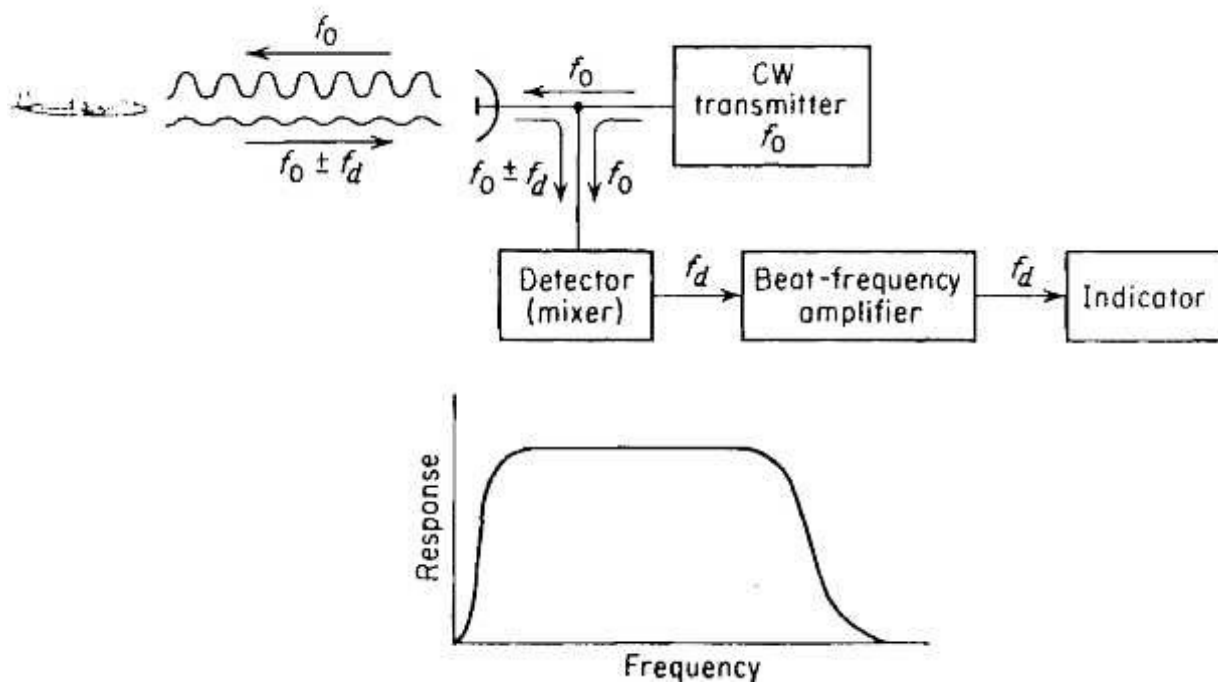


Fig. 4.3 CW Radar with frequency response

Pulse Radar: Pulse radar that extracts the Doppler frequency-shifted echo signal. A simple way to convert the CW radar to the pulse radar by turning on and off CW oscillator to generate pulses. This way of generation of pulses removes the reference signal, which is required to recognize the Doppler shifts. One way to introduce the reference signal is shown in fig. 4.4. Here the power amplifier is turned on and off to generate the high power pulses. The received echo signal is mixed with the output of CW oscillator, which acts as coherent reference to allow the recognition of any change in the frequency. Here coherent means that the transmitted pulses are synchronously used as reference signal. The change in frequency is detected through Doppler filter.

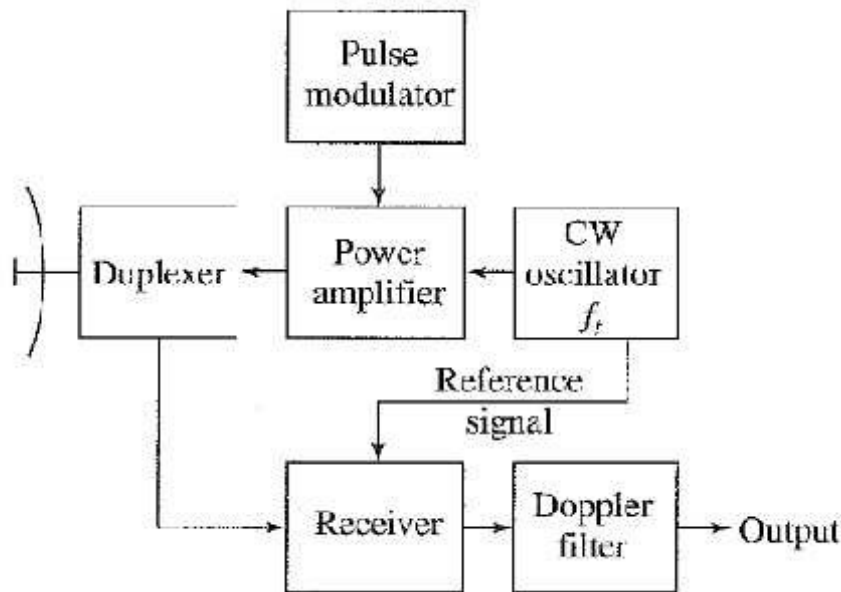


Fig. 4.4 Block diagram of simple Pulse Radar

Sweep to sweep subtraction:

The bipolar video (signal has positive and negative values) from two successive sweeps of MTI radar is shown in fig. 4.5. If one sweep is subtracted from the previous sweep, fixed clutter echoes will get cancel, and will not be detected. On the other hand, moving target change its amplitude from sweep to sweep due to the Doppler frequency shift. If one sweep is subtracted from another, the result will be canceled residue as shown in fig. 3.5.

Subtraction of the echoes from two successive sweeps is accomplished in delay line cancellers as shown in fig. 4.6. The delay-line canceller acts as a filter to eliminate the dc component of fixed targets and to pass the a-c components of moving targets. The video portion

of the receiver is divided into two channels. One is a normal video channel. In the other, the video signal experiences a time delay equal to one pulse-repetition period (equal to the reciprocal of the pulse-repetition frequency). The outputs from the two channels are subtracted from one another. The fixed targets with unchanging amplitudes from pulse to pulse are canceled on subtraction.

However, the amplitudes of the moving-target echoes are not constant from pulse to pulse, and subtraction results in an uncanceled residue.

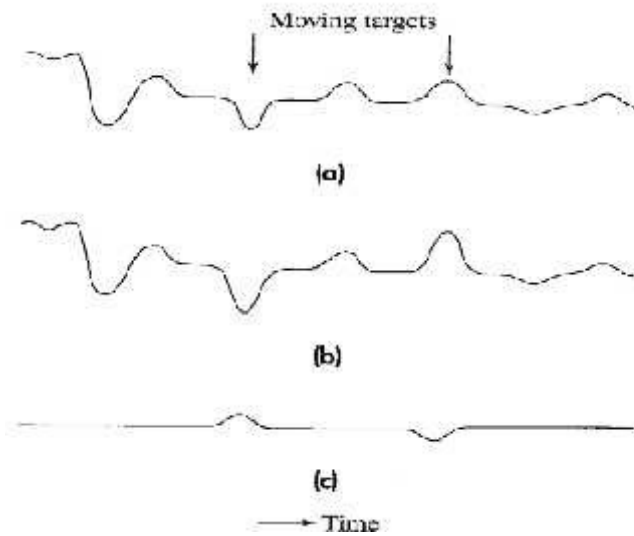


Fig. 4.5 Sweep to sweep subtraction

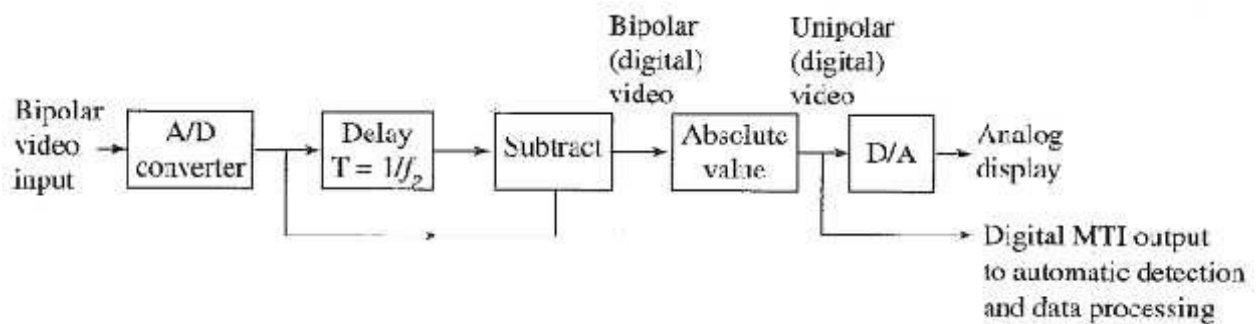


Fig. 4.6 Block diagram of single delay line canceller

MTI Radar Block Diagram:-

The doppler frequency shift [Eq. (3.2)] produced by a moving target may be used in a pulse radar. just as in the CW radar discussed in Chap. 3, to determine the relative velocity of a target

or to separate desired moving targets from undesired stationary objects (clutter). Such a pulse radar that utilizes the doppler frequency shift as a means for discriminating moving from fixed targets is called an MTI (moving target indication) or a pulse doppler radar.

The block diagram of a more common MTI radar employing a power amplifier is shown in Fig. 4.5. The significant difference between this MTI configuration is the manner in which the reference signal is generated. In Fig. 4.7, the coherent reference is supplied by an oscillator called the coho, which stands for coherent oscillator.

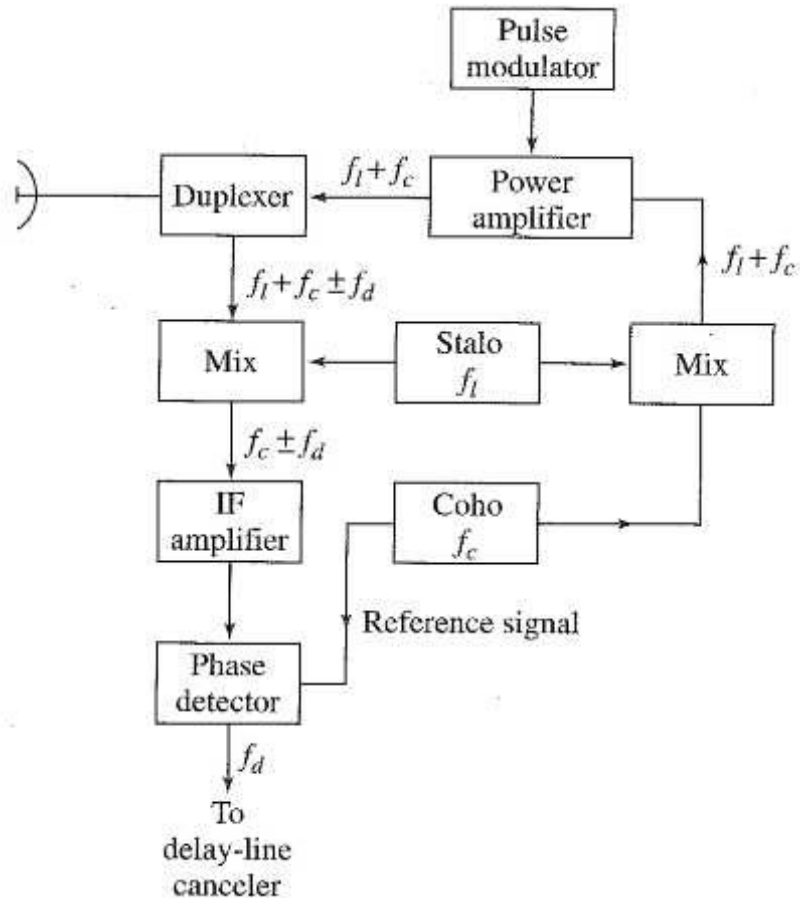


Fig. 4.7 Block diagram of MTI radar with power-amplifier transmitter

- The coho is a stable oscillator whose frequency is the same as the intermediate frequency used in the receiver. In addition to providing the reference signal, the output of the coho, f_c is also mixed with the local-oscillator frequency f_l .
- The local oscillator must also be a stable oscillator and is called stalo, for stable local oscillator.

- The stalo, coho, and the mixer in which they are combined plus any low-level amplification are called the receiver-exciter because of the dual role they serve in both the receiver and the transmitter.
- The characteristic feature of coherent MTI radar is that the transmitted signal must be coherent (in phase) with the reference signal in the receiver.
- The reference signal from the coho and the I F echo signal are both fed into a mixer called the phase detector. The phase detector differs from the normal amplitude detector since its output is proportional to the phase difference between the two input signals.

Delay Line Cancellor:-

The simple MTI delay-line canceller shown in Fig. 4.6 is an example of a time-domain filter. The capability of this device depends on the quality of the medium used as the delay line. The delay line must introduce a time delay equal to the pulse repetition interval. For typical ground-based air-surveillance radars this might be several milliseconds. Delay times of this magnitude cannot be achieved with practical electromagnetic transmission lines. By converting the electromagnetic signal to an acoustic signal it is possible to utilize delay lines of a delay line must introduce a time delay equal.

One of the advantages of a time-domain delay-line canceler as compared to the more conventional frequency-domain filter is that a single network operates at all ranges and does not require a separate filter for each range resolution cell. Frequency-domain doppler filter banks are of interest in some forms of MTI and pulse-doppler radar.

Frequency Response of Delay Line canceller

The delay-line canceler acts as a filter which rejects the d-c component of clutter. Because of its periodic nature, the filter also rejects energy in the vicinity of the pulse repetition frequency and its harmonics.

The signal from a target at range R_0 , the output of the phase detector can be given as:

$$V_1 = k \sin(2\pi f_d t - \phi_0) \quad \dots (5)$$

Where f_d is Doppler frequency, ϕ_0 constant phase of $4\pi R_0 / \lambda$. The signal from the previous radar transmission is similar, which is delayed by time T_p

$$V_2 = k \sin[2\pi f_d (t - T_p) - \phi_0] \quad \dots (6)$$

Everything else is assumed to remain essentially constant over the interval T_p so that k is the same for both pulses. The output from the subtractor is

$$V = V_1 - V_2 = 2k \sin(\pi f_d T_p) \cos\left[2\pi f_d \left(t - \frac{T_p}{2}\right) - \phi_0\right] \quad \dots (7)$$

The magnitude of the relative frequency-response of the delay-line canceler [ratio of the amplitude of the output from the delay-line canceler, $2k \sin(\pi f_d T_p)$, to the amplitude of the normal radar video k] is shown in Fig. 4.8.

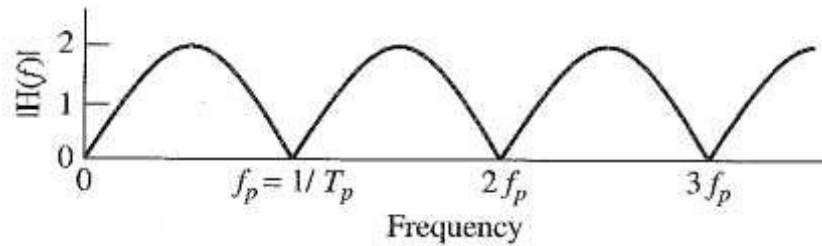


Fig. 4.8 Frequency response of the single delay-line canceler; T = delay time = $1/f_p$

Blind Speed:-

The response of the single-delay-line canceler will be zero whenever the argument $\pi f_d T_p$ in the amplitude factor of Eq. (7) is $0, \pi, 2\pi, \dots$, etc., or when

$$f_d = \frac{2V_r}{\lambda} = \frac{n}{T_p} = n f_p \quad n = 0, 1, 2, 3, \dots \quad \dots (8)$$

The delay-line canceler not only eliminates the d-c component caused by clutter ($n = 0$), but unfortunately it also rejects any moving target whose doppler frequency happens to be the same as the prf or a multiple there of. Those relative target velocities which result in zero MTI response are called blind speed and can be given as:

$$v_n = \frac{n\lambda}{2T_p} = \frac{n\lambda f_p}{2} \quad n = 0, 1, 2, 3, \dots \quad \dots (9)$$

where v_n is the nth blind speed. If λ is measured in meters, f_p in Hz, and the relative velocity in knots, the blind speeds are

$$v_n = \frac{n\lambda f_p}{1.02} \approx n\lambda f_p \quad \dots (10)$$

The blind speeds are one of the limitations of pulse MTI radar which do not occur with CW radar. They are present in pulse radar because doppler is measured by discrete samples (pulses) at the prf rather than continuously.

Pulse Doppler Radar:-

A pulse radar that extracts the doppler frequency shift for the purpose of detecting moving targets in the presence of clutter is either an MTI radar or a pulse doppler radar.

The distinction between them is based on the fact that in a sampled measurement system like a pulse radar, ambiguities can arise in both the doppler frequency (relative velocity) and the range (time delay) measurements. Range ambiguities are avoided with a low sampling rate (low pulse repetition frequency), and doppler frequency ambiguities are avoided with a high sampling rate. However, in most radar applications the sampling rate, or pulse repetition frequency, cannot be selected to avoid both types of measurement ambiguities.

The pulse doppler radar is more likely to use range-gated doppler filter-banks than delay-line cancelers. Also, a power amplifier such as a klystron is more likely to be used than a delay-line cancelers. A pulse doppler radar operates at a higher duty cycle than does an MTI. Although it is difficult to generalize, the MTI radar seems to be the more widely used of the two, but pulse doppler is usually more capable of reducing clutter. .

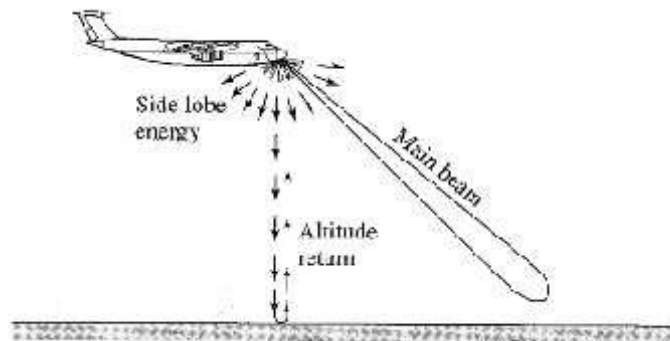


Fig. 4.9 Sketch of airborne Pulse Doppler radar

- A radar that increases its prf high enough to avoid the problems of blind speeds is called as Pulse radar.
- A high-prf pulsed Doppler radar is one with no blind speeds within the Doppler space.
- A medium-prf pulsed Doppler radar is one that operates at slightly lower prf and accepts both range and Doppler ambiguities.
- A brief comparison between different Doppler pulse radar is given in table 4.1

Table. 4.1:- Comparison of different pulse Doppler radar

Radar	prf*	Duty Cycle*
X-band high-prf pulse doppler	100–300 kHz	< 0.5
X-band medium-prf pulse doppler	10–30 kHz	0.05
X-band low-prf pulse radar	1–3 kHz	0.005
UHF low-prf AMTI	300 Hz	Low

References

- 1- www.wikipedia.com
- 2- Introduction to Radar Systems by Merrill I. Skolnik, 3rd Edition, PHI Publications.

UNIT – I TELEVISION ENGINEERING

1.1 TV FUNDAMENTALS

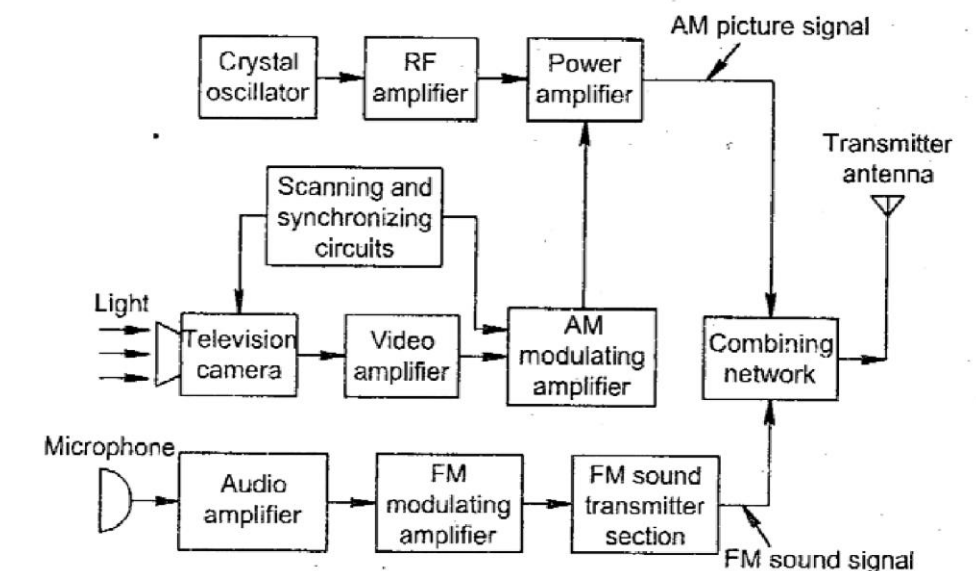
INTRODUCTION:

Television means Tele + Vision, i.e., Television is used to see the picture telecast from long distance.

In TV transmission both picture and sound are transmitted. For picture AM Modulation is used and for sound FM modulation is used.

1.1.1 BASIC BLOCK DIAGRAM OF TV TRANSMISSION:

The simplified block diagram of a Monochrome TV Transmitter is shown.



It consists of Television Camera, Video amplifier, AM Modulating amplifier, Audio amplifier, FM Modulating amplifier, FM sound transmitter, Crystal oscillator, RF amplifier, Power amplifier, Scanning and Synchronizing Circuits, Combining network, Transmitting antenna and Microphone.

- **TELEVISION CAMERA:**

Its function is to convert optical image of television scene into electrical signal by the scanning process.

- **VIDEO AMPLIFIER:**

Video amplifier amplifies the video signal.

- **AM MODULATING AMPLIFIER**

The video signals are amplified by the modulating amplifier to get the modulated signal.

- **AUDIO AMPLIFIER**

Audio amplifier amplifies the electrical form of audio signal from the microphone.

- **FM MODULATING AMPLIFIER:**

Sound signal from audio amplifier is frequency modulated by FM Modulating amplifier.

- **FM SOUND TRANSMITTER:**

FM modulated amplified signal is transmitted through this FM sound transmitter to transmitting antenna through the combining network.

- **CRYSTAL OSCILLATOR:**

Crystal Oscillator generates the allotted picture carrier frequency.

- **RF AMPLIFIER:**

RF amplifier amplifies the picture carrier frequency generated by crystal oscillator to required level.

- **POWER AMPLIFIER:**

Power amplifier varies according to the modulating signal from AM modulating amplifier.

1.1.2 SCANNING AND SYNCHRONIZING CIRCUITS

Scanning is the process where picture elements are converted into corresponding varying electrical signal

COMBINING NETWORK

Combining network is used to isolate the AM picture and FM sound signal during transmission.

TRANSMITTING ANTENNA:

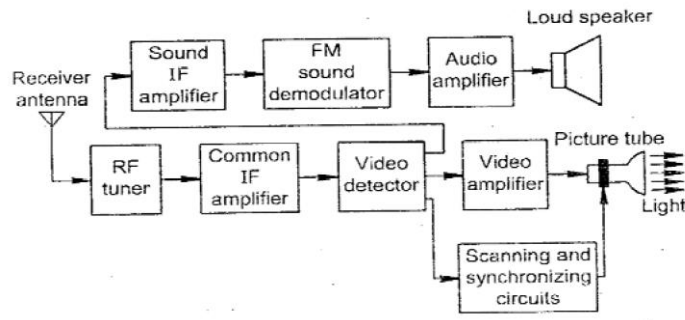
Transmitting antenna receives the AM picture signal and FM sound signal from combining network for radiation as electromagnetic waves.

MICROPHONE:

Converts sound associated with picture being televised into proportionate electrical signal.

1.1. 3 SIMPLE BLOCK DIAGRAM OF TV

RECEPTION BASIC MONOCHROME TV



RECEIVER

Block diagram of a monochrome TV receiver is shown. It consists of RF Tuner, Receiver antenna, common IF amplifier, video detector, video amplifier, scanning and synchronizing circuits, sound IF amplifier, FM Sound demodulator, Audio amplifier, Loud Speaker, Picture tube.

RF TUNER:

RF Tuner selects the desired channel frequency band from the receiving antenna.

RECEIVER ANTENNA:

Receiver antenna intercepts the radiated RF signals and sends it to RF Tuner.

COMMON IF AMPLIFIER:

There are 2 or 3 stages of IF amplifiers.

VIDEO DETECTOR:

Used to detect video signals coming from last stage of IF amplifiers.

VIDEO AMPLIFIER:

It amplifies the detected video signal to the level required.

SCANNING AND SYNCHRONIZING CIRCUITS:

Scanning is the process where picture elements are converted into corresponding varying electrical signals.

SOUND IF AMPLIFIER:

Detected audio signal is separated and selected for its IF range and amplified.

FM SOUND DEMODULATOR:

FM Sound signal is demodulated in this stage.

AUDIO AMPLIFIER:

FM demodulated audio signal is amplified to the required level to feed into the loud speaker.

LOUD SPEAKER:

Loud Speaker converts FM demodulated amplifier signal associated with picture being televised into proportionate sound signal.

PICTURE TUBE:

In picture tube the amplified video signal is converted back into picture elements.

SCANNING:

Scanning is the process used to convert the optical into electrical signal. Fastest movement of electron beam on the image is called scanning.

1.2 SCANNING PROCESS:

Scanning process is a technique similar to reading of written information on a page starting at the top left and processing line by line downwards to the end at the bottom right.

Scanning is done frame by frame. Each frame consists of 625 horizontal lines. Each frame is scanned at a rate of 25 frames / sec.

Scanning types,

1. Horizontal Scanning
2. Vertical Scanning
3. Sequential (or) Progressive Scanning
4. Interlaced Scanning.

1.3 HORIZONTAL SCANNING (H-SCANNING)

Movement of electron beam from left to right on the screen is known as trace period. When the beam returns quickly from right to left is called retrace or fly back.

Trace and retrace period together in horizontal direction is known as Horizontal Scanning.

$$\begin{aligned}\text{Horizontal frequency} &= \text{Number of lines in a Frame} * \text{Number of frames/sec} \\ &= 625 * 25 = 15,625 \text{ Hz}\end{aligned}$$

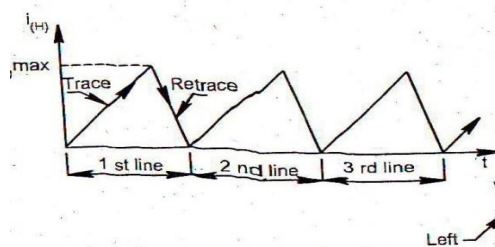
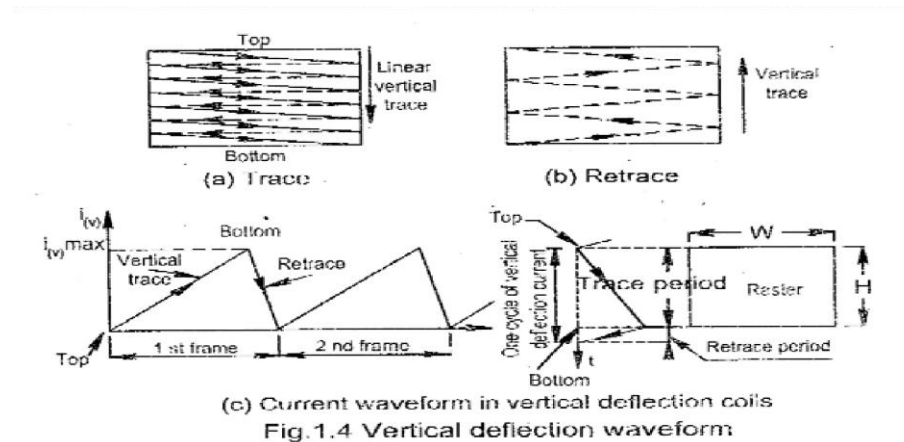


Fig.1.3 Waveform of horizontal deflection coils.

1.4 VERTICAL SCANNING (V – SCANNING)

Movement of electron beam in vertical direction. Movement of electron beam from top to bottom is called trace. Movement of beam from bottom to top of the frame is called retrace.

Vertical frequency = Number of frames /sec= 25 Hz



1.5 SEQUENTIAL (OR) PROGRESSIVE SCANNING:

Sequential or progressive Scanning is the process in which both horizontal and vertical directions are scanned simultaneously to provide complete pictures. Horizontal lines are scanned one by one. So complete picture will be scanned through this type.

1.6 FLICKER:

The sensation produced by incident light on the nerves of the eyes retina does not cease immediately. It persists for about $1/25^{\text{th}}$ of a second (.062 Sec.) This storage characteristic is called as persistence of vision of eye.

Flicker means if the scanning rate of picture is low, the time taken to move one frame to another frame will be high. This results in alternate bright and dark picture in the screen. This is called "Flicker".

To avoid flicker, the scanning rate of the picture should be increased i.e. 50 frames/Sec.

1.7 INTERLACED SCANNING:

To reduce flicker, the vertical scanning is done 50 times per second in TV system. However only 25 frames are scanned per sec.

In interlaced scanning the 625 lines are grouped into two fields. They are called as even field and odd field. Each field contains 312.5 lines. Even field contains even numbered lines and odd field contains odd numbered lines.

During first scanning line numbers 1, 3, 5 are scanned. During next scan, line numbers 2, 4, 6.... are scanned. That is alternate lines are scanned every time. So to cover each frame, scanning is

done two times. Here the vertical rate of scanning is increased twice. So it will reduce flicker.

Interlaced scanning is shown. Now the vertical frequency is 50 Hz. But there is no change in horizontal frequency.

$$\begin{aligned}\text{Horizontal frequency} &= \text{Number of lines in a Frame} * \text{Number of frames/sec} \\ &= 312.5 * 50 = 15,625 \text{ Hz}\end{aligned}$$

1.7.1 SCANNING PERIODS:

Useful video signals are obtained during the trace period only. So the trace time is larger than the retrace time.

HORIZONTAL:

$$\text{Tracing} = 52 \mu\text{s}$$

$$\text{Retracing} = 12 \mu\text{s}$$

$$\text{Total time period} = 64 \mu\text{s}.$$

VERTICAL:

$$\text{Tracing} = 18.722\text{ms}$$

$$\text{Retracing} = 1.27\text{ms}$$

$$\text{Total time period} = 20\text{ms}.$$

$$\text{Horizontal frequency} = 15,625 \text{ Hz}$$

$$\text{Horizontal time} = \frac{1}{T} = \frac{1}{15,625} = 64\mu\text{s}.$$

$$\text{Vertical Frequency} = 50 \text{ Hz Vertical Time}$$

$$= \frac{1}{50} = 20 \text{ ms}$$

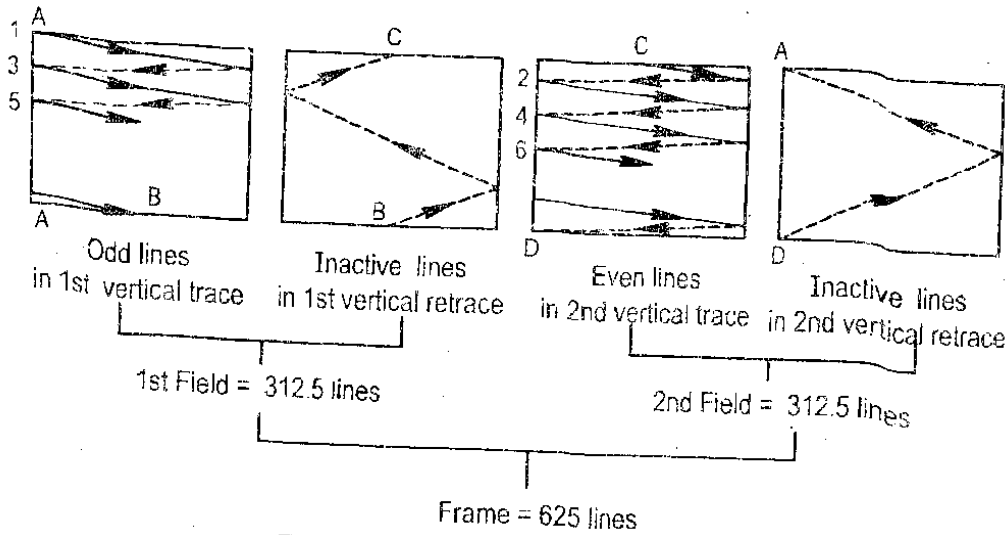
$$\text{Number of Horizontal lines lost during Vertical retrace} = \frac{\text{Vertical retrace time}}{\text{One horizontal time}}$$

$$= \frac{1.28 \text{ ms}}{64\mu\text{s}} = 20 \text{ lines}$$

So 20 lines are lost per field and in total 40 horizontal lines are lost during the scanning of each Frame.

Active number of lines (Na) = $625 - 40 = 585$ lines.

Detailed structure of interlaced scanning is shown. This is also called as 2: 1 interlaced scanning.



1.8 NEED FOR SYNCHRONIZATION:

At any time the same co-ordinate will be scanned by the electron beam in both the camera tube and picture tube. Otherwise distorted picture will be seen on the screen. So synchronization between the transmitter and receiver is needed. For that we are using Sync pulses.

At the receiver side these pulses are identified, separated and used for triggering the oscillator

circuit.

Horizontal Sync pulse time period	= $4.7 \mu\text{Sec.}$
Horizontal Sync pulse Frequency	= $15,625 \text{ Hz.}$
Vertical Sync pulse time period	= $160 \mu\text{Sec.}$
Vertical Sync pulse frequency	= 50 Hz.

1.9 BLANKING PULSES :

The video signal obtained during the horizontal and vertical retrace are not useful one. So there is no need to transmit them.

So to make the retrace signal invisible we are using blanking pulses. During horizontal blanking, horizontal retrace is blanked. This is 19% of horizontal time period.

$$\text{Horizontal blanking} = 64 * .19 = 12 \mu\text{Sec.}$$

Remaining 52 v Sec contains picture information and this is called as active line period. For a single line one blanking pulse is needed. So for 1 sec, 15,625 blanking pulses are needed.

In vertical retrace, for one frame two vertical blanking pulse is needed. So in 1 sec, 25 frames are scanned and so 50 V blanking pulses are needed.

$$\begin{aligned}\text{Vertical blanking} &= 20 H \\ &= 20 \times 64 \mu \text{ Sec.} = 1280 \mu \text{ Sec.}\end{aligned}$$

1.10 ASPECT RATIO:

The ratio between width to height of rectangle picture frame adopted in TV system is known as aspect ratio.

$$\text{Aspect ratio} = \frac{\text{Width}}{\text{Height}} = \frac{4}{3} \text{ or } 4:3$$

Reasons for having this ratio is,

1. Most of the objects are moving only in horizontal plane.
2. Our eye can see the movement of object comfortably only in horizontal plane than in vertical plane.
3. The frame size of motion picture already existing is having the aspect ratio of 4 : 3

1.11 HORIZONTAL AND VERTICAL RESOLUTION

The ability of the image reproducing system to resolve the fine details of the picture distinctly in both horizontal and vertical direction is called as “resolution”.

- **VERTICAL RESOLUTION:**

The ability to resolve and reproduce fine details of picture in vertical direction is called as Vertical resolution.

$$\begin{aligned} \text{Vertical resolution (VR)} &= \text{No. of active lines} * \text{Kell factor or resolution factor} \\ &= N_a * k = 585.69 = 400 \text{ Lines} \end{aligned}$$

- **HORIZONTAL RESOLUTION :**

The ability of the system to resolve maximum number of picture elements along the scanning determines the horizontal resolution.

$$\begin{aligned} \text{Horizontal resolution} &= \text{VR} * \text{Aspect ratio} \\ &= 400 * 4/3 = 534 \text{ Pixels} \end{aligned}$$

1.12 VIDEO BANDWIDTH :

$$\begin{aligned} \text{Video Bandwidth} &= \frac{\text{One horizontal line signal}}{\text{One horizontal line tracing}} \\ &= \frac{267}{52 * 10^{-6}} = 5 \text{ MHz} \end{aligned}$$

$$\text{Video Bandwidth} = \frac{\text{Horizontal Resolution}}{2 * \text{One Horizontal line scan}} = \frac{534}{2 * 52 * 10^{-6}} = 5 \text{ MHz}$$

1.13 POSITIVE AND NEGATIVE TRANSMISSION:

- **POSITIVE TRANSMISSION (POSITIVE MODULATION)**

In this type of transmission, if the brightness of picture increases, then video signal amplitude also increases. So peak white corresponds to 100% modulation level. And sync level corresponds to minimum level.

- **NEGATIVE TRANSMISSION (NEGATIVE MODULATION)**

In negative transmission, if the brightness of the picture increases, then video signal amplitude decreases. So the peak white corresponds to near zero level.

1.13.1 ADVANTAGES OF NEGATIVE TRANSMISSION:

1. Due to noise pulses, the video signal amplitude increases and produce black dots on the screen. This will create much low disturbance compared to white dots produced in positive modulation.
2. Since most of the video signal are white, the video signal is low and transmitted power is less.
3. The sync pulse level at 100% are used at the receiver as AGC reference levels.

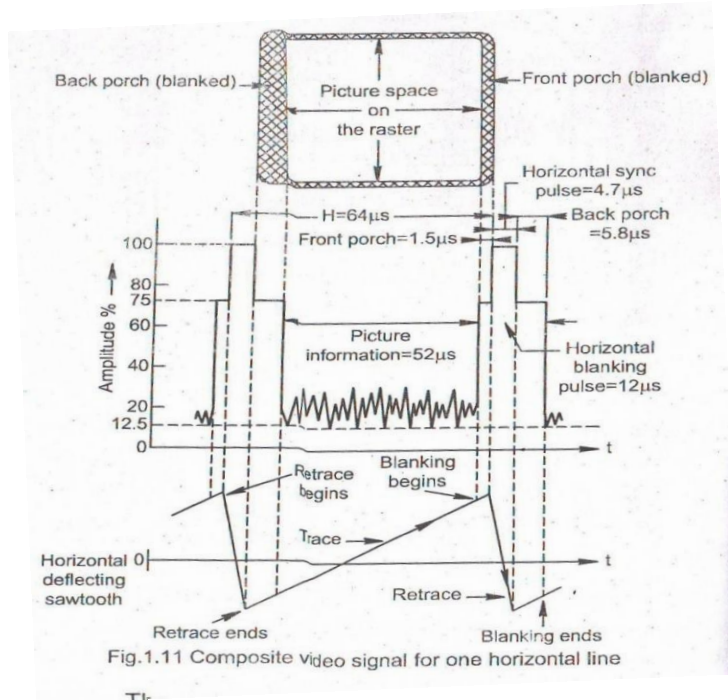
1.13.2 COMPARISON OF POSITIVE AND NEGATIVE TRANSMISSION

POSITIVE MODULATION	NEGATIVE MODULATION	PARTICULARS
White dots	Black dots	Noise
High	Low	Transmitting – power
Low	High	Efficiency
100%	10 %	White level
25%	75 %	Black level
28 %	78 %	Blanking level
0 %	100 %	Syno pulse level

1.14 COMPOSITE VIDEO SIGNAL (CVS)

CVS consists of,

- Camera signal corresponding to the picture to be transmitted.
- Blanking pulses to made the retrace invisible.
- Sync pulse to synchronize the transmitter and receiver.



Details, Total amplitude is 100%

Y-axis Amplitude:

Extreme White level = 10%

Tolerance $\pm 2.5\%$

Black level = 70 % amplitude. Blanking retrace period amplitude increase to 70 % . But actually, blanking pulse of amp 75 % used

Blanking Pulse = 75% amplitude

Sync Pulse = 75% to 100% amplitude

X- axis Time details

Horizontal tracing time = 52 v Sec.

Horizontal retracing time = 12 v Sec.

H – Sync pulse time = 4.7 v Sec.

Difference between black level and blanking level is called as Pedestal.

Average value of video signal is DC component. Distance between DC Component and pedestal is called as pedestal height.

- **FRONT PORCH:**

Rising edge of sync pulse and blanking does not coincide. The time difference between the raising edge of sync and blanking pulse is called as ‘Front Porch’. It is 1.5 vs, $\pm .34$ is tolerance. If front porch is not their sync. Pulse is build at varying fixed level and varying brightness level.

- **BACK PORCH:**

Difference between the failing edge of sync pulse and blanking pulse is called back porch.

1. It allows horizontal fly back.
2. Used as reference level to preserve DC component.
3. Used to send colour burst signal in colour Transmission.
4. Used as AGC reference level in receiver circuits.

1.15 VERTICAL SEPRATED SYNC PULSE:

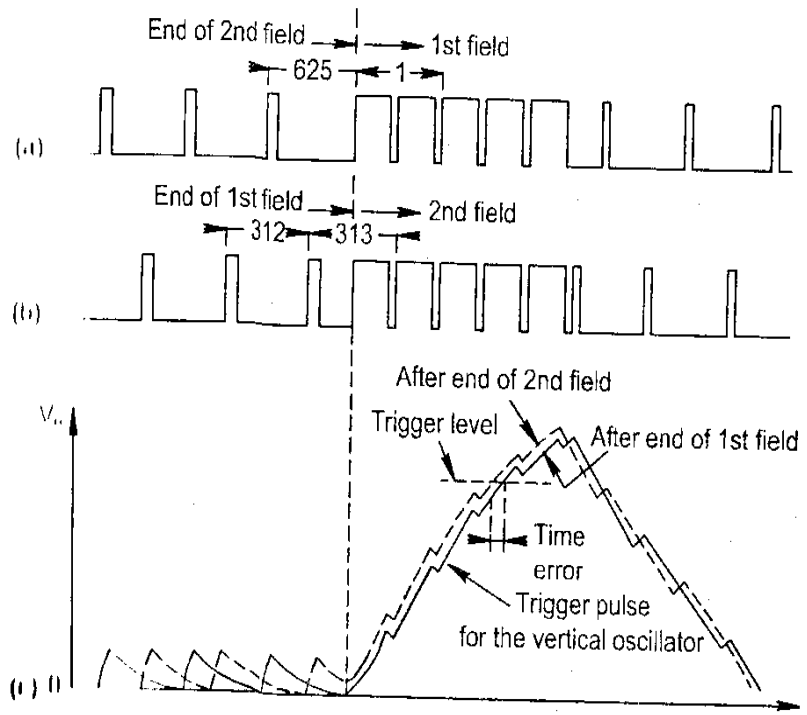


Fig 1.17 Integrating waveforms (a) pulses at the end of 2nd (even) field (b) pulses at the end of 1st (odd) field (c) integrator output.

Here, vertical sync pulse of duration 160 μ s is divided into 5 pulses of duration 32 μ s that too 4.7 μ s ON and 27.3 μ s OFF period. This process is called as “serration”. This 4.7 μ s ON is separated to have horizontal synchronization and it is given to differentiator the serrated pulses are given to integrator to get it as a single sync pulse.

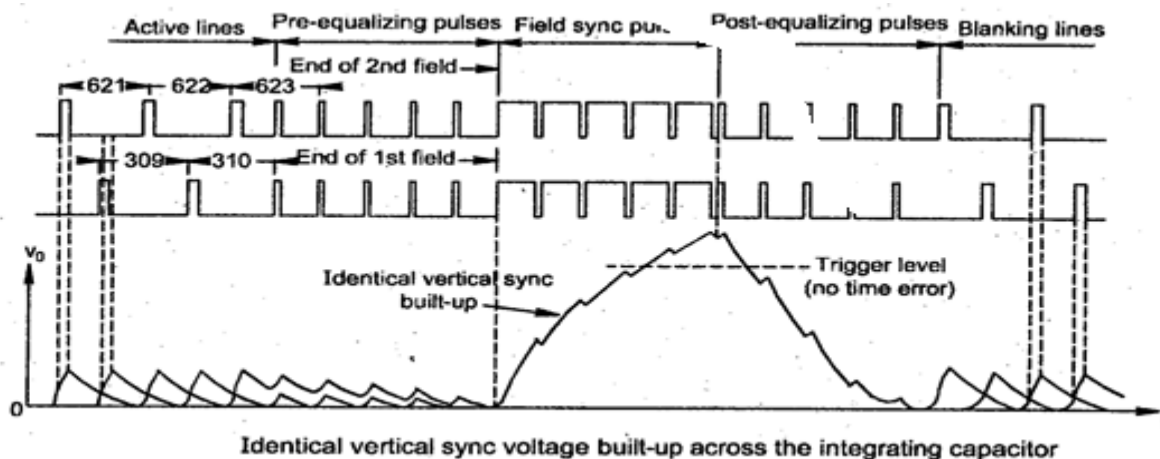
But here for odd and even fields there occurs time error due to trigger level in both fields. Because of charging and discharging of capacitor in the integrator.

The time error due to trigger level of fields is called as “Half line discrepancy” occurs. To avoid half line discrepancy we are adding the equalizing pulses.

Time error is because for second field in capacitor residual potential is zero. But for odd field, charging occurs of first field i.e., 312.5 lines. So there is some residual voltage and half line discrepancy occurs.

1.16 EQUALISING PULSES:

To avoid half line discrepancy due to time error in trigger level, equalizing pulses are used.



These pulses are having duration of 2.3 μ s ON period and 27.4 μ s OFF period. Due to these pulses time error is completely avoided. The pulses added before the vertical sync pulse are called as “pre-equalising pulse and that added after the vertical sync pulses are called as post equalising pulses. Since the pulses are having a short duration 2.3 μ s the capacitor is charged to only small value. So before the start of vertical sync, during both field the capacitor is discharged to zero level.

Similarly due to post-equalising pulses this capacitor is discharged quickly. If the discharge is slow than the trailing edge, of integrator may false trigger the oscillator. The structure of pre and post equalising pulses are shown.

1.17 LIST OF TV STANDARDS

- i) FCC (Federal Communication Commission)
- ii) NTSC (National Television system Committee)
- iii) CCIR (International Radio Consultative Committee)
- iv) SECAM (Sequential Couleures A Memory)

1.18 COLOUR TV FUNDAMENTALS:

In system we are sending only the luminance information. But in colour system we have to send information about the colours also. All colour TV system are based on the principle of our eye. Here wavelength unit is Angstrom. Visible spectrum – 4000 Å to 7000 Å.

$$1\text{Å} = 10^{-10}\text{m} \quad 1\text{nm} = 10\text{Å}$$

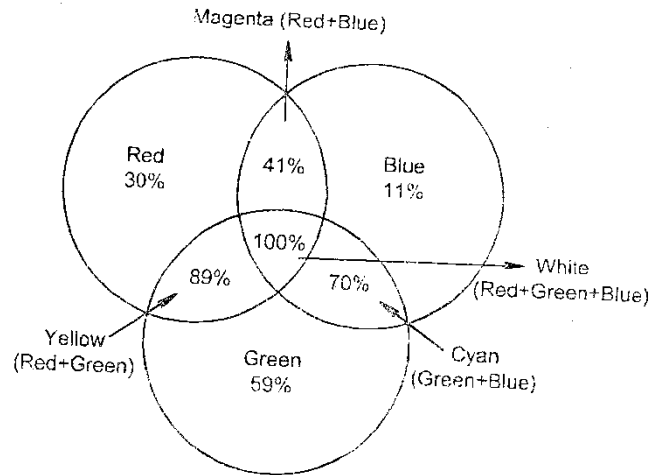
The three basic colors are called as primary colors. They are Red, Green and Blue. To get different color shading we have to mix primary colors. We have two types of mixing

1. Additive Mixing
2. Subtractive Mixing.

1.19 ADDITIVE MIXING:

In this method two or three primary colours are mixed together to form a new color. By mixing primary colours with different intensities we can obtain all types of colours.

Fig shows the method of additive mixing. By mixing 30% Red, 59% Green and 11% blue we can get white color



$$Y = 0\% + 59\%R + 11\%B$$

$$\text{Red} + \text{Blue} = \text{Magenta (41\%)}$$

$$\text{Blue} + \text{Green} = \text{Cyan (70\%)}$$

$$\text{Red} + \text{Green} = \text{yellow (89\%)}$$

1.20 COMPLEMENTARY COLOUR:

Color obtained by mixing only two primary colours is called as complementary colours.

Primary	Complementary
Red + Green	= Yellow
Red + Blue	= Magenta
Blue + Green	= Cyan

1.21 SUBTRACTIVE MIXING.

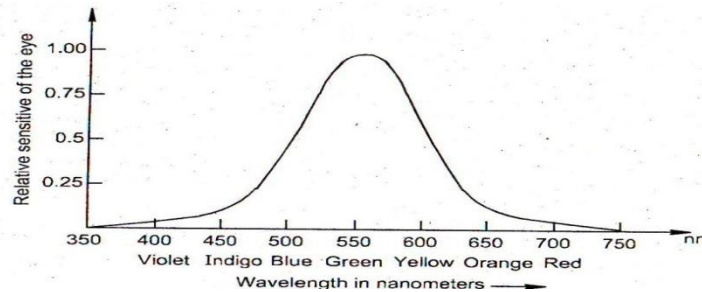
In Subtractive mixing, the reflecting properties of colour pigments are used. A colour pigment can absorb all the colour wavelength except its characteristic colour wavelength. Its characteristic colour frequency alone is reflected. If we are mixing two or three colour pigments, then a color wavelength common to them only reflected. This method of mixing is generally used in colour printing and colour painting. By mixing primary colours, black colour is got.

Different colours are obtained by subtracting primary and secondary colours from white. So this is called as subtractive mixing.

1.22 COLOUR PERCEPTION:

The retina on the backside of our eye has light sensitive organs. They can be able to sense the light variations. Also the retina is connected to optical centre of the brain optical nerves.

We have two types of light sensitive organs. They are called rods and cones. Rods are used to identify brightness variations. Cones are used to identify color information. The colours are transferred to optical nerves. They are then mixed together to identify the original colour.



1.23 CHROMATICITY DIAGRAM:

Chrominance or chromaticity diagram is a graphical representation of primary colours and all other colours in a space co-ordinate. Based on principle of tristimulus value, white color is formed by mixing 30% red, 59% green and 11% blue.

Below Fig is a two dimension graph representing hue and saturation on x-y plane. In 3D representation 2 axis is used to identify the brightness of the color.

Chromaticity diagram is in shape of horse shoe. On the three corners we have primary colours and on perimeter different colours are available. On moving towards centre pure colours are mixed with white and desaturated. Point 'C' represents white color. This point is at co-ordinate of $x = 31$, $y = .32$. Sunlight, sky light and day light are all different forms of white light.

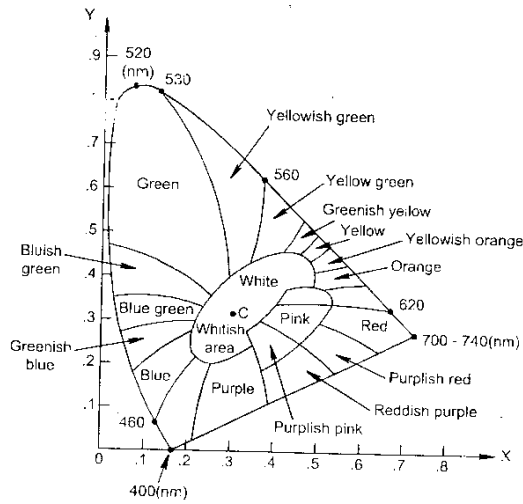
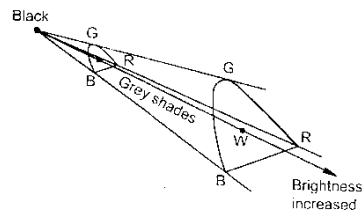


Fig.1.18(a) Chromaticity diagram.



1.23.1 ADVANTAGES:

Using this diagram we can identify the color obtained by additive mixing process. If bright increases, Z axis also increase and chrominance diagram becomes enlarged in 3D representation.

1.24 LUMINANCE, HUE AND SATURATION:

All the colours are having the following three characteristics. 1. Hue, 2. Saturation, 3.Luminance.

- **LUMINANCE:**

It is the amount of light intensity as perceived by the eye regardless of the colour. It is also called as brightness signal, y signal, and white signal.

- **HUE (TINT)**

It is the predominant spectral colour. For example, green leaf has a green hue and red apple has red hue.

- **SATURATION:**

It will indicate the spectral purify of colour. i.e., it will indicate how much white mixed with a particular colour.

- **CHROMINANCE:**

Hue and Saturation together are called as chrominance or chroma signal.

1.25 FORMATION OF CHROMINANCE SIGNAL IN PAL SYSTEM WITH WEIGHTING

FACTOR:

PAL system u or v signals.

$$U = .44 B - .29G - .15 R$$

$$V = .61R - .52G - .1B$$

Es: Yellow colour,

$$y = R + G$$

$$U = -.29 + (-.15)$$

$$= -.44$$

$$V = .61 + (-.52) = .09$$

Yellow colour chrominance signal

$$C = \sqrt{u^2 + v^2}$$

$$= \sqrt{(-.44)^2 + (.09)^2}$$

$$C = \pm .44$$

Yellow colour y signal value,

$$y = R + G$$

$$= .3 + .59 = .89$$

Table of PAL system.

S.No.	Colour	Basic Colour	Y	U	V	C
1.	White	R1G1B	1	0	0	0
2.	Yellow	R14	.89	-.44	.09	±.44
3.	Cyan	G1B	0.7	.15	-.6	±.63
4.	Green	G	0.59	-.29	-.52	±.59
5.	Magenta	R. 4	.41	.29	.51	±.59
6.	Red	R	.3	-.15	.61	±.63
7.	Blue	B	.11	.44	.1	±.44
8.	Black	-	0	0	0	0

REVIEW QUESTIONS

PART-A

1. Define television (TV) or what is TV?
2. Define scanning.
3. Define scanning process.
4. Mention the value for horizontal frequency.
5. Mention the value for vertical frequency.
6. Define flicker.
7. How many number of horizontal lines lost during vertical retrace?
8. How many active lines are there in interlaced scanning?
9. List the value for H-sync pulse period.
10. List the value for V-sync pulse period.
11. Mention the H-sync pulse frequency.
12. Mention the v-sync pulse frequency.
13. Mention the H-blanking period.
14. Mention the v-blanking period.
15. What is the vertical resolution factor?
16. Define interlaced scanning.
17. Define resolution.
18. Mention video bandwidth frequency.
19. Define front porch.
20. Define back porch.
21. What is vertical serrated sync pulses?
22. What is serration?
23. What is half line discrepancy error?
24. Define equalizing pulse.
25. List some TV standards.
26. What is additive mixing?
27. What is subtractive mixing?
28. What is color perception?
29. List out the advantage of chromaticity.
30. Define luminance.
31. Define Hue (tint).
32. Define saturation.

PART-B

1. Define video bandwidth.
2. Compare different TV standards.
3. What is horizontal scanning?
4. What is vertical scanning?
5. Explain sequential or progressive scanning.
6. Define blanking pulses.
7. Define aspect ratio.
8. Explain the reason for having this ratio as aspect ratio?
9. Define horizontal and vertical resolution.
10. Define positive and negative transmission.
11. Mention the advantage of negative transmission.
12. Compare positive and negative transmission.
13. Explain CVS?

PART – C

1. With neat block diagram explain the working of TV transmitter.
2. With neat block diagram explain the working of TV receiver.
3. Explain interlaced scanning in detail.
4. Explain the CVS for one horizontal line in detail.
5. With neat block diagram explain the working of vertical serrated sync pulses in detail.
6. With neat block diagram explain the working of equalizing pulses in detail.
7. Explain additive mixing.
8. Explain subtractive mixing.
9. Explain the chromaticity diagram in detail.

UNIT II

CAMERA AND PICTURE TUBES

2.1 CAMERA TUBES:

INTRODUCTION:

A camera tube is an important unit that is used to convert the optical image into electrical signal.

T.V. Camera tubes use photo emission or photo conduction principle for converting the optical source.

2.2 CHARACTERISTICS OF CAMERA TUBES:

1. LIGHT TRANSFER CHARACTERISTIC:

It gives the relation between light falling on the camera tube and the electrical current produced.

2. SPECTRAL RESPONSE:

It is the ability of the camera tube to response equally to all colours like the human eye.

3. SENSITIVITY:

Good camera tubes have high sensitivity. It is the ability to respond for even very low illumination.

4. DARK CURRENT:

Even if there is no illumination on the face plate of a camera tube, there is a small amount of signal, current flow in the output circuit. This current is called 'Dark Current'.

5. LAG CHARACTERISTICS:

It is the inability of photo sensitive layer to follow faster changes in illumination on the camera tube.

6. RESOLVING POWER:

Number of black and white lines of resolution in the picture increased the signal current produced is not able to full changes in the black and white level.

2.3 TYPES OF CAMERA TUBES:

1. BASED ON PRINCIPLE:

Three photo electric effects are used for converting variations of light intensity electrical variations.

1. Photo emissive camera tubes.
2. Photo conductive camera tubes.
3. Photo voltaic camera tubes.

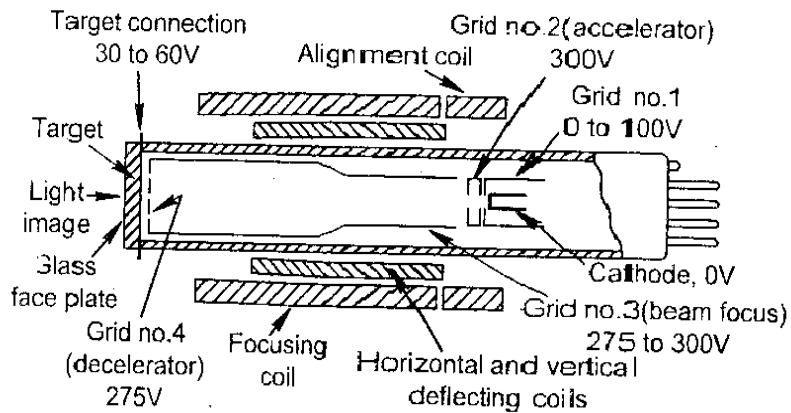
2. BASED ON TARGET PLATE :

1. Videocon
2. Plumbicon
3. Saticon
4. Newicon
5. Chalnicon
6. Silicon diode array.

2.4 VIDICON CAMERA TUBE

A small size camera tube that operate on the principle of Photo Conductivity.

• CONSTRUCTION:



TARGET PLATE OR FACE PLATE:

It consists of thin photo conductive layer of either selenium or antimony. This is deposited on transparent conducting film coated on inner surface of face plate. This conductive coating is known as signal electrode or plate.

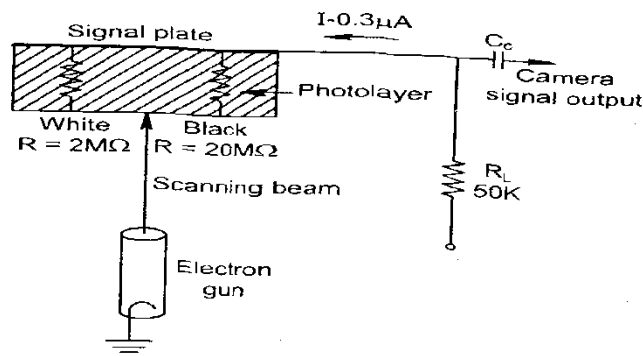
SCANNING SECTION:

Beam that emerges from the electron gun is focused on the surface of photo conductive layer by combined action of uniform magnetic field of an external coil and electrostatic field. Deflection is obtained by vertical and horizontal deflecting coils.

2.4.1 ELECTRON GUN SECTION:

Heater, Cathode, Control grid, focussing coils and accelerating anodes form the electron gun section. Focussing coils are used to focus e^{-} beam.

- **WORKING:**



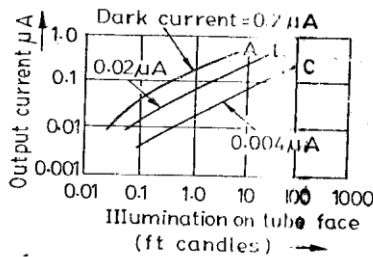
with light focused, the photon energy enables more electrons to go to conduction band and this reduces resistivity. When bright light falls on any area of photo conductive coating, resistance across the thickness of that portion gets reduced to about $2 * 10^6$. Thus with target, each point on sun side of photo layer assumes a certain potential with respect to dc supply, depending on its resistance to signal plate.

As electrons beam scans, sufficient number of electrons on photo layer reduce the potential towards zero potential. Remaining electrons are not deposited on target, return back and not utilized. However sudden changes in potential, while scan causes current flow producing varying voltage across

RL. The current in RL and Voltage across RL are directly proportional to light intensity variations on the scene. Video signal developed across RL is very small in amplitude. It is therefore amplified by amplifiers it leaves the camera tube.

2.4.2 LIGHT TRANSFER CHARACTERISTICS:

Each curve represents the characteristic curve of a particular dark current. By adjusting the target voltage, both dark current and sensitivity are increased.



ADVANTAGES:

1. High resolution
2. Long life, small size and low cost.
3. Gamma Cancellation circuit is not necessary.

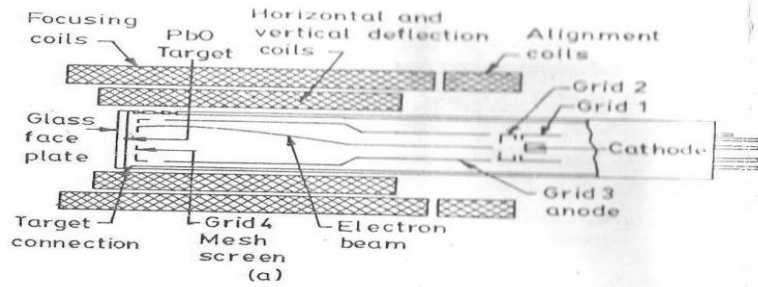
DISADVANTAGES:

1. High dark current.
2. Poor sensitivity
3. Image lag is more.

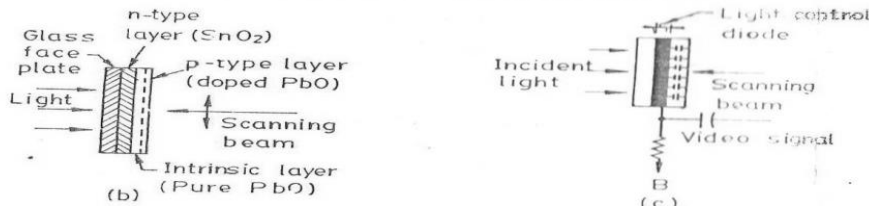
2.5 PLUMBICON

Many of the drawbacks of videocon tube are removed in plumbicon tube. It has very fast response and produces high quality pictures even at low light. It has small size and light weight.

- **CONSTRUCTION:**



a) Sectional view
Fig 2.6 Plumbicon camera tube



Construction is similar to vidicon except target plate and output signal.

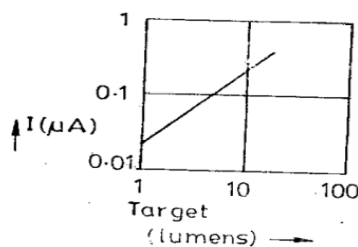
The target plate acts as a PIN semi conductor diode. The inner surface of glass plate is coated with a transparent conducting layer of SnO_2 .

- **PRINCIPLE OF WORKING:**

In plumbicon each element is considered as a capacitor in series with a reverse biased light dependent diode.

The conductive coating of SnO_2 is connected to a supply of 40V through a load resistor. The PIN diode is reverse biased and its resistance is high. So charge on capacitor is not discharged and no current flow. Whenever light is falling on target plate, the resistance of PIN diode decrease due to photo excitation of semi conductor junction. The current and output voltage taken across R_L is directly proportional to incident light intensity on target plate.

- **LIGHT TRANSFER CHARACTERISTICS:**



Output current Vs target illumination is shown. Here slope of response curve is higher than videocon tube. Spectral response is very close to that of human eye.

- **ADVANTAGES:**

1. Reduced lag.
2. Higher sensitivity.
3. Medium size and compact.

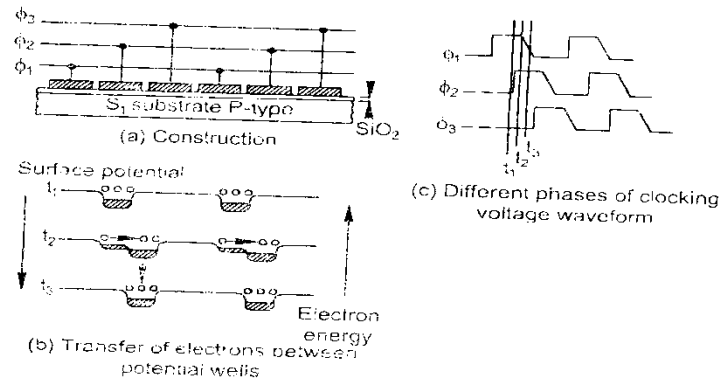
- **DISADVANTAGES**

1. High Cost
2. Spectral response in poor for red colour.

COMPARISON OF VARIOUS CAMERA TUBES

S.N	PARAMETERS	VIDEOCON	PLUMBICON	SATICON	NEWVICON	CHALNICON
1.	Photo electric conversion	Photo conductive	Photo conductive	Photo conductive	Photo conductive	Photo
2.	Material used in Target plate	Antimony or selenium compound	Tin oxide SnO ₂ + lead mono oxide + Pure PbO ₂	Selenium + Arsenic + Tellurium	Tin oxide + 2nse+znTe + CdTe+Sb ₂ S ₃ (a imoni tri sulphate)	Tin oxide + Cdse + cdsep ₃ +As ₂ s ₃
3.	Sensitivity	Good	Better	Good	Very high	Good
4.	Dark Current	High	Low	Low	High	Low
5.	Speed	Severe lag	Reduced Lag	High Lag	High lag	High Lag
6.	Resolution at 400 line (5MHz)	55 %	40-50%	High	High	High
7.	Spectral Response	Good	Poor in Red	Good	Good	Very Good
8.	Gamma	0.4 to 0.9	0.9 to 1	0.9 to 1	—	—
9.	Operation	Simple	Simple	Simple	Setting the target voltage is tedious.	Simple
10.	Cost	Cheaper	Costlier	Low cost	Medium	Medium
11.	Size	Small compact	Medium	Medium	Medium	Medium

2.6 CCD IMAGE SENSOR



These sensors are operating on the principal of charge coupled devices. Here a large number of CCD array are formed together to construct the image plate.

P-type substrate, a thin layer of silicon dioxide is formed. Then by masking and etching process, an array of metal electrodes are formed. Large number of smalls MOS capacitors are formed on the surface of the substrate. By the application of small positive potential at the gate, every third electron is connected to common conductor.

The spot under each metal electrode serve as a light sensitive element. These electrons are collected in the potential well and represent the optical image. The charge stored in one element is transferred to next element by applying more positive voltage to the next gate.

The charge movement takes place. Like this the charge is moved to the end. It is collected to form the signal current. The one dimensional array as explained about is used to represent one scanning line. These lines are independently addressed and output is read out using the address register and drive phases.

ADVANTAGE

1. Good image quality.
2. Not troubled by noise.
3. No need of electron gun and beam.

LIMITATIONS

1. Requires external processing unit.
2. Relatively high power consumption.
3. Expensive.

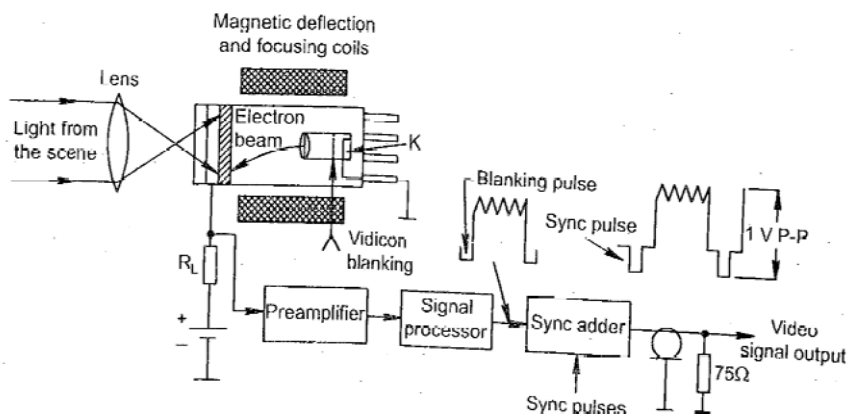
APPLICATION

1. Barcode scanners.
2. Cam coders.
3. Fax machine.

2.7 VIDEO PROCESSING OF CAMERA PICKUP SIGNAL

The optical image is focused by the lens on the glass face of target plate.

The lens regulates the light, by the iris build into the lens housing. The output of video signal is taken across the load resistor.



• IMPORTANT WORKS:

- Amplify the weak, low voltage signal from the load resistance R_L .
- Addition of blanking pulses.
- Addition of sync pulse.

The signal current or voltage across the load resistance R_L . So a pre-amplifier is used at the first stage. The output terminal of camera tube to avoid external interferences.

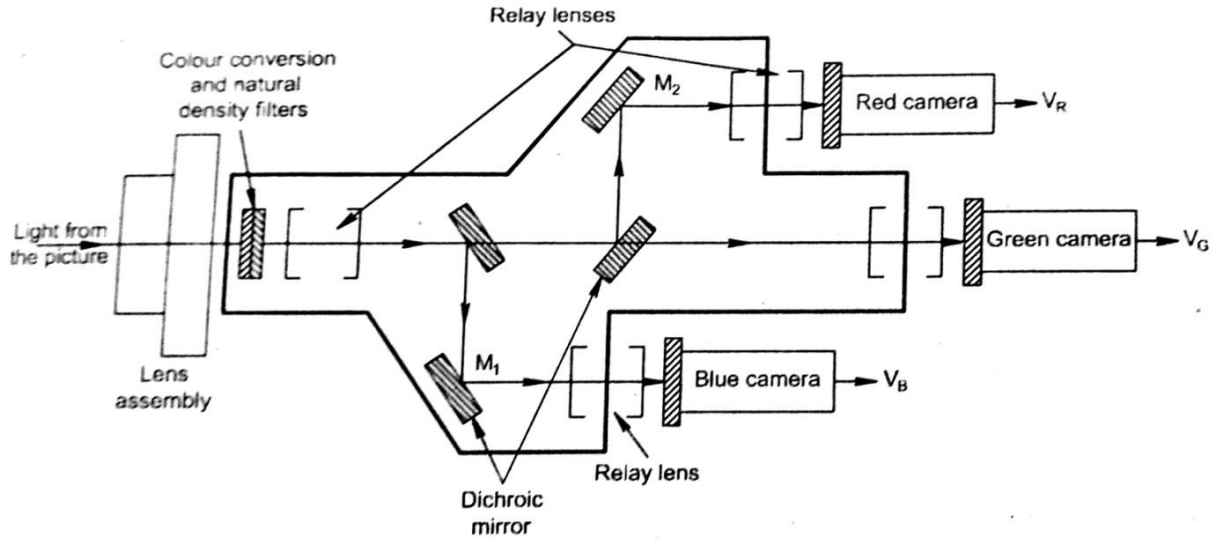
In second stage we are using signal processor to add a blanking Rise during the horizontal and vertical retrace intervals.

Sync adder circuit is used to add the synchronizing pulses. The output waveform has a voltage of about 1V p-p across 75 ohms as shown.

That is located at some distance from the Camera.

2.8 PRINCIPLE OF WORKING & BLOCK DIAGRAM OF COLOUR TV CAMERA

A colour camera tube is used to split the optical image into primary colours. A special type of mirror called dichroic mirror is used.



That is red dichroic mirror reflect red colour and allow other colours to pass through it. The scene is focused by the zoom lens package on the dichroic mirror setup. Then they are passed through the colour filters. These filters can provide precise primary colour images. Each camera tube develops video signal voltage, proportional to the colour intensity received by it.

A video pre amplifier amplifies V_R , V_B , V_G signals. In the output stage a resistance network is used to generate the luminance (y) signal and colour signal.

The resistance values are so related, such that $Y = 0.3R + 0.59G + 0.11B$. If only red colour light is focused, then we have only red camera output V_R .

$$\text{Then, } y = \frac{30}{30+70} * V_R = .3 V_R.$$

2.9 PICTURE TUBES

- **SPECIFICATIONS:**

The size of picture tube in general denotes the diagonal length. The size of the picture tube ranges from about 1" (2.5 cm) to 30" (76 cm) or more.

Most of the commonly used tubes in B/W TV and colour TV are 51 cm and 36 cm screen size.

Eg:

Tube 500 AmP4 has a diagonal length of 500 mm (20"). The last alphabet 'P' specifies the screen phosphor.

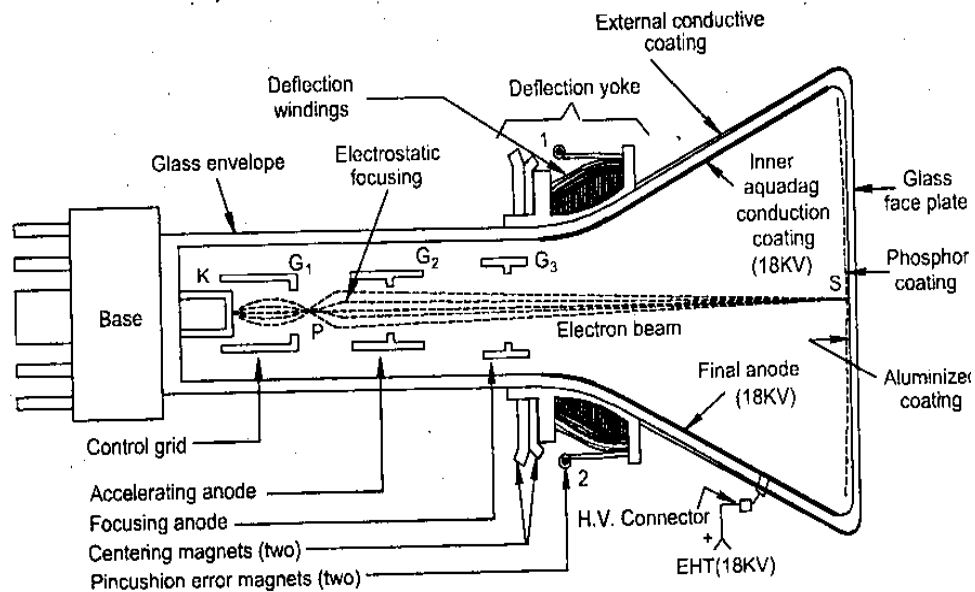
2.9.1 MONOCHROME PICTURE TUBE SPECIFICATION:

The commonly used picture tubes manufacture in India and marketed by Bharat Electronics Ltd., are 310 C1p4, 470C1p4 and 610C1p4, 590 Cp4. Picture tube employs electrostatic focusing and electromagnetic deflection.

- **CONSTRUCTION AND WORKING PRINCIPLE OF MONOCHROME PICTURE TUBES**

The picture tube is used to convert the video signal into optical signals.

- **CONSTRUCTION:**



Mainparts :

- Electron gun
- Focusing anode
- Deflection Coils
- Final anode.
- Phosphor screen
- External conductive Coating.

- **ELECTRON GUN**

The electron gun unit consists of Cathode, control grid and accelerating anode.

It is indirectly heated by a filament Thoriatedm Tungsten or borium and strontium oxides are having low work function and so release a sufficient number electrons of when heated.

The control grid is used to control the flow of electrons from the cathode. It is also in the form of cylinder, end for flow of electrons.

Screen grid is maintained at 400V and focusing grid is maintained at 600V. Through this base pin only the hated voltage for different grids are supplied.

- **FOCUSSING ANODE**

Electro static method is used to focus the electrons beam. The positive potential at the accelerating anode is extended. This is considered as first lens action. Screen grid and focus grid forms the second lens system. The focus anode is larger in diameter and also its potential is higher than the first anode.

The voltages given to the grid are so selected that the second convergence point is on the screen picture tube.

- **DEFLECTION COILS**

Electromagnetic system is used to deflect electrons beam in horizontal and vertical direction. The picture tube produces horizontal deflection and another pair of coil placed left and right produces vertical deflection.

The two pair of coils are collectively called as deflection yoke. In deflection yoke, centering magnet and pin cushion magnet are also provided for centering electrons beam. At the movement of electrons beam at corners.

- **FINAL ANODE.**

To provide sufficient velocity and energy for electrons beam a final anode is included in the tube. This aquadong coating is provided with a high voltage of 10KV or more. The secondary electrons emitted from the screen are attracted by these coating.

- **PHOSPHOR AQUADAG SCREEN**

Phosphor chemicals are light metals such as zinc and cadmium in the form of sulphate, sulphide and phosphate compounds. The atoms while hitting the coating, hitting spot fluorescence emit light.

- **EXTERNAL CONDUCTIVE COATING.**

Aquadag is also coated on the outer surface of the glass bell. A spring clip used to connect this coating with the chassis ground. A.C. ripples in high voltage and provide a perfect higher voltage.

- **WORKING PRINCIPLE:**

An a.c. supply of 6.3 V is given to the heater filament. This filament heats cathode and cathode emits electrons. The number of electrons in the beam is controlled. The accelerating anode increase the velocity of moving electrons A point and strike the phosphor coating on the screen. The aquadog coating inside the tube is given a high voltage in order of to 15 kv. Because of the deflection coil current the beam is deflected both in horizontal and vertical direction. The useful video signal is given to the cathode or control grid. It's called contrast control and brightness control Due to persistence of vision of eye, the viewer accumulates all picture elements as a whole picture.

2.9.2 PHOSPHOR SCREEN:

The phosphor chemicals are light metal such as zinc and cadmium in the form of sulphate. The kinetic energy of the moving electrons in the beam are transformed to the atoms in the phosphor coating. External conductive coating is also outer the surface of the glass bell. Decay time of phosphors used in picture tubes is approximately 5 ms in monochrome picture tube.

2.10 SCREEN BURN:

It is a defect in picture tube due to electrons. But the EHT voltage is present for long time. Because of absence of deflection field there electrons continues to strike. This defect can be overcome.

2.11 ALUMINIZED SCREEN:

A very thin coating of aluminium is provided on the back surface of the screen phosphor on all modern picture tubes. The aluminium coating is connected to high voltage anode coating. Aluminium coating reflects light from the screen.

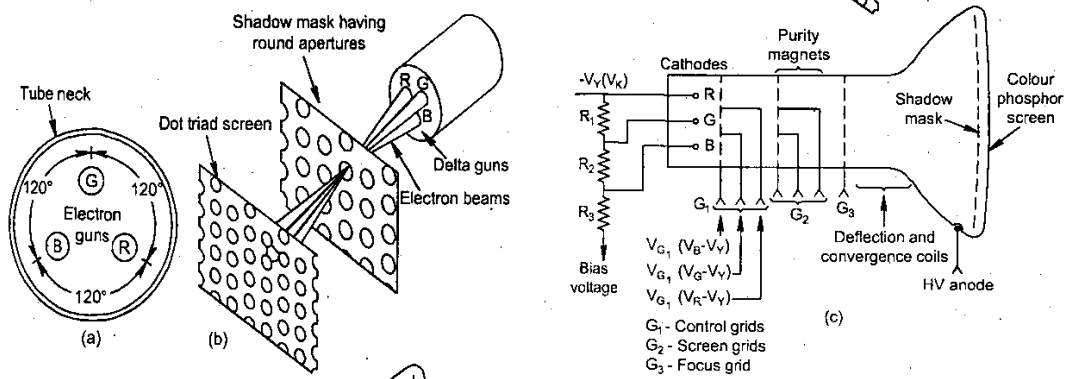
2.12 TYPES OF COLOUR PICTURE TUBES:

The screen of colour picture tube is coated with three different colour phosphor. However the three colour phosphor are separated from each other physically.

Three types of picture tubes are

1. Delta – gun picture tube.
2. Precision – In – Line or Gun – In – Line picture tube.
3. Trinitron picture tube.

• CONSTRUCTION AND WORKING PRINCIPLE OF DELTA GUN PICTURE TUBES



DELTA GUN

Radio Corporation of America developed this tube. Arranges in delta shape.

MAIN SECTION

Electron gun consists of three electron guns spaced equally at 120 Screen and shadow mark section.

- **WORKING PRINCIPLE**

The video signals corresponding to each primary colour are given to the three electrons gun. The axis of even electrons beam are adjusted by the purity magnet. And during this time other triode are by the mask.

The overall colour depends upon the phosphor which are being energised and the intensity of each beam. Red and green beams are 'ON', screen become yellow.

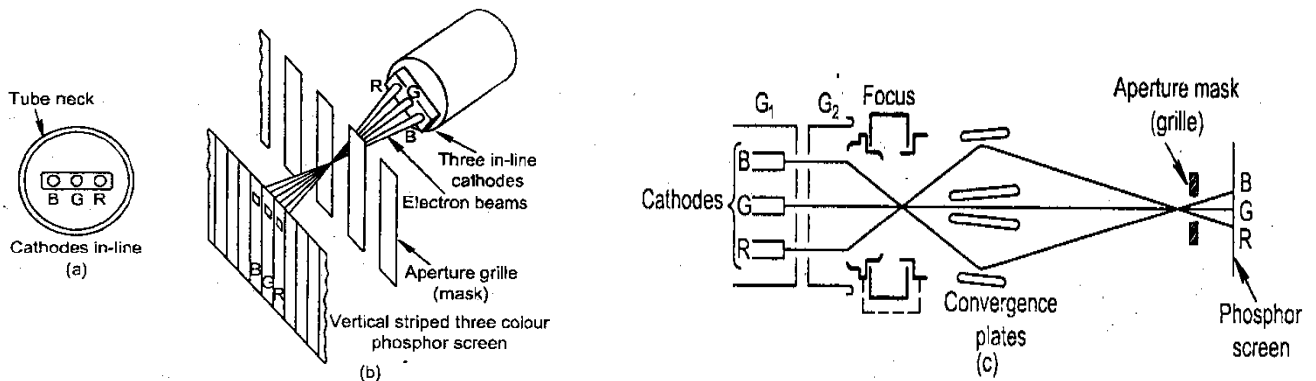
- **DRAWBACKS OF DELTA GUN TUBE:**

Convergence is difficult.

Focus cannot be sharp over the entire screen, electron transparency of the mask.

2.13 TRINITRON COLOUR PICTURE TUBE:

This type of tube was developed by Sony corporation of Japan. These tubes are having a single gun with three in-line cathodes.



- **ELECTRON GUN SECTION:**

Here there is only one electron gun, but with three cathodes for each primary colour, screen and mask construction. The outer plates are supplied with above 450V less than the final anode voltage.

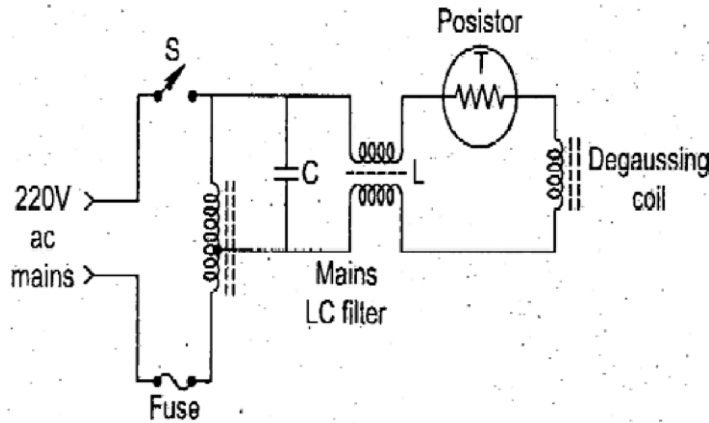
Four convergence plates are used. Since the green beam is in the center, it passes through the center plate. But the red and blue beams pass between the other plates. Since the center plate is connected internally to the final anode, zero potential is found between these plates. So the green beam is not affected by convergence voltage.

Due to voltage difference, an electronic force is developed and converging action taken place. So convergence is done for red and blue beams.

- **ADVANTAGES:**

1. Construction is simple.
2. Brightness is more.

2.14 AUTOMATIC DEGAUSSING:



Degaussing means demagnetizing. It is the process of removal of magnetic flux from magnetized parts in TV. Steel Chasis and internal frames that hold mask are subject to induced magnetization, whenever picture tube is switched off.

These induced magnetic fields can affect the electron beam path and produce errors in colour purity. To prevent such effect picture tubes are magnetically shielded. For this a thin silicon steel is housed around belt of tube. Mask structure and shield material have non zero retentivity and so they get weakly magnetized by magnetic field of earth.

Automatic degaussing circuit is shown. When the receiver is switched 'ON', a strong main current passes through the degaussing coil. After a few seconds this current is dropped to very low level.

REVIEW QUESTIONS

PART-A

1. What is camera tube?
2. What is picture tube?
3. Mention the characteristics of camera tube.
4. Define spectral response of a camera tube.
5. Define sensitivity.
6. Define dark current.
7. Define lag characteristics.
8. Define resolving power.
9. Mention the types of camera tubes.
10. Mention the specification of picture tube.
11. What type of focusing and deflection is used in monochrome picture tube.
12. Mention the types of color picture tube.
13. Define degaussing

PART-B

1. What is screen burn?
2. Explain aluminized screen.
3. Explain automatic Degaussing

PART-C

1. With neat block diagram explain the working and construction of Videocon camera tube.
2. With neat block diagram explain the working and construction of plumbicon camera tube.
3. Compare various camera tube
4. With neat block diagram explain the working and construction of CCD image sensor.
5. Explain with neat diagram the video processing of camera pickup signal.
6. With neat block diagram explain the working of colour TV camera.
7. With neat block diagram explain the working of monochrome picture tube.
8. With neat block diagram explain the working of delta gun picture tube.
9. With neat block diagram explain the working of Trinitron picture tube.

UNIT - III
TELEVISION TRANSMITTER

3.1 TWO TYPES OF MODULATION

1. HIGH LEVEL MODULATION:

In this, both the audio and video signals are amplified to the required level before modulation.

2. LOW LEVEL MODULATION:

In this, the signal is modulated before amplification.

- **ADVANTAGES OF LLM (Low Level Modulation)**

1. Simplicity of design.
2. Ease of operation.
3. Good linearity.
4. Superior performance.

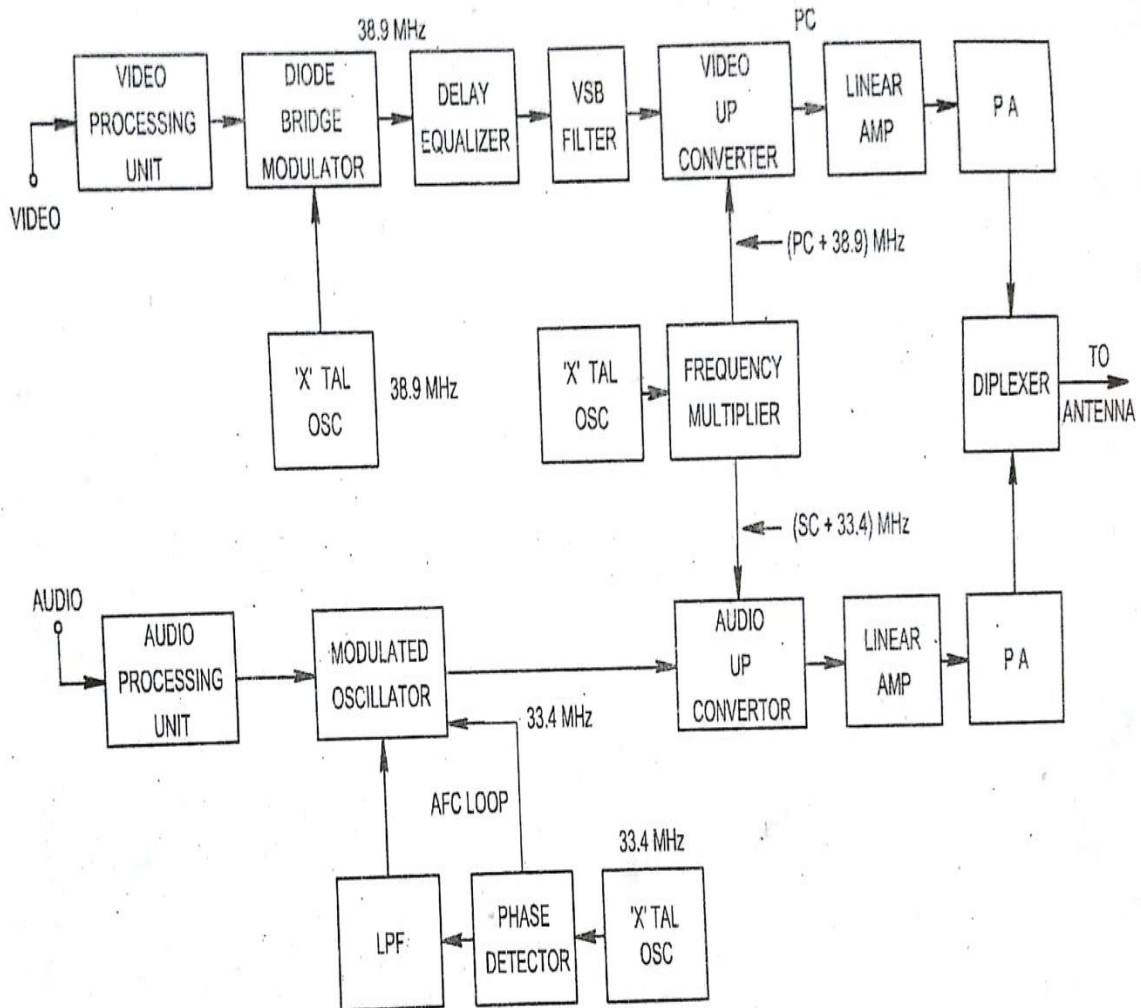
3.2 Comparison between high level modulation and low level modulation

S.No	High level modulation	Low level modulation
1	Both audio and video signals are amplified to required level before modulation	Both audio and video signals are amplified to required level after modulation
2	Transmitter power high	Transmitter power is low
3	Difficult to design and operation	Simple is design and operation

- **Principles**

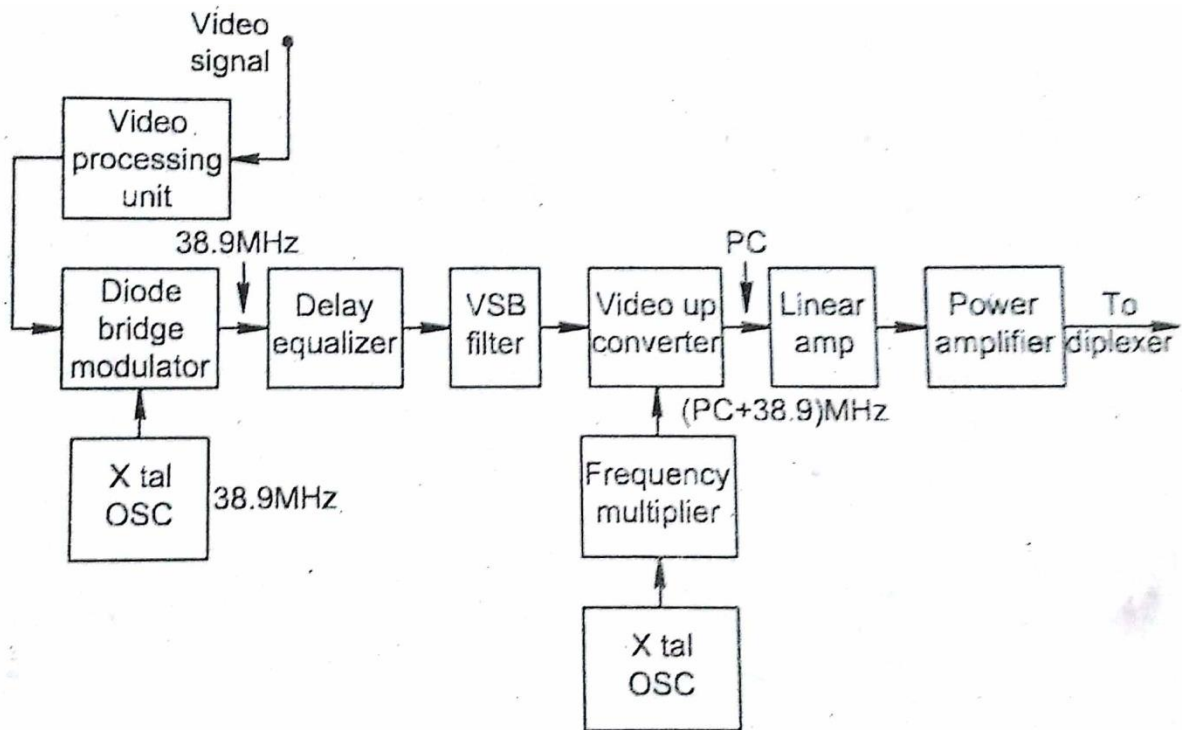
A television transmitter both audio and video signals using a channel bandwidth of 7 MHz. The two outputs, one from picture signal transmitter and the other from sound signal transmitter are combined in suitable network and then fed to a common antenna network for transmission.

3.3 BLOCK DIAGRAM OF LOW LEVEL IF MODULATED TV TRABSMITTER



In this video modulation is done at IF frequency of 38.9 MHz and sound modulation is done at IF frequency of 33.4 MHz. Both video and sound IF UP converted after modulation. A VSB filter is also included at lower IF power level. After up conversion they are given to lines, amplifier for power amplification and then it is connected to the diplexer unit.

3.4 VISUAL EXCITER:

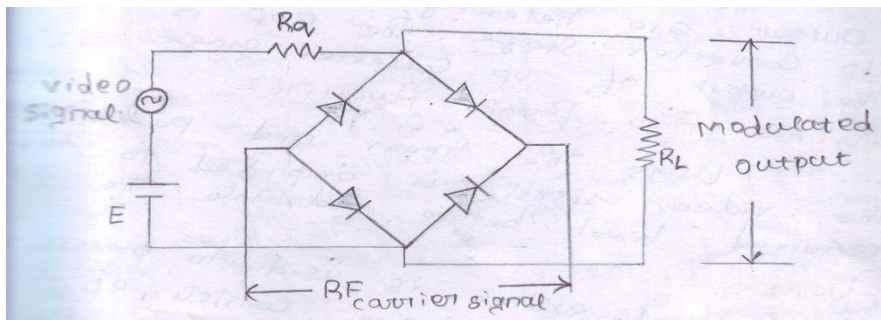


Visual exciter deals with circuits related to video signals. It consists of video processing unit, video modulator, VSB filter, Delay equalizer, Frequency up converter, Linear and power amplifier.

VIDEO PROCESSING UNIT:

In video processing unit, the Camera output signal having IVP-P amplitude is converted into standard form by eliminating hum and noise. Also after proper amplification sync pulses and blanking pulses are added to the Camera signal to get CVS.

VIDEO MODULATOR:



A bridge diode modulator or a diode balanced modulator is used for LLM.

In diode bridge modulator, the diodes are switched ON and OFF by the carrier voltage ($E_c \cos \omega c t$)

convert by the positive and negative half cycles. During the positive half cycle of carrier signal, R_L is short circuited. So output across R_L is zero. During negative half cycle, R_L is series with R_S . So output is proportional to the potential divider ratio formed by R_S and R_L .

Instantaneous amplitude of output voltage is,

$$e_o = \frac{R_L}{R_S + R_L} (E_o + E_m \sin \omega_m t) \cos \omega_c t$$

$$= A_o (1 + m \sin \omega_m t) \cos \omega_c t$$

From the above equation, the video signal is amplitude modulated by the carrier signal.

VSB FILTER:

It consists of four sections of LPF networks. This is used to attenuate the frequencies beyond 1.5 MHz.

DELAY EQUALIZER:

This is used to avoid the phase distortions.

FREQUENCY UP CONVERTER:

The VSB filter output and crystal oscillator output are heterodyned in the frequency UP converter stage. The BPF is used at the output of UP converter stage.

LINEAR AND POWER AMPLIFIER:

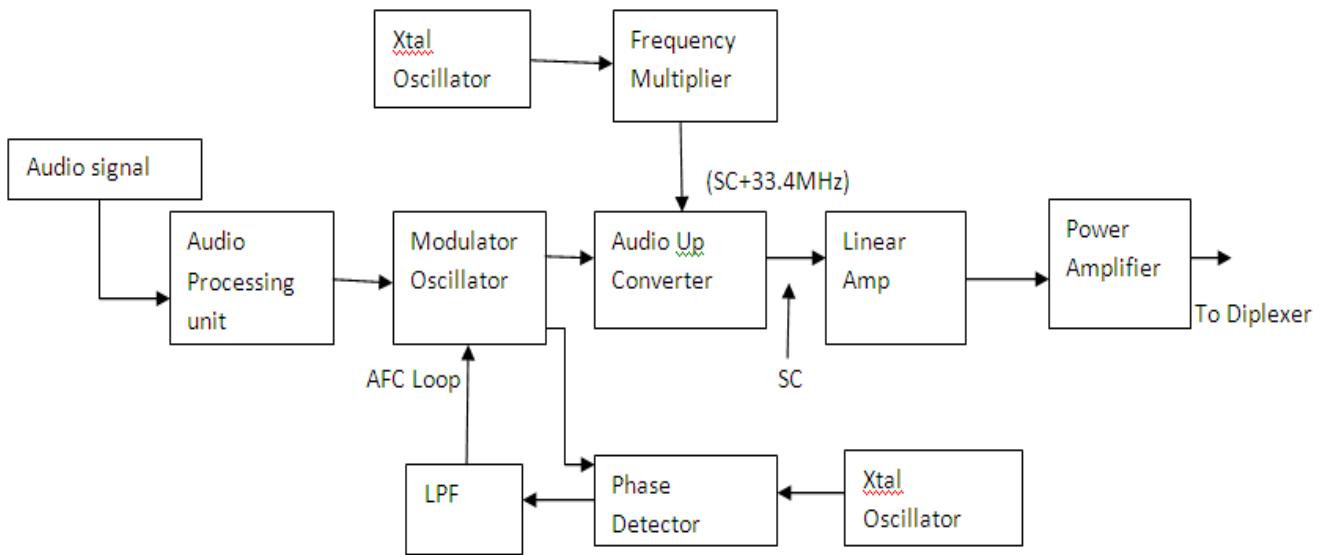
Using the linear and power amplifier, the video signal is amplified to the required level before fed into the diplexer.

3.5 AURAL EXCITER:

Aural exciter is used to process the audio signal. This section consists of, Audio processing unit, Audio modulator, Audio UP converter, Linear and power amplifier.

Block diagram of aural exciter is show

Block Diagram of Aural Exciter



AUDIO PROCESSING UNIT:

In this section, pre emphasis circuit and amplifier are used to improve the signal to noise ratio and amplify the audio signal to the required level.

AUDIO MODULATOR:

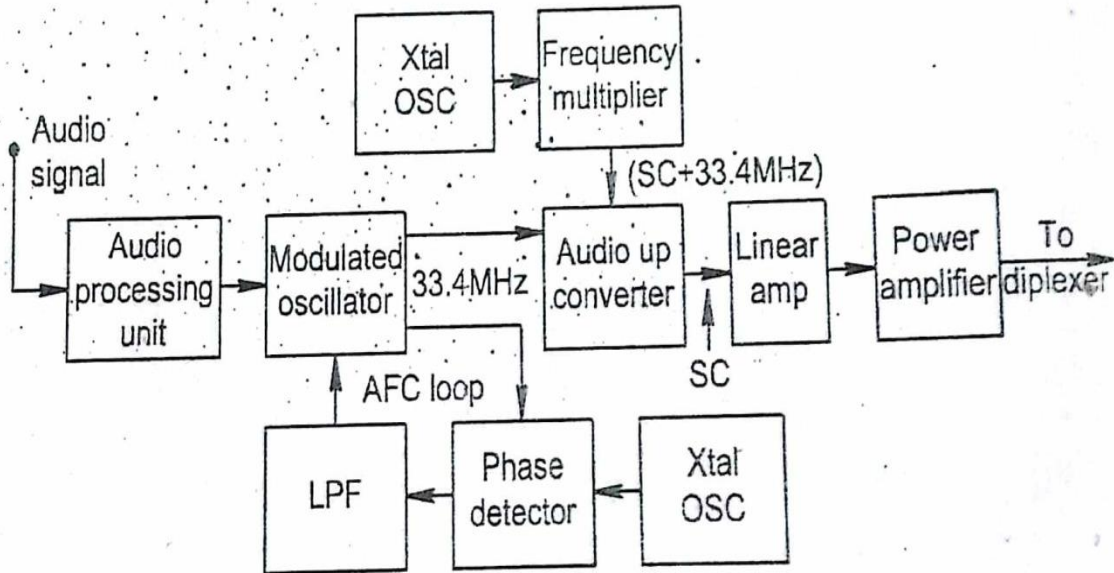
Audio modulator has two inputs, one is from the video processing unit and the other is from crystal oscillator. These two frequencies are given to Varactor diode in parallel with LC tank circuit. The output is sound IF of 33.4 MHz.

If there is any change in sound IF, the phase detector produces an error voltage. This voltage is given to the varactor diode to correct sound IF. Here the audio signal is frequency modulated.

AUDIO UP CONVERTER:

The output of audio modulator and crystal oscillator are heterodyned to produce the required audio signal output.

3.6 LINEAR AND POWER AMPLIFIER:



Using the linear and power amplifier the audio signal is amplified to the required level and is fed into the diplexer unit along with the video signal.

3.7 CIN DIPLEXER (CONSTANT IMPEDANCE NOTCH)

Working Principle of CIN Diplexer

Diplexer acts as the combining network, which is used to combine the audio and video signals without mixing i.e. it provides isolation between the two inputs.

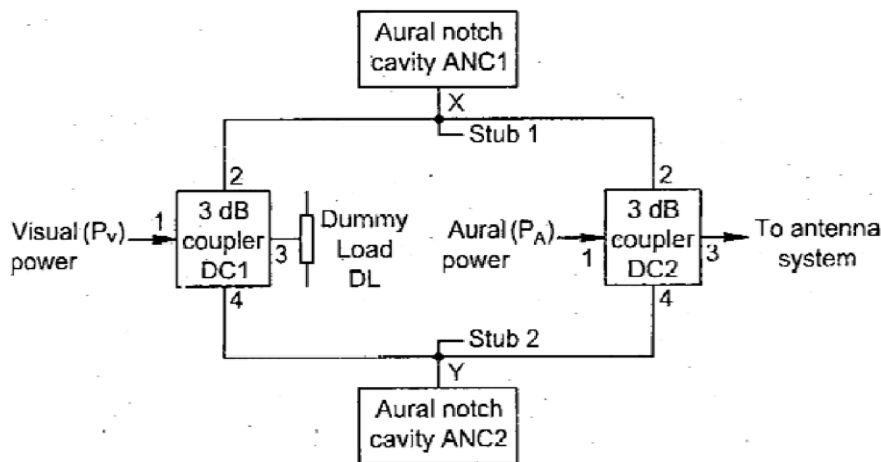


Fig.3.4 Block diagram of CIN diplexer

It consists of,

1. Two 3db Directional Couplers (DC)
2. Two Aural Notch Cavities (ANC)

These two 3db directional couplers are joined using Co-axial transmission line and two ANC's are connected in parallel with co-axial line.

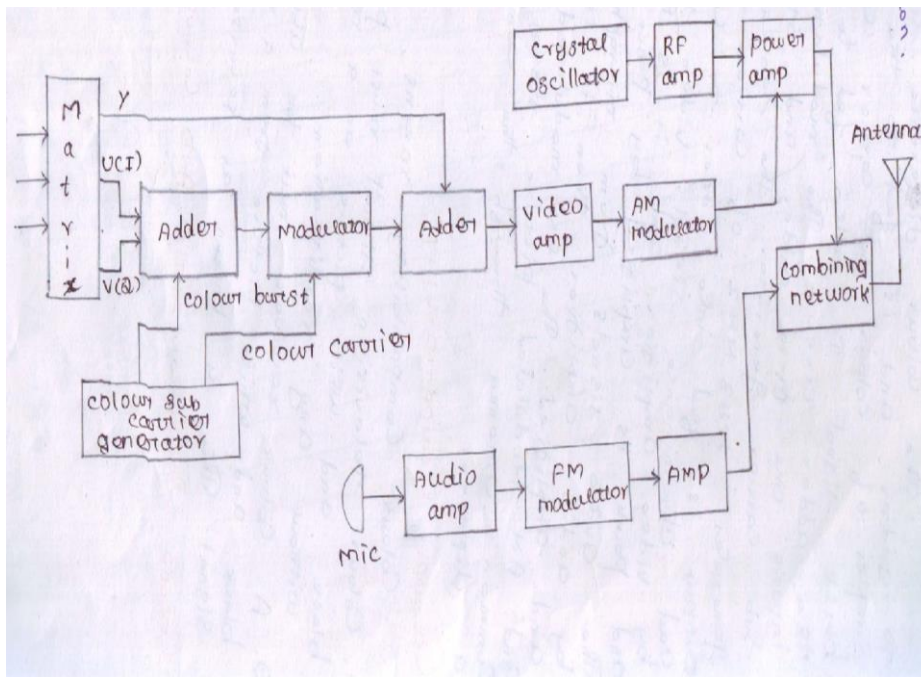
Dc1, and Dc2 has 4 ports. Port 1 is the input port and other 3 are output ports. Visual power is fed into port 1 of Dc1. This signal passes through port 2 and port 4 of Dc1 with 90° phase shift. Port 3 connected with dummy load to avoid leakages.

These two signals are passed through co-axial line to port 2 and port 4 of DC2. These two are added up and taken from port 2 of Dc2.

Audio power is fed into port 1 of Dc2, this signal divided equally into port 2 and port 4 of Dc2 with 90° phase shift. They are passed to ANC1 and ANC2 and reflected to come back to port 2 and 4 of Dc2.

The reflected signals are added and taken from Port 3 of Dc2. After this processing the audio and video signal fed to common antenna without mixing.

3.8 BLOCK DIAGRAM OF COLOUR TV TRANSMITTER



The gamma corrected R,G, and B signals are given to the matrix network to form the Y, u and v signals.

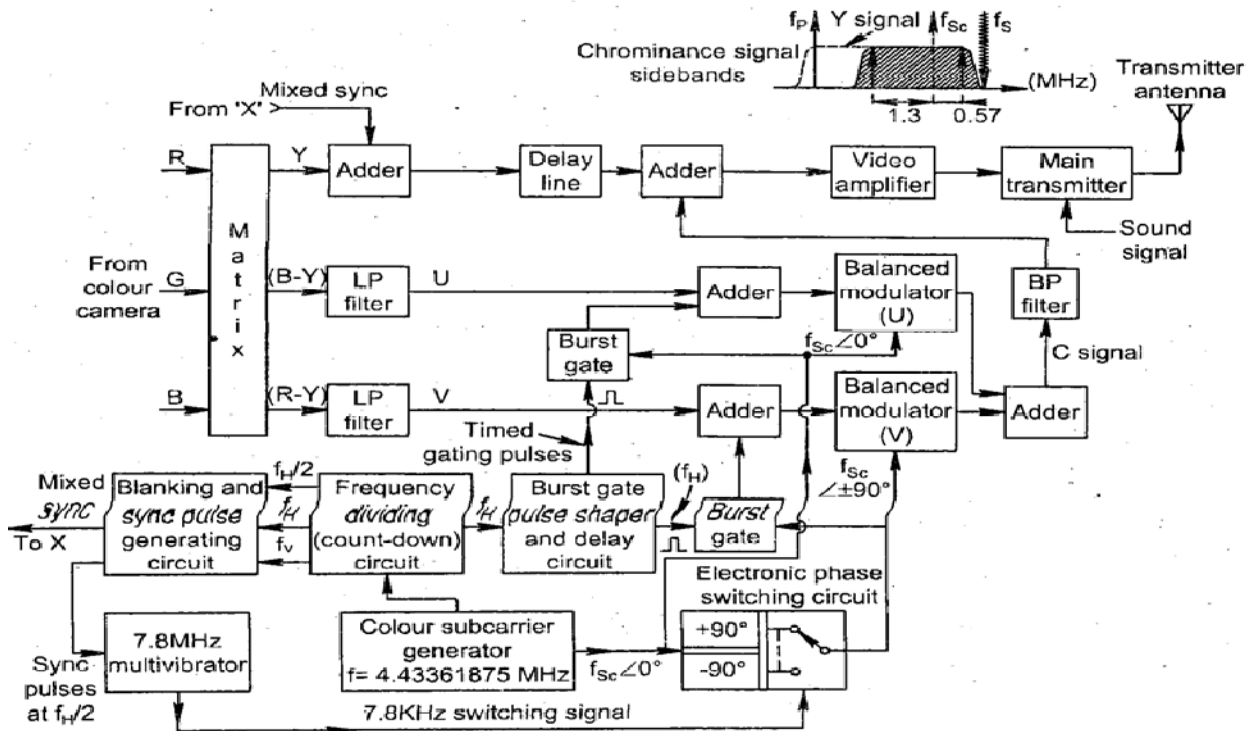
The colour difference signals are fed to adder then fed to the modulator. Some samples of colour sub carrier called as colour burst signal is also fed to the modulator using the adder circuit. The modulator take two inputs one from adder and other from colour sub carrier generator. The sub carrier generator generates 4.43 MHz of carrier signal. Then the output is fed into adder to combine Y signal and chrominance signal. Video signal is amplified by video amplifier and it is AM modulated and power is amplified by power amplifier. The audio signals from microphone are amplified by audio amplifier then it is FM modulated and amplified. The FM modulated sound signal and AM modulated picture signal is fed into common antenna through the combining network, a diplexer.

3.8.1 COLOUR COMPATIBILITY:

Colour compatibility means,

1. Colour television signal must produce a normal black and white picture on a monochrome receiver without any modification.
 2. A colour receiver must be able to produce black and white picture from a normal monochrome signal.
- This is known as reverse compatibility.

3.9 PAL COLOUR CODER (FUNCTIONAL BLOCKS AND WORKING OF EACH BLOCK, OUTPUT WAVEFORMS OF DIFFERENT STAGES)



The gamma corrected R,G and B signals are given to matrix network and Y, R-y and B-y signals are formed. Bandwidth of R-y and B-y is restricted to 1.3 MHz using LPF.

Sync and blanking pulses are added with Y signal. A delay line is inserted in the path of Y signal, because the colour difference signals (R-y) (B-y) take some time to process these signals. So to avoid this delay, a delay line is used in Y signal path.

The colour difference signals from filter are fed to balanced modulator. The output of filter and subcarrier oscillator is fed to balanced modulator, subcarrier generator is used to generate 4.43 MHz of carrier signal.

This carrier signal is directly fed to 'U' modulator,± but for 'v' modulator $\pm 90^\circ$ phase shifted carrier signal is provided on alternate lines by the use of 7.8 KHz switching circuit .

The DSBSC signal of U and V modulators are added together to yield the quadrature amplitude modulated chrominance signal. Then it is passed through a BPF to remove harmonics of subcarrier frequency. Then this filtered output is fed to adder to combine the Y and C signals.

The colour burst signal is also fed into the modulators along with U and V signals through adders. Before feeding this burst signals into U and V adders these are passed through separate burst gate. Each burst gate is controlled by delayed pulse at line frequency (fH).

These pulses are appeared during back porch period. During this interval 'U' modulator gets a burst with 90° phase shift, while V modulator gets burst with $\pm 90^\circ$ phase shift on alternate lines. At the output of modulators, the two burst signals are combined and produce the subcarrier burst at $+45^\circ$ on one line and -45° on the next line with reference to 'U' phase.

The CCVS formed is fed into the main transmitter. The frequency modulated sound signal is also combined to picture signal to diplexer and is fed into common antenna.

- **Merits of Pal system**

- i) Differential phase error have been successfully eliminated
- ii) Eliminate the hue errors, so manual hue control becomes unnecessary
- iii) More picture details because greater number of scan lines
- iv) Wider luminance signal bandwidth
- v) Higher gamma ratio
- vi) Easy studio mixing greater resolution

- **Demerits of pal system**

- i) The use of phase alternation by line technique is more complicated and expensive, because it needs a delay line in the receiver.
- ii) This system presents problems in magnetic recording
- iii) More flicker – because of lower frame rate
- iv) Lower signal to noise ratio
- v) Loss of colour editing accuracy
- vi) Variable colour saturation

REVIEW QUESTION

PART – A

1. List the types of modulation used in TV transmission.
2. What is duplex?
3. List out sections (components) in low level IF modulation.
4. List out the sections in aural exciter.
5. List out the sections in visual exciter.
6. What is the function of TV transmitter?
7. Mention the colour sub carrier frequency of PAL colour system.

PART – B

1. Compare high level and low level modulation.
2. What is high level modulation and low level modulation?
3. List out the advantages of LLM.
4. With neat diagram explain video modulator.
5. Explain colour compatibility and reverse compatibility.
6. List the merits (advantages) of PAL system.
7. List the demerits (disadvantages) of PAL system.

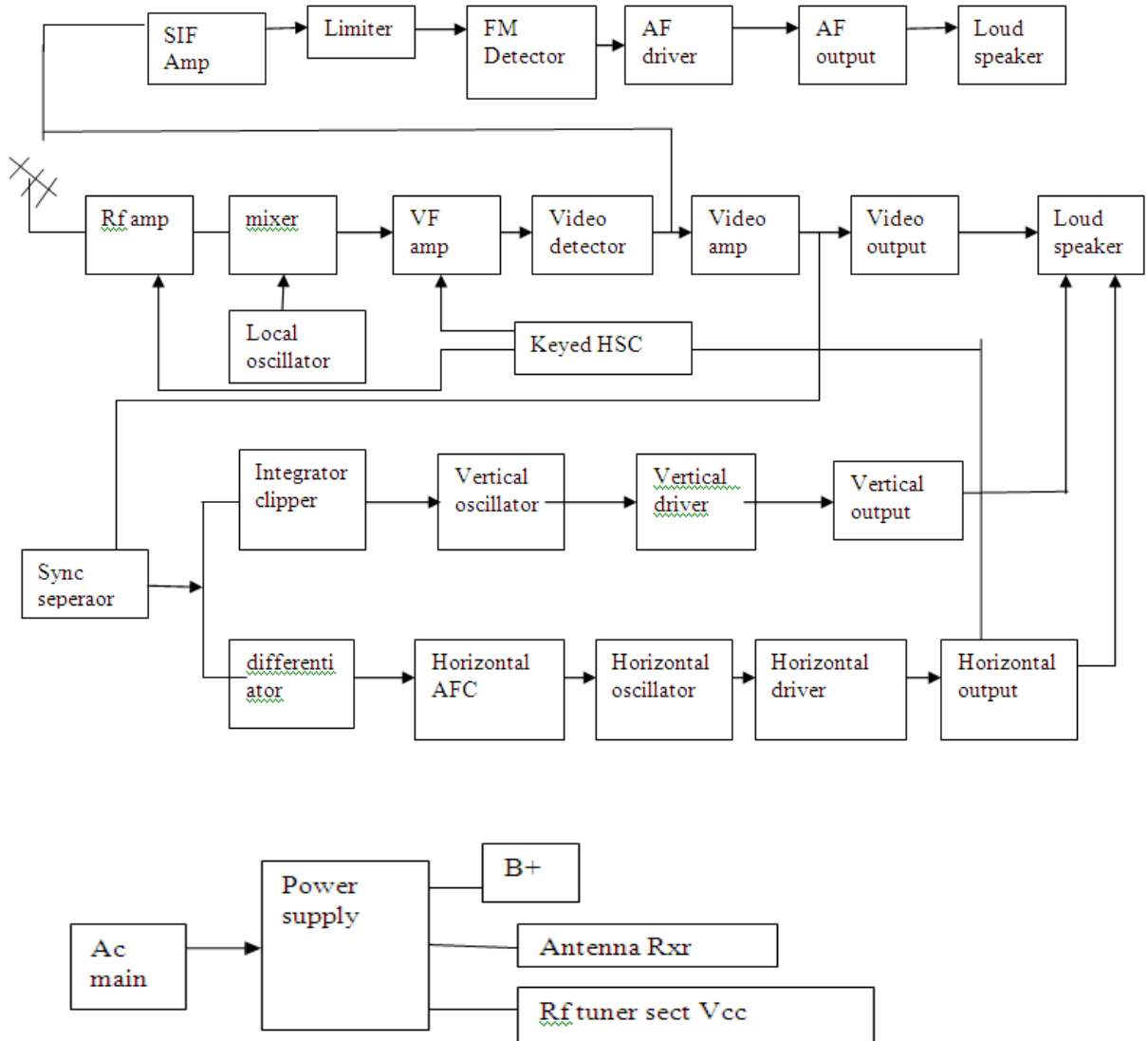
PART-C

1. With neat block diagram explain the working of low level IF modulated TV transmitter.

2. With neat block diagram explain the working of aural exciter.
3. With neat block diagram explain the working of visual exciter.
4. With neat block diagram explain the working of CIN diplexer.
5. With neat block diagram explain the working of colour TV transmitter.
6. With neat block diagram explain each functional block of PAL colour system.

UNIT-IV
TELEVISION RECEIVER

4.1 BLOCK DIAGRAM OF MONOCHROME TV RECEIVER



- Video signal and AGC section
- Audio signal section
- Synchronous separator section
- Oscillator section
- EHT section

4.2 Function of various blocks

4.2.1 Antenna section:

- To receive the TV signals, antenna is mounted at the top of a building. Converts the received electromagnetic waves into electrical signals.
- A half wave length antenna is mostly used for UHF band channels. Normally yagi antenna is used in TV receiver.

4.2.2 RF tuner section:

- RF amplifier, mixer and local oscillator are collectively called as RF tuner.
- The other input to the mixer is fed from a local oscillator
- Used to select the desired band and channel.

Picture 1F = 38.9MHz
Sound 1F = 33.4MHz

4.2.3 Video signal and AGC section:

- The video section consists of 1F amplifier video detector, video amplifier and picture tube.
- So a video amplifier is used at the output of video detector.
- So an automatic gain control (AGC) circuit is used to automatically control the gain of the amplifiers.

4.2.4 Audio signal section:

- In this section we have audio IF amplifier, FM demodulator audio amplifier and loud speaker.
- A loud speaker is used for the reproduction of sound.

4.2.5 Sync separator section:

- This section consists of a sync separator integrator and differentiator
- So the output of sync separator contains both the horizontal and vertical sync pulses.
- The differentiated horizontal sync pulses of line frequency are used to trigger the horizontal oscillator.

4.2.6 Horizontal and vertical oscillator section

- Vertical section consists of vertical oscillator output amplifier and vertical deflection coil.
- Similarly the horizontal is synchronized by the trigger pulses from the differentiator.

EHT section (Extra High Tension section)

- In this section only the high voltage needed by final anode is developed.
- Using the damper diode section boosted B^+ supply is taken out.

4.3 Need for AGC:

- The amount of signal received depends on the transmitter power.
- AGC also permits increase in gain for weak signals. It is achieved by delaying the application of AGC.
- Flutter in the picture due to passing aero planes and other folding effects are reduced.
- Separation of sync pulses becomes easy.
- AGC bias voltage in a D.C voltage proportional to strength of input signal. This bias voltage is received from output of video detector after rectification.
- This AGC bias voltage change the gain of IF and RF amplifiers in accordance with amplitude and maintain the output of video signal as constant amplitude.
- By using AGC amplitude of video signal at output of video detector is constant irrespective of variation of input signal.

4.4 Advantages of AGC:

- Intensity and contrast of the picture. Once set with manual controls remain almost constant.
- Contrast in the reproduced picture does not change much when the receiver is switched from one channel to another.
- Amplitude and cross modulation distortion on strong signal is avoided due to reduction in gain.
- Fading and flutter decreases.
- Controls sound signal level.
- Sync pulses can be separated easily.

4.5 Video amplifier requirements and response curve requirements:

Requirements:

To produce a satisfactory image on the screen of picture tube, video amplifier must meet the following requirements

4.5.1 Gain

Video signal at output of video detector is very low (**2vp-p**). To increase the required contrast level in screen, video signal must be increased to high level of **80vp-p**. For this video amplifier is needed.

4.5.2 Bandwidth:

Frequency response of video amplifier must be 0HZ to 5MHZ. Then only picture without distortion will be seen in screen. For this video amplifier is used.

4.5.3 Frequency distortion:

The inequality gain at different frequency components of the signal is called frequency distortion. Excessive frequency distortion cannot be tolerated because it changes picture information.

In poor high frequency response, rapid changes between black and white for small adjacent picture elements in horizontal line cannot be reproduced. This result in loss of horizontal details. Low frequency range is required for sharpness of picture. To avoid frequency distortion video amplifier is needed.

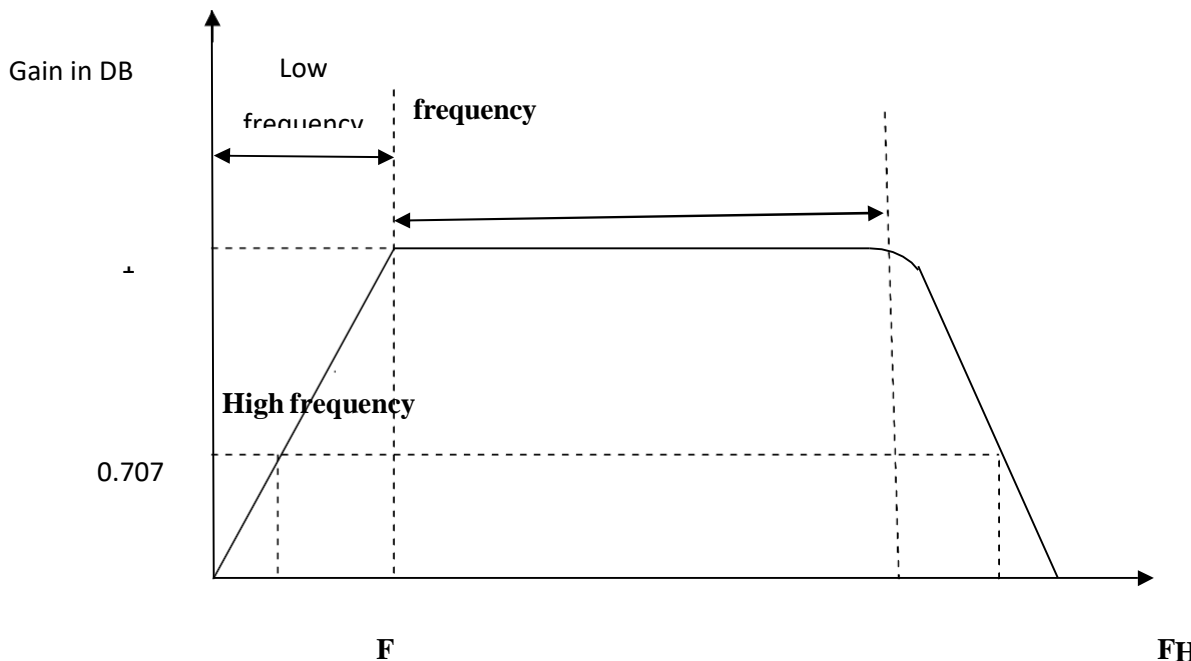
4.5.4 Phase distortion:

In video amplifiers, phase shift implies time shift , which in turn means position shift in the reproduced picture image. So to avoid phase distortion the video amplifier should not change the phase of the frequency component. So to avoid phase distortion video amplifier is needed.

4.5.5 Amplitude distortion (non linear distortion):

When different amplitude components get different amplifications. Then amplitude distortion occurs. To avoid this, video amplifier is needed.

4.5.6. Frequency response curve:



- From the response curve, we find that the gain of amplifiers is reduced very much for low frequency and high frequency.
- So HF and LF compensations are necessary for a video amplifier circuit.

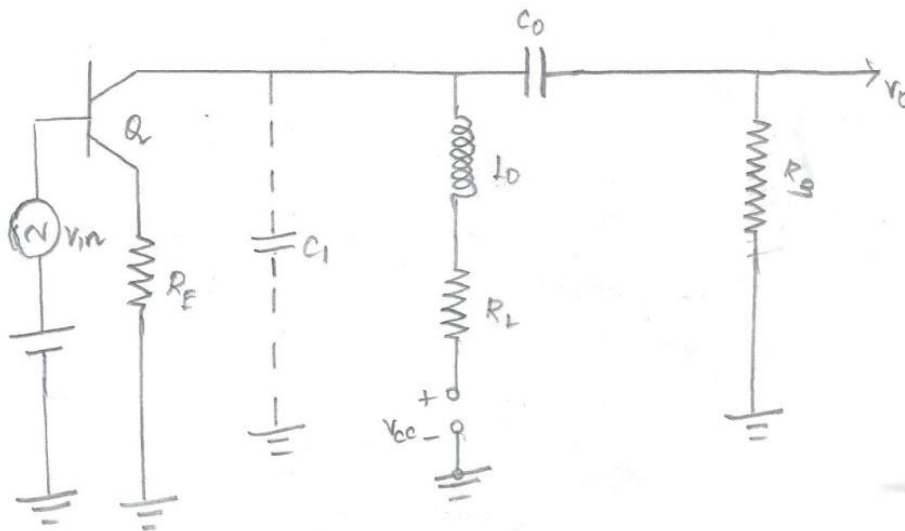
4.7 HF AND LF COMPENSATION TECHNIQUES:

4.7.1 High frequency compensation: (HF compensation)

- Shunt peaking.
- Series peaking.
- Combination peaking.

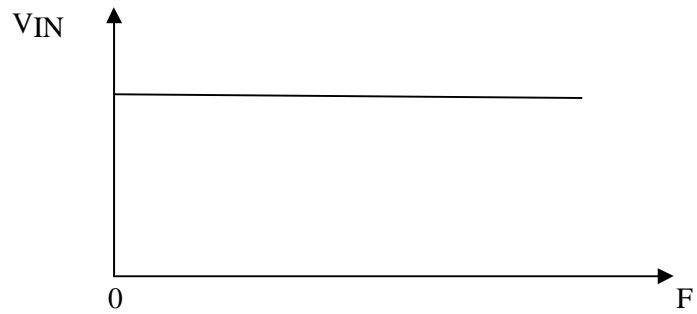
4.7.1.1 Shunt peaking

- Here the peaking coil L_0 is connected in shunt to the video amplifier.
- C_1 is stray capacitance. This reduces gain at high frequency..
- So peaking coil will resonate with C_1 and increases the gain at high frequency.

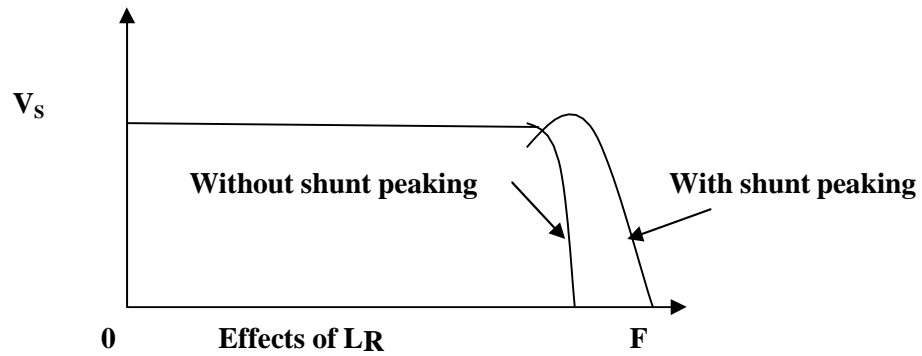
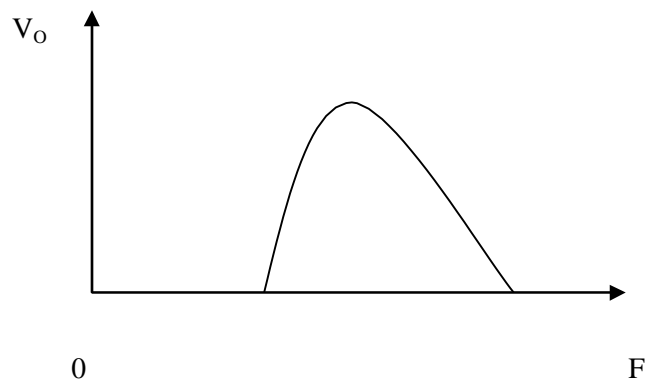


Shunt peaking

Shunt peaking:

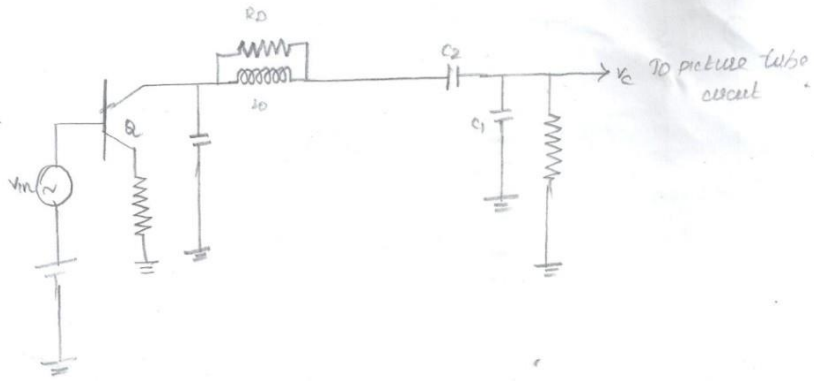


The response curve of C and L_0 in peaking

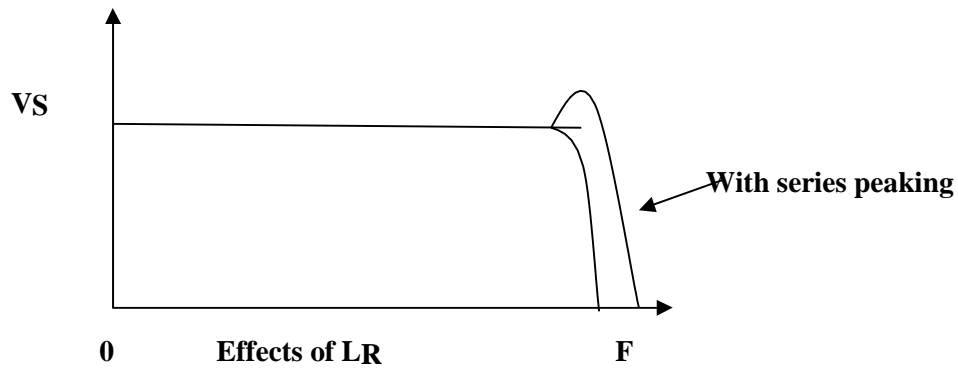
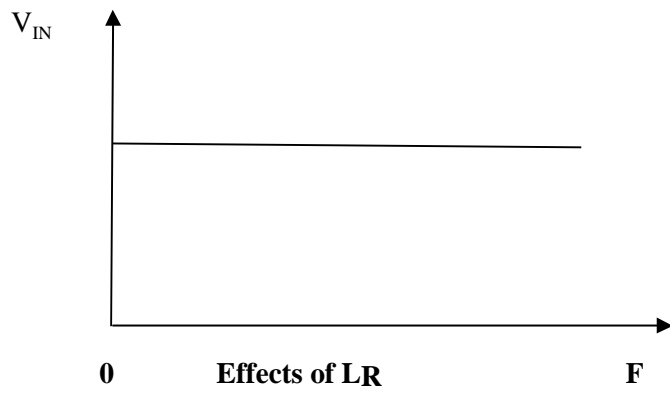


4.7.2 Series peaking

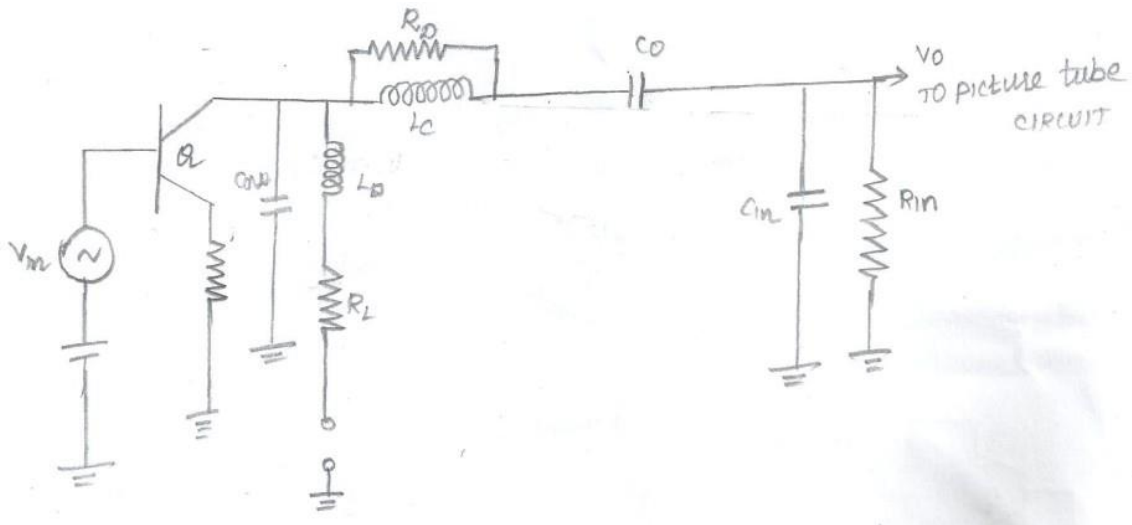
- The peaking coil L_0 is connected in series with the signal path. C is divided into C_{in} and C_{out} .
- The reduced shunt capacitance across R_L . A damping resistor R_d in shunt with its peak coil is used to prevent any oscillation in the coil.



Video amplifier with series peaking



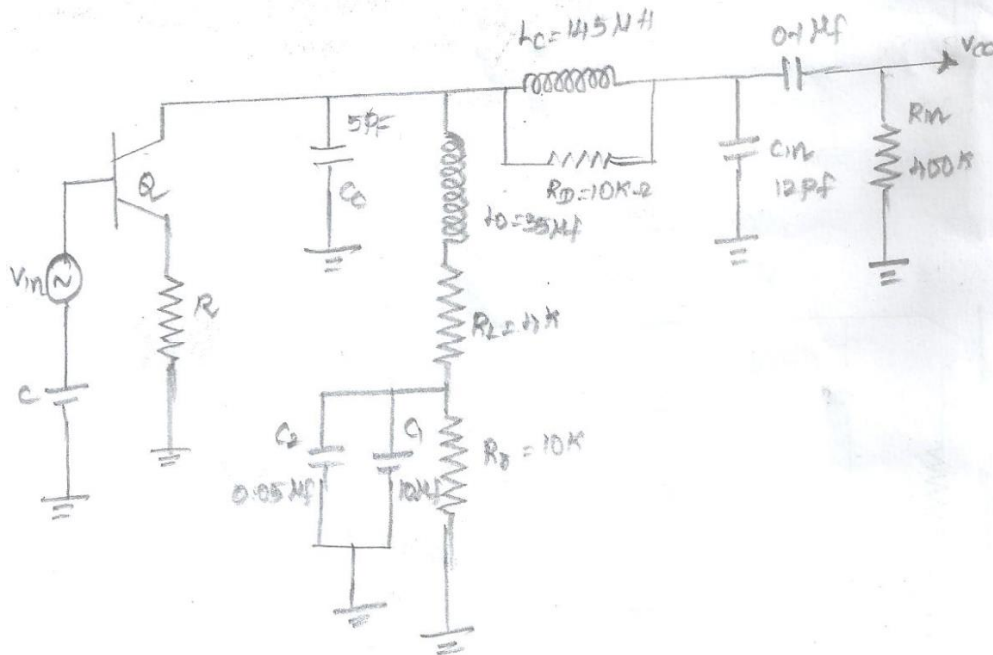
4.7.3 Combination peaking:



- To improve gain in high frequency combination of both series and shunt peaking are used.e

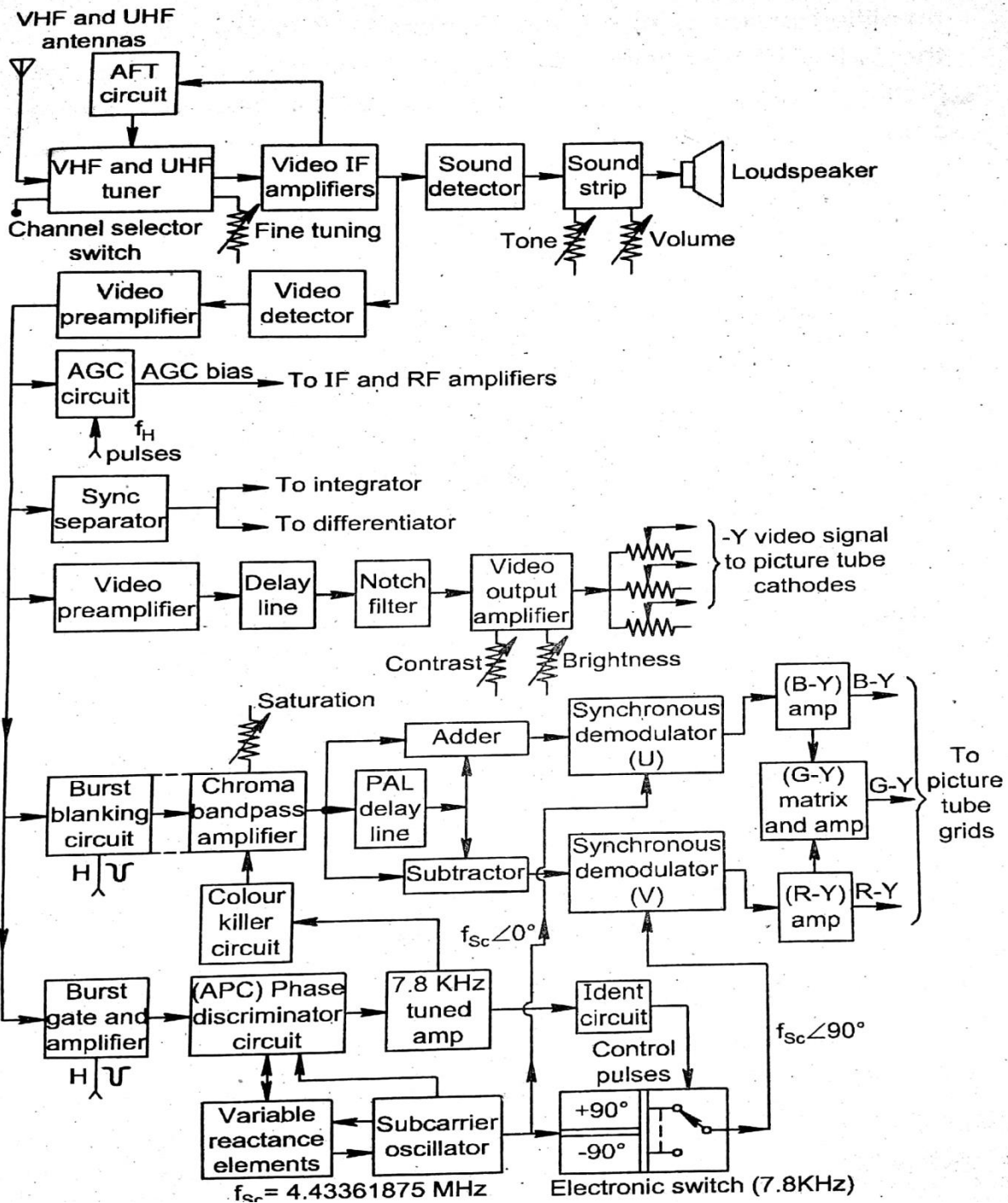
4.8 LOW FREQUENCY COMPENSATION; (LF COMPENSATION)

Coupling and by pass capacitors reduces gain at low frequency. R_f , C_f components is connected to B^+ Supply line. This increases gain at low frequency and phase distortion is reduced.



4.9 PAL COLOUR RECEIVER:

The colour TV receiver is similar to the monochrome system except that here we have a colour demodulator section.



4.9.1 The sections of the PAL colour receiver are

1. Colour chroma section
2. Colour band pass amplifier
3. Burst gate
4. Colour killer circuit
5. Colour subcarrier oscillator
6. PAL delay line and discrimination
7. Matrix network

Signal from antenna is selected by the tuner and converted to video and sound IF. It is amplified by the IF amplifier and detected by video amplifier. Inter carrier sound IF is sent to sound IF section and audio signal is produced. Video is amplified and sent to CRT and vertical & horizontal sync pulses are separated and transmitted to respective sections.

4.9.2 Monochrome and tuner section:

- The RF tuner is used to select the RF signal for different channel from the antenna.
- The sync pulses for horizontal and vertical oscillator are separated by the sync separator and its associated circuit.

4.9.3 Chroma band pass amplifier:

- This section consists of a chroma filter and two stage chroma amplifiers.
- In this section we have a color control. This control adjusts the gain of the band pass amplifier.

4.9.4 Colour burst gate:

- Separates colour burst signal and gives it to phase discriminator.

4.9.5 Colour killer:

- Zero and the output of 7.8 KHZ tuned amplifier also falls to zero.
- The colour killer turns off the chroma amplifier stage.

4.9.6 PAL Delay line stage:

- The purpose of this section is to delay the signal by about 64 micro seconds.
- The normal (U-V) and delayed (U+V) signals are simultaneously available.

Separation of U and V signals:

At the adder circuit

$$(U-V) + (U+V) = 2U$$

$$(U+V) + (U-V) = 2U$$

At the subtractor circuit

$$(U-V) - (U+V) = -2V$$

$$(U+V) - (U-V) = 2V$$

For adder and subtractor 64 microns seconds delay signal needed. To provide this PAL delay line is needed.

4.9.7 Colour subcarrier oscillator:

- Keeping colour bunt as reference produce carrier signal of 4.43 MHZ.

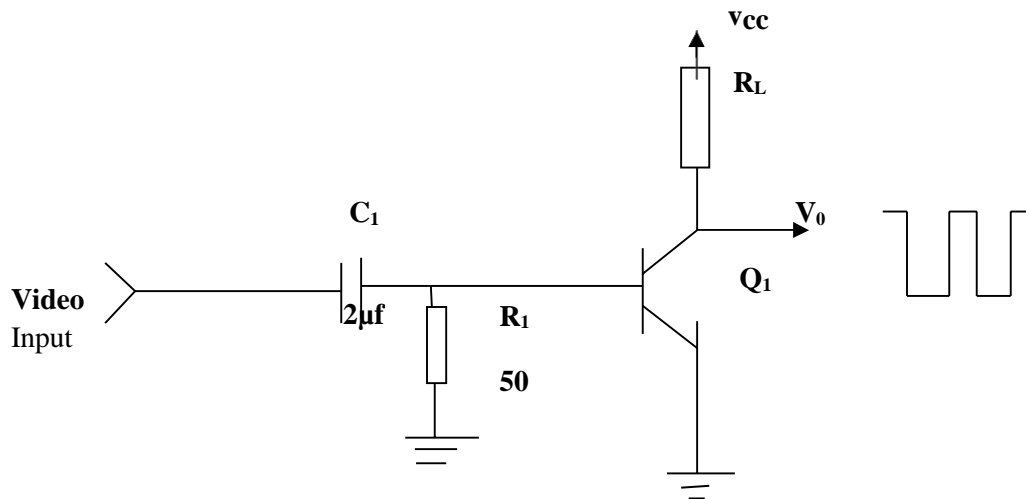
4.9.8 Matrix network:

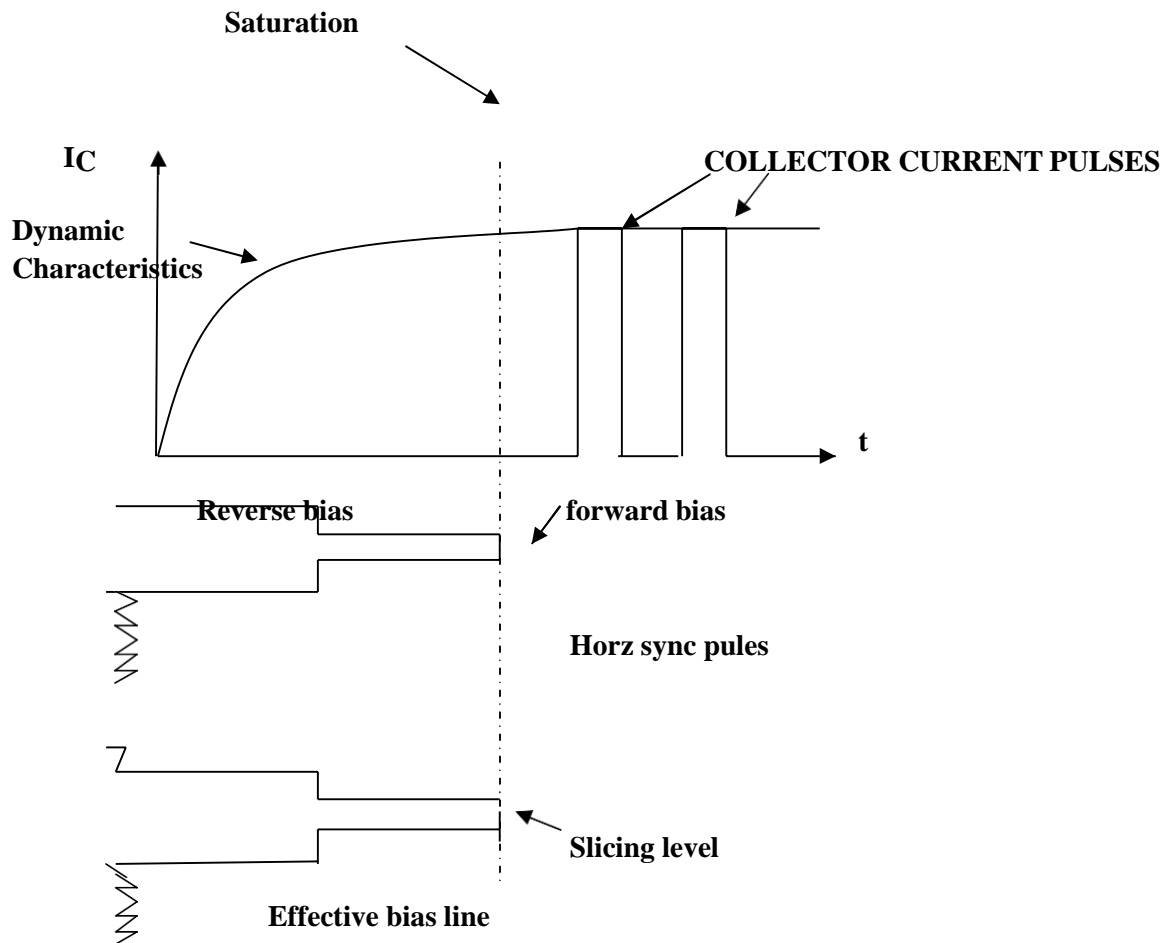
To generate (R-Y) (B-Y) and (G-Y) colour signals from U, V&Y signals matrix network is needed.

4.10 Need for synchronization pulse separator:

- The horizontal and vertical sync pulses exist in the top 25 percent of the composite video signal.
- At the output of video detector we have composite signals that contain video information and sync information for triggering of oscillator only sync pulses are needed.
- The sync separator separates both the horizontal and vertical sync pulses from the composite video signal.
- By using differentiator circuits, horizontal sync pulses (15625 HZ) are separated and by using integrator, vertical sync pulses (50HZ) are separated. They are used for triggering corresponding oscillators.

4.11 Basic principle of synchronization pulse separator:



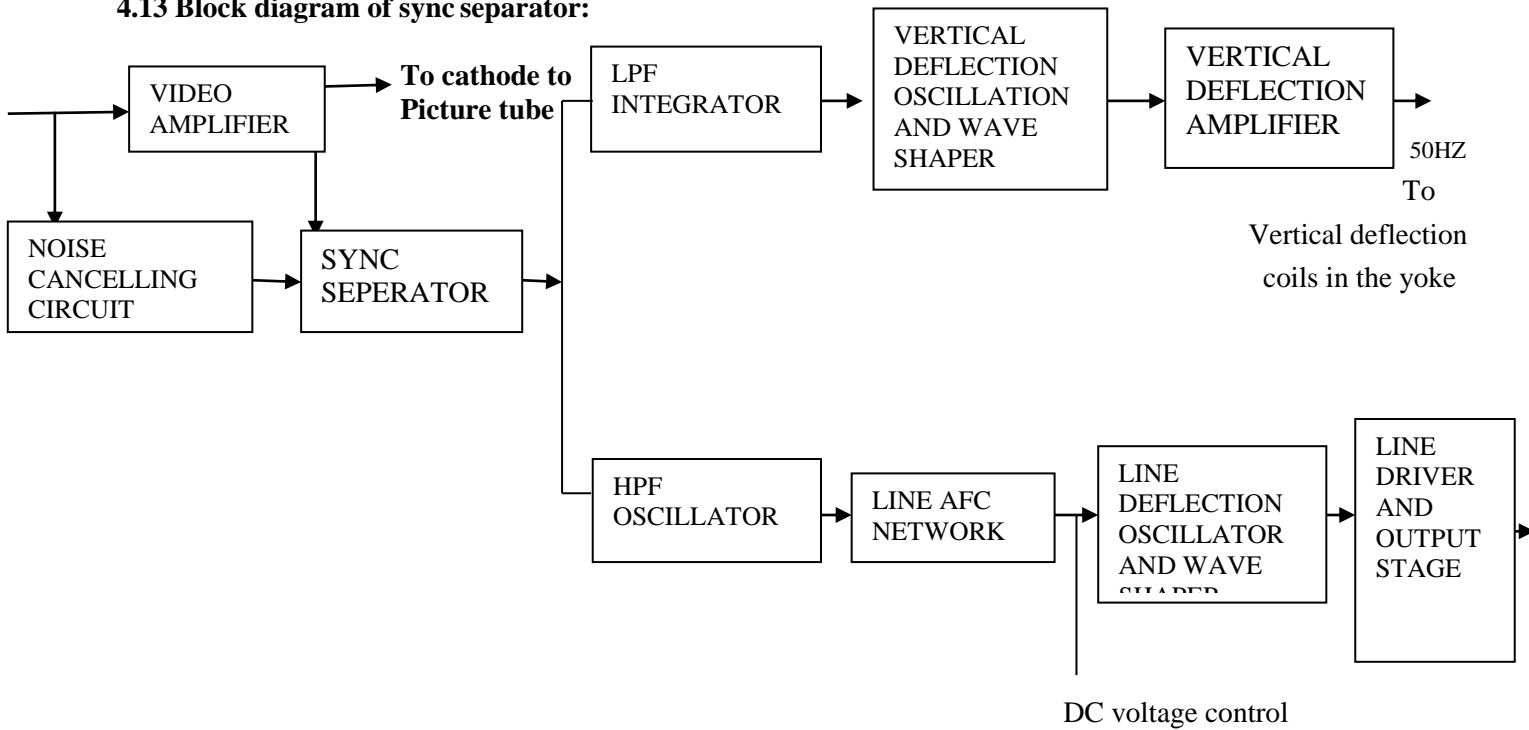


- The basic principle of merely biasing the devices used in sync separator the composite video signal makes current flow in the device.
- In self biasing the DC bias voltage is produced by the input AC signal itself.
- The transistor is operating the class 'C' mode. Input stage provides necessary DC bias voltage.
- R&C is used to provide the self bias between base and emitter of the transistor.
- Emitter circuits conduct heavily and charges the capacitor 'C'. This negative voltages then reverse bias the emitter bias base junction.
- The peaks of consecutive input video signal discharge through RC .discharge only 10% between the peak input signals.
- So the output of transistor we have only the separated sync pulses. These are shown clearly.

4.12 Condition must be satisfied

- β of the transistor should be large.
- Output leakage current must be small.
- The time constant RC must be long.
- A low power transistor can be used, since the transistor is off for most of the period.

4.13 Block diagram of sync separator:



The video signal from the video amplifier is fed to the sync separator circuit.

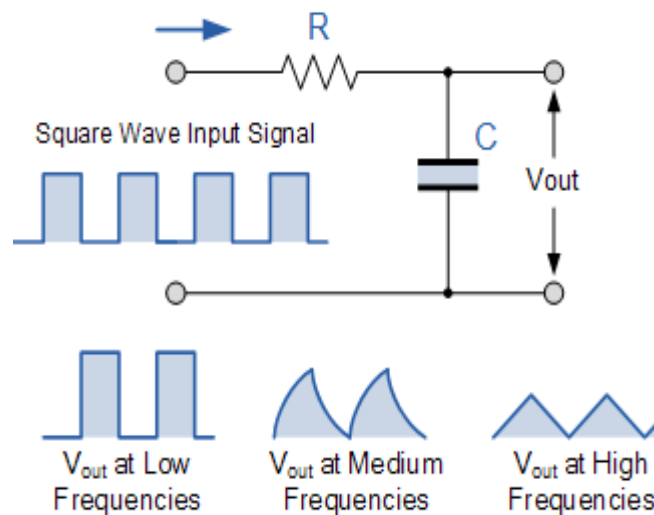
- At the output of sync separator we have a train of horizontal and vertical sync pulses.
- After the proper amplification they are fed to vertical deflection coil.
- Similarly the horizontal deflection oscillator is triggered by the differentiator output.
- To maintain the horizontal frequency at constant value an automatic frequency circuit is used in horizontal deflection section.

4.14 Separator (Vertical and Horizontal Sync)

4.14.1 Vertical sync separator: (INTEGRATOR CIRCUIT) LPF

- The resistor R, capacitor C forms a low pass filter which act as an integrator circuit.
- The time constant RC is chosen to be much larger than the width of separated vertical pulses.
- Usually about 10 times the serrated pulse width is sufficient when the horizontal sync pulses and equalizing pulses are applied to integrator.

Integrator circuit:

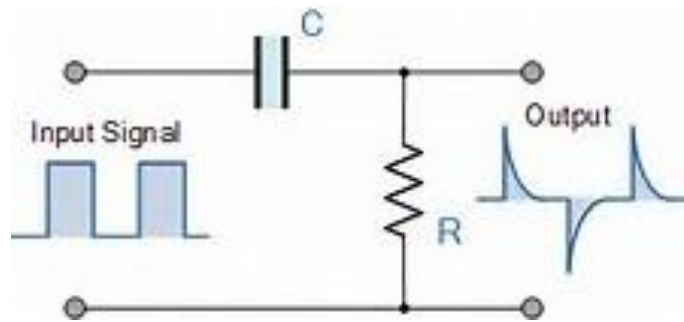


- The C charges and discharges quickly and the duration of ON period of these pulses are very less compared to time constant RC.
- The capacitor is charged for a period of 27.3 micro seconds and discharge for a period of only 4.7 micro seconds. This process is repeated.
- So, once a again capacitor is charged for 27.3 micro seconds and discharges for only 4.7 micro seconds this process is repeated.
- Due to this the voltage across the capacitor is gradually increased with small spikes super imposed on it.
- If vertical sync pulses has passed then the integration capacitor discharge almost to zero.
- In general a time constant of 50 μ s to 60 μ s is set for the integrator circuit.

4.15 Horizontal Synchronous Separator: Differentiator (HPF)

- When the leading edge of incoming pulse train is applied to RC, the output waveS follows almost the shape of input leading edge.
- When the flat top rectangular wave is reached, no further charging with time constant.

- Since the time constant is very short compared to input pulse, discharge completes before trailing edge of input pulse occurs.
- When trailing edge input pulse occurs it produces another pulse of opposite polarity to that of first pulse.
- Since horizontal frequency is very high this will be affected by noise so horizontal AFC is provided.



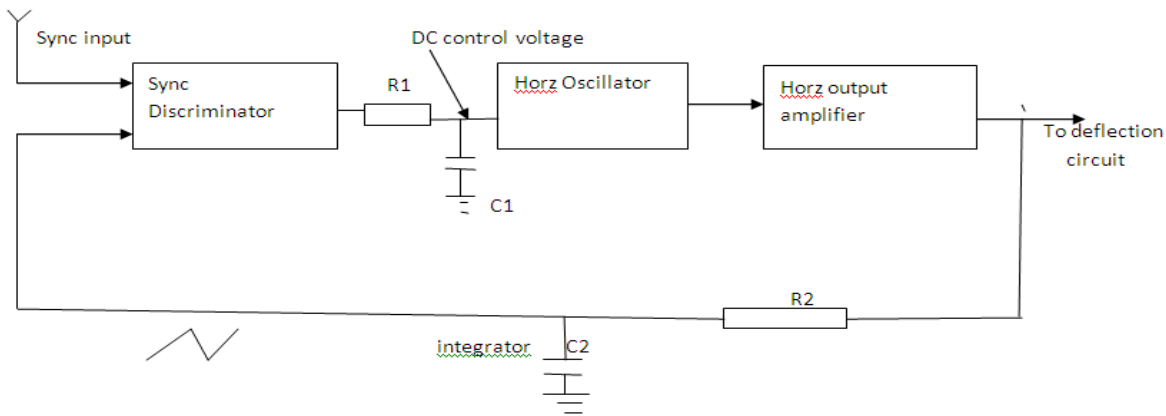
4.16 Automatic frequency control: (AFC)

Noise pulses which arrive during intervals between sync pulses tend to trigger the drive oscillators prior to their proper time. Picture rolls vertically upwards or downwards in vertical oscillator is so triggered and a series of lines will be jumped up in horizontal oscillator causing tearing of picture. This system is automatically controlled by using AFC circuits. AFC means **Automatic Frequency Control**. To maintain synchronization AFC is needed.

4.17 Need for AFC:

AFC means automatic frequency control. Horizontal and vertical sync pulses are separated using HPF and LPF. Vertical sync pulse frequency is 50HZ. So it is not affected by noise pulses. But horizontal sync pulses frequency is 15625 HZ. So it is affected by noise pulses. This causes out of synchronization. So to maintain constant frequency AFC is needed.

4.18 Block diagram of horizontal AFC:



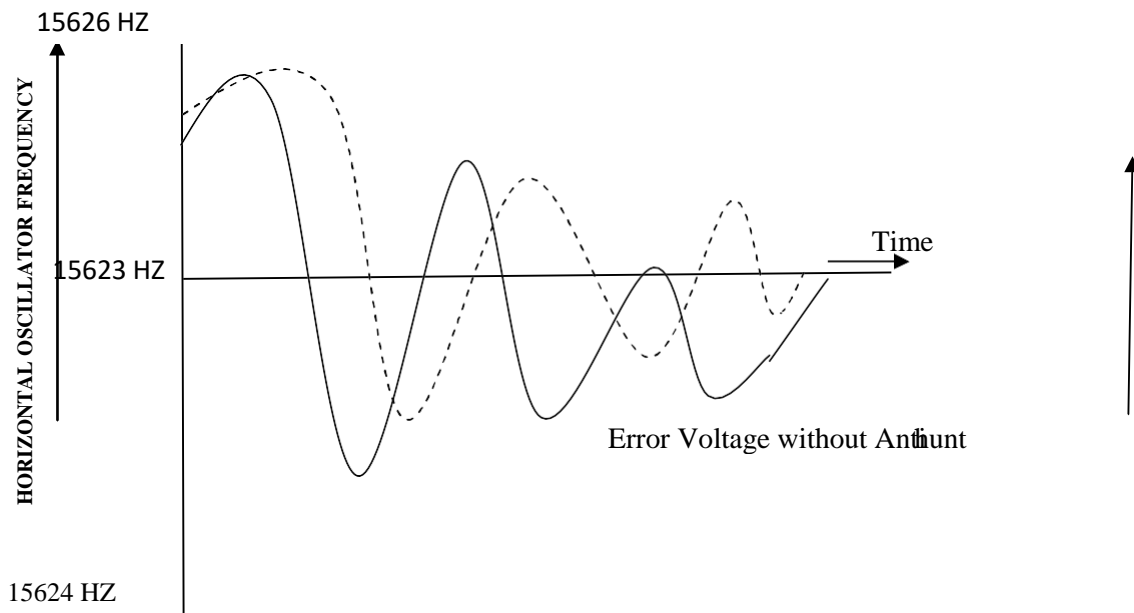
It consist of

1. Sync discriminator.
2. Horizontal oscillator.
3. Horizontal output amplifier.

The horizontal synchronization voltage and fraction of horizontal output voltages are given to sync discriminators terminals. It detects difference frequency and develops dc output voltage proportional to difference voltage. This DC voltage is fed to large time constant filter and output of which is used to control the oscillator frequency. The capacitor in the LPF terminates the effect of noise pulses.

4.19 Hunting in AFC:

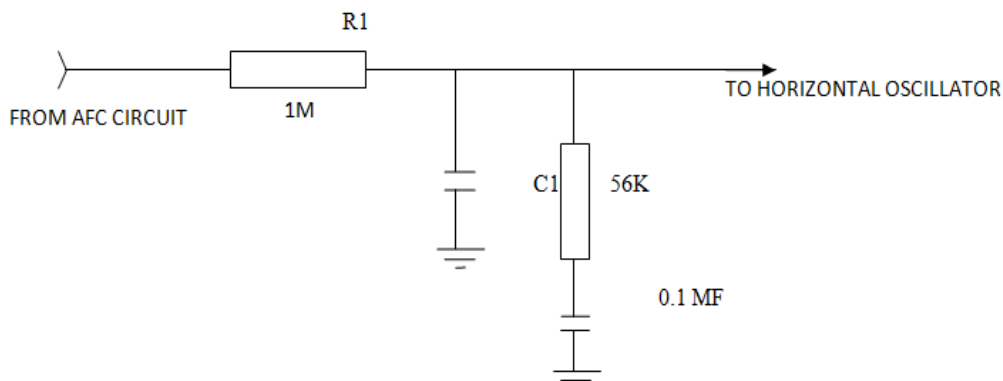
The low power frequency followed by differentiator controls the performance of AFC. If time constant is too large control is sluggish. If time constant is low oscillator is hunt while returning to the correct frequency. Excessive hunting in AFC circuit appears as “WEAVING” or “GEAR-TOOTH” effect on picture. Hunting in AFC is shown.



Because of hunting effect horizontal frequency deviates from correct values. To prevent this hunting double section filter is used.

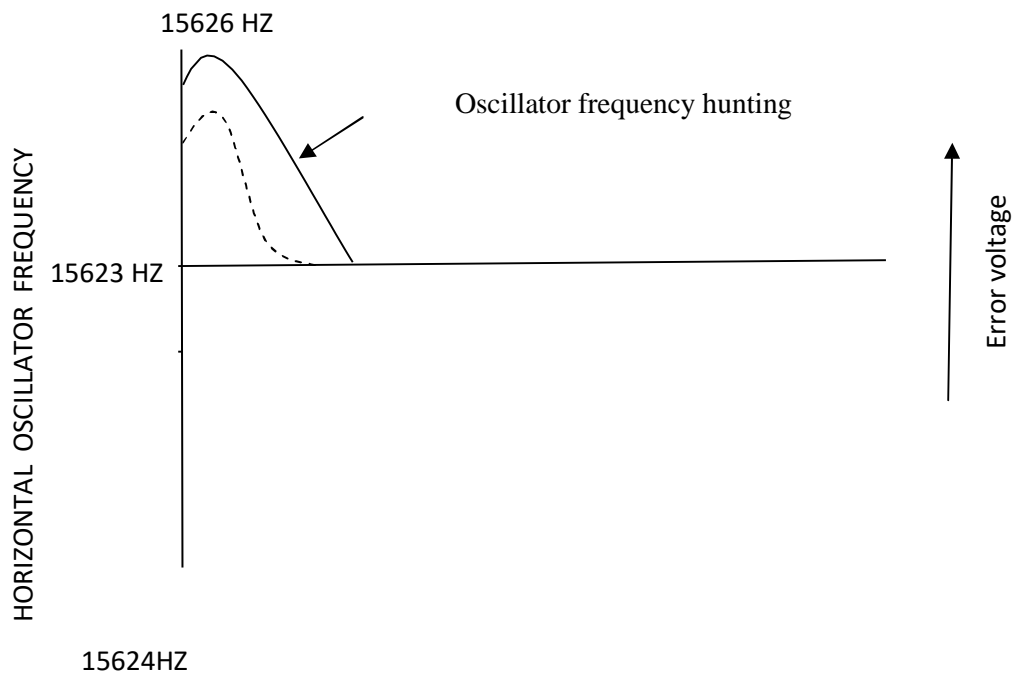
4.20 ANTI-HUNT network:

Fig shows anti-hunt network



R1C1 time constant of 5ms is large enough to filter noise, horizontal sync and fly back pulses effects. Second section R2C2 in series is known as “ANTI HUNT” network.

In anti hunt network R2 act as a damping resistance across C1 making output voltage more resistive and less capacitive. Because of addition of anti hunt network the time delay in charge of control voltage is reduced.



REVIEW QUESTION

PART-A

1. List out the sections (components) of monochrome TV receiver.
2. List out the values of picture IF and sound IF in TV transmission.
3. What is AGC?
4. List out the sections of PAL color receiver.
5. What is sync separator?
6. What is the function of colour killer section?
7. What is AFC?

8. Why AFC is used in horizontal section?
9. What is an antenna?
10. Mention the types of FM sound detectors?

PART-B

1. Explain the need of AGC.
2. List the advantages (merits) of AGC.
3. Mention the video amplifier requirements.
4. Explain the need for sync pulse separator.
5. With neat diagram explain integrator (vertical) or (LPF) working in details.
6. With neat diagram explain differentiator (or) HPF working in details.
7. Explain the need for AGC.
8. What is hunting in AFC?
9. What is anti hunt network?
10. What is the compensation technique employed to extend the bandwidth of an amplifier?

PART-C

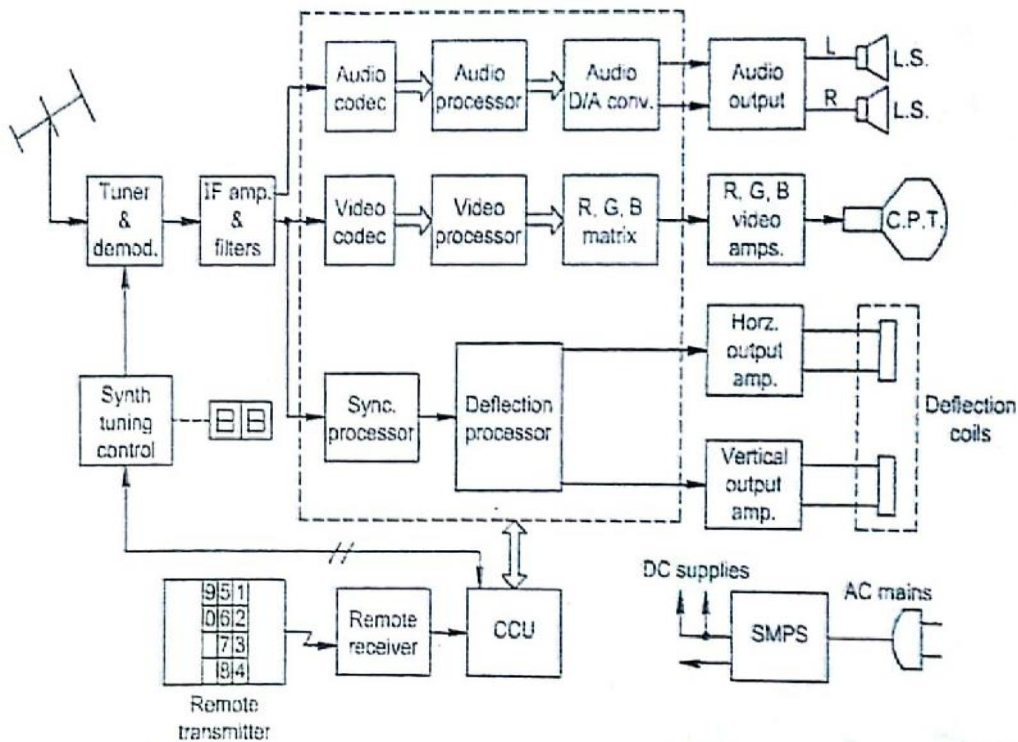
1. With neat block diagram explain the working of monochrome TV receiver.
2. With necessary diagram explain the HF and LF compensation technique.
3. With neat block diagram explain the working of PAL color receiver.
4. With neat block diagram explain the working of basic principle of sync pulse separator.
5. With neat block diagram explain the working of sync separator.
6. With neat block diagram explain the working of hunting in AFC.
7. Explain the anti hunt network in detail.
8. Explain the requirement of video amplifier in detail.

UNIT V

ADVANCED TELEVISION SYSTEM

5.1 Block diagram of digital colour TV receiver:

- Digital television means the digital processing of TV signal both at the transmitter and at the receiver.
- The luminance and chrominance signal process are in digital form.
- The central control unit is a microcomputer based device used to control and coordinate all circuit in this receiver.
- The main block used in digital receivers are,
 - 1) Video codec
 - 2) Video processor
 - 3) Deflection processing unit
 - 4) Audio codec
 - 5) Audio processor
 - 6) Central control unit



5.1.1 Video codec:

The signal from the IF stage is converted to analog CVS by the high speed flash A/D converter into 8 bit digital signal and given to video processor.

5.1.2 Video processor:

The output of video codec is separated into two channels – luminance and chrominance. Brightness and contrast of luminance signal are adjusted in accordance with user's settings. Chrominance signal is encoded to relative weightage of red, green and blue.

These signals are then given to video codec. The D/A converter in video codec convert it to analog form. By the delay line technique and demodulation R,G,B signals are obtained amplified and applied to corresponding guns.

5.1.3 Deflection processing unit:

This unit senses the standard TV signals and synchronizes the vertical and horizontal sweep generators and amplified and given to corresponding deflection yokes.

5.1.4 Audio codec:

This samples the input signal to produce 1 bit data stream and convert this into 16 bit resolution stream. This is given as input to audio processor.

5.1.5 Audio processor:

The input signal is split into two channels. Then the stereo balance, tone, loudness, and other necessary function are controlled.

5.1.6 Central control unit (CCU):

It is a microcomputer based device used to control and coordinate all circuits in the receiver. It is supported by an EEPROM, a timer, a control bus and circuits to decode user commands.

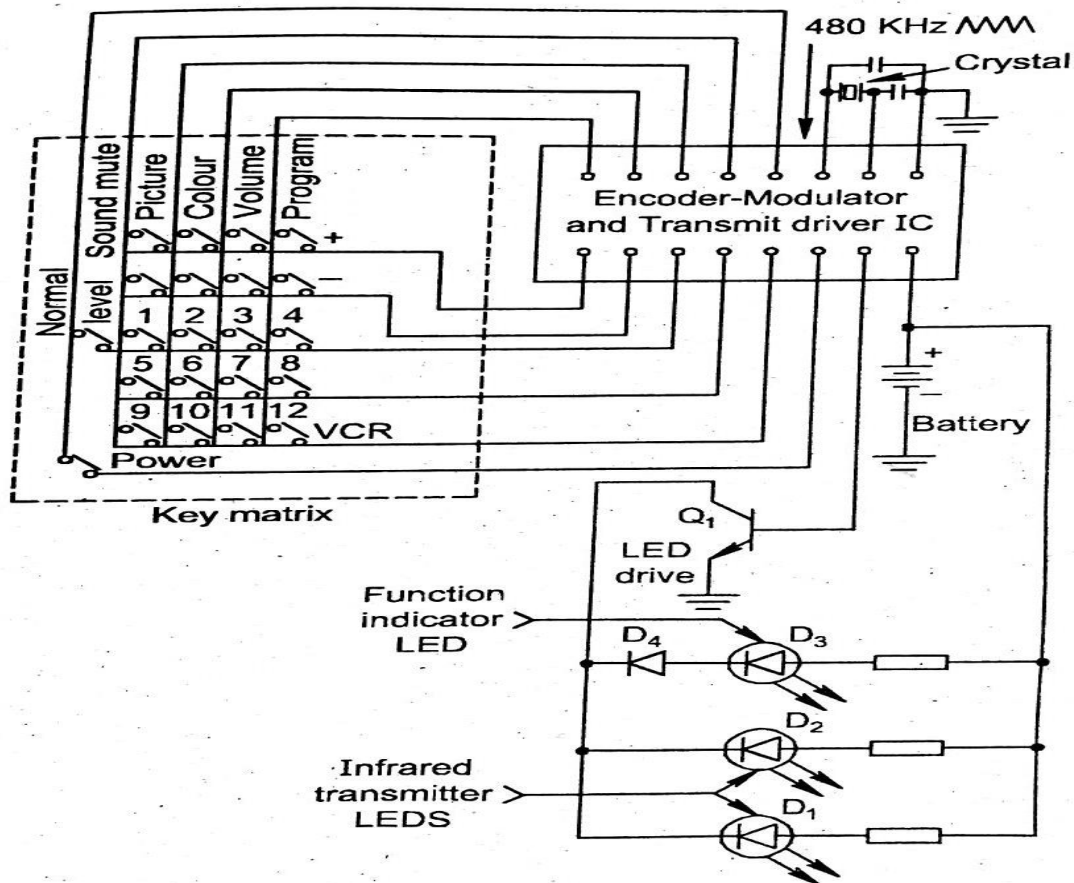
5.1.7 Merits of digital receiver:

- Resolution is high
- No interference of electrical appliances
- Synchronization is better.
- Picture in picture is possible.
- Improved reception in for fringe areas.

5.2 Remote control circuit:

- To operate the various receiver controls from a distance by the viewer, he is provided by the remote control circuits.
- The main function done by it are changing the channels, varying the sound level, turning ON and OFF the TV set , contrast level.
- Two signaling methods used for remote control.
 - 1) By ultrasonic waves
 - 2) By infrared wave using LED'S.
- We have 11 buttons for channels selection, one for VCR connection. Power ON / OFF button, volume control, color control are provided.
- The remote transmitter is somewhat directional since we are using the infrared waves.
- We can operate within 7 meters and at a radians of 30° from the receiver point, labeled for remote operation.

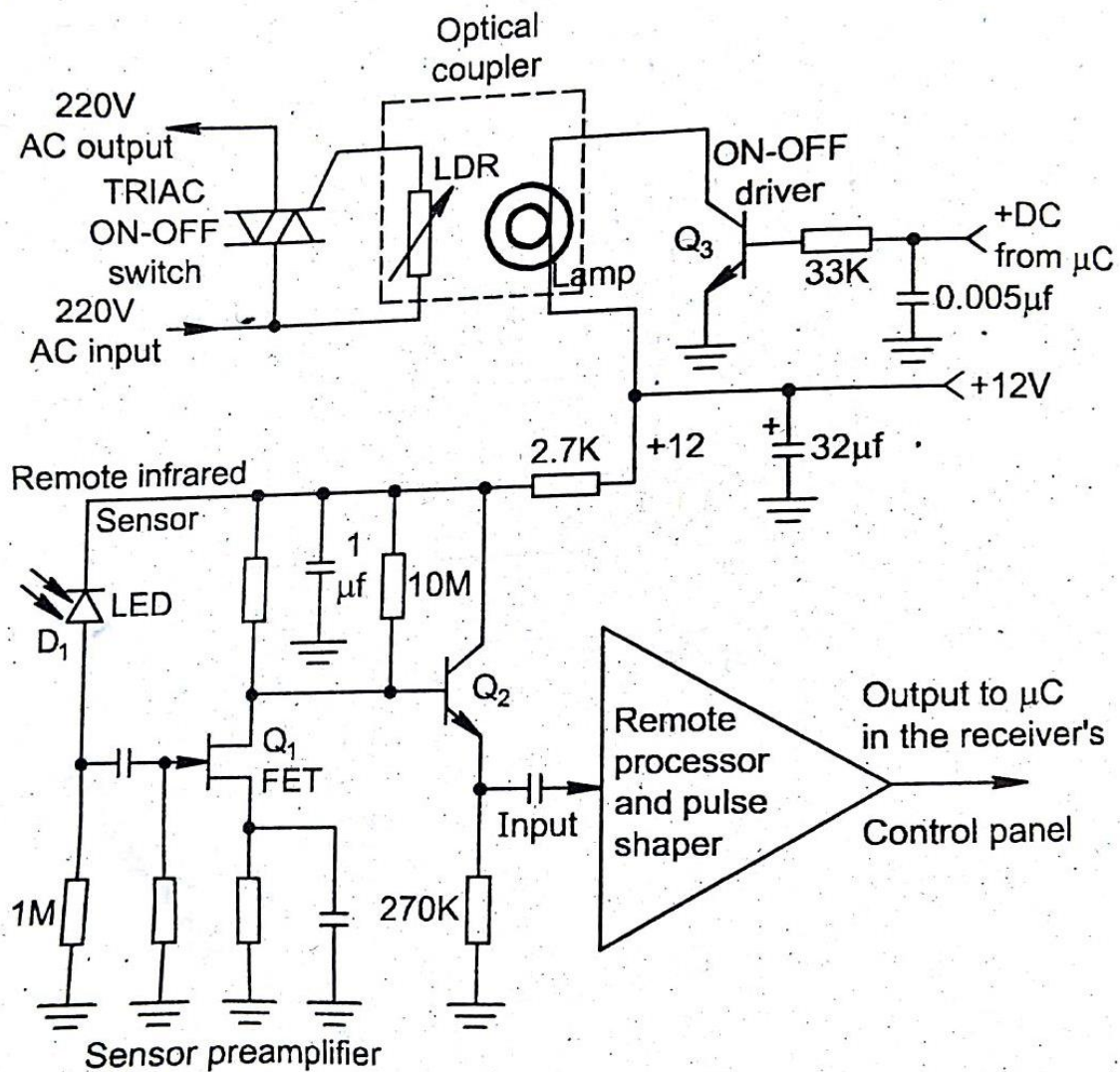
5.3 Remote control IR transmitters:



- To achieve all the necessary basic function 24 different commands are needed. So 24 different pulse patterns are generated. The modulator IC (encoder) performs the main function.

- The waves are modulated through a 480 KHZ carrier by one of the 24 pulse pattern.
- If any one of the key is pressed, it produces a distinctive pulse train which modulates the crystal controlled 480KHZ carrier.
- After proper amplification, it is fed to LED driver (Q1).The output of the Q1 drives the infrared LED D1 and D2 then the IR signal is transmitted.
- Then the function indicates LED D3 comes to ON state.
- If the LED is not glow on depression of a button then it indicates that the battery is to be replaced.

5.4 Remote control IR receiver:



- A simplified circuit diagram used for the synthesis of remote control receiver.
- The remote infrared sensor D1 is used to pick up the pulse modulated infrared signals send by the IR transmitter.

- The A.C signal picked up by D1 is fed to the FET Q1 for some amplification.
- The output of Q1 is given to emitter follower Q2 through remote processor and given to pulse shaper. Here signal is amplified and then demodulated.
- Demodulated distinct pulses belong to distinctive function.
- This is given to microcontroller.
- This microcontroller on receiving different pulses produces different output necessary to perform the ordered function.

For example:

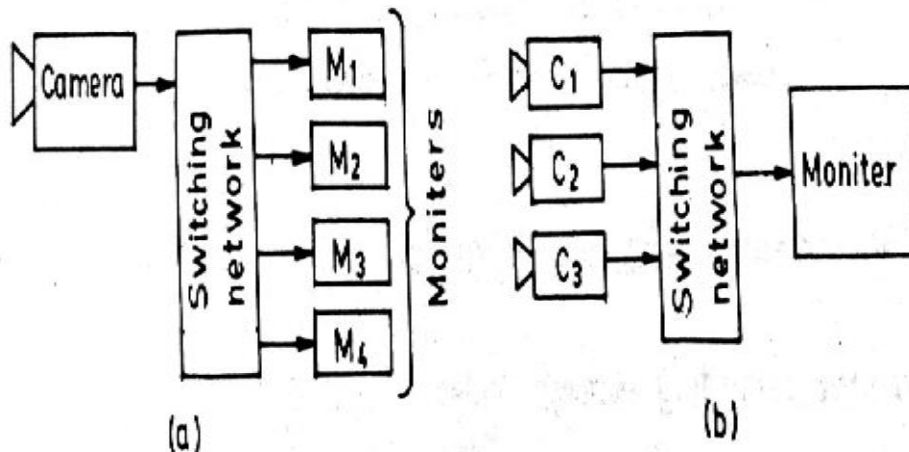
- The power ON/OFF button is pressed it is demodulated by the receiver then the micro computer output at the receiver is a positive voltage.
- Positive voltage through a 33k resistor turns 'ON' the transistor Q3 and operates the opto coupler and lamp is now glowing.
- The resistance of LDR decreases. Due to the resistance 220 V A.C applied to the gate of the transmitter, the TRIAC comes to ON state, so the TV receiver is switched ON.
- To turn the receiver OFF the ON button of the transmitter is pressed once again.
- The positive voltage to the base of Q3 is removed the TRIAC is deactivated and so the lamp goes OFF in the opto coupler unit.
- So the AC supply to the receiver is cutoff. The above sequence is repeated for successive depression of the ON/OFF button.

Similarly several different circuits are employed at the output of microcontroller to achieve different functions like volume control, color control and contrast control etc.

5.5 CCTV (closed circuit television system):

If a single camera output is given to TV receiver through cable or the output of many cameras is connected to a TV monitor, then the system is called CCTV system.

Two types of switching network are made possible between the camera and TV monitor. This makes us to select the camera / monitor. Both CCTV systems is shown,



In diagram (a) a single camera(C) is connected to many monitors (M) through switching network (SN).in this we can see a single program in monitors at many places.

In diagram (b) many cameras(C) are connected to single monitor (M) through switching network. In this at single place, we can see many programs happening at different places.

5.5.1 Application of CCTV:

1. **Education** – lecture classes and demonstration experiments.
2. **Business** - used to keep on eye over customer and sales personal
3. **Home** – seeing the caller before opening the door.
4. **Industries** – for remote inspection of objects in place where human resources cannot be used.
5. **Aerospace & oceanography**: To see the inaccessible objects or places.
6. **Medicine**: To visualize the surgery.

5.6 Scrambler-Necessity-Basic Principles

This channel provided by the cable TV owners to its customers is of two types.

They are

1. Basic services
2. Premium services

Several basic channels and local TV programmes offered by cable companies for a minimum charge level is called basic services.

For new movies, sports etc., separate channels are provided with additional charges called as premium services.

Cable TV connections provided for viewing premium services with additional charges is called as Conditional Access System (CAS).

In TVs provided with CAS connection only premium service programmes to be received.

For TVs provided with basic services connections premium services channel follow certain methods different from basic services. This is called scrambling. Equipments used for scrambling is called as scrambler.

5.7 Types of scrambling:

1) TRAP:

Here the signal is blocked by inserting and interfering carrier in the pay channel and notching it out.

2) Sync suppression scrambler:

Here the sync details from RF signal is removed and transmitted. So in basic services channels without H and V sync pulses pictures cannot be reproduced. Without sync pulses reference for AGC is also not provided. Without AGC bias contrast is overloaded.

So the picture continuously rolls with horizontal tearing of video signal.

3) Data encryption method:

In this method the audio and video signals are converted to digital forms. They are encoded using digital signal processing method. This is called as data encryption.

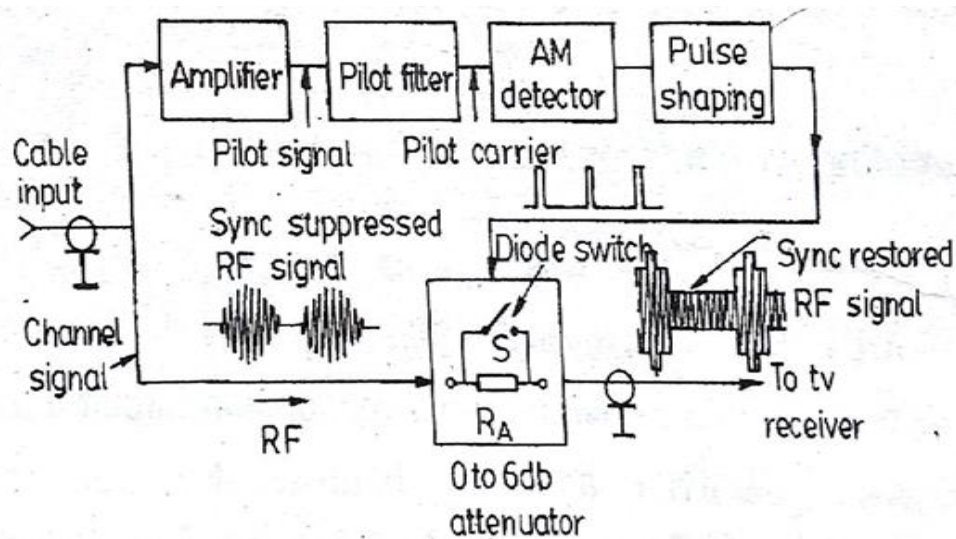
4) Baseband scrambling:

In this method the polarity of the randomly selected H- line is inverted. Line code for that particular H- line is transmitted with the video band.

5.8 Descrambler:

For channels that are scrambled, the signal cannot be reproduced normally. For that descrambler are needed. Signals that are scrambled is descrambled by an equipment is called descrambler. This process is called descrambling.

Descrambler block diagram:



- Descrambler reverses the effect of scrambling at the head end of the cable system. Simple sync suppression scrambling and descrambling method is mostly used.
- In this sync signals from the final output is removed and this information is sent through a pilot carrier.
- for this purpose a pilot carrier signal having a frequency lower than that of the selected channel is used.

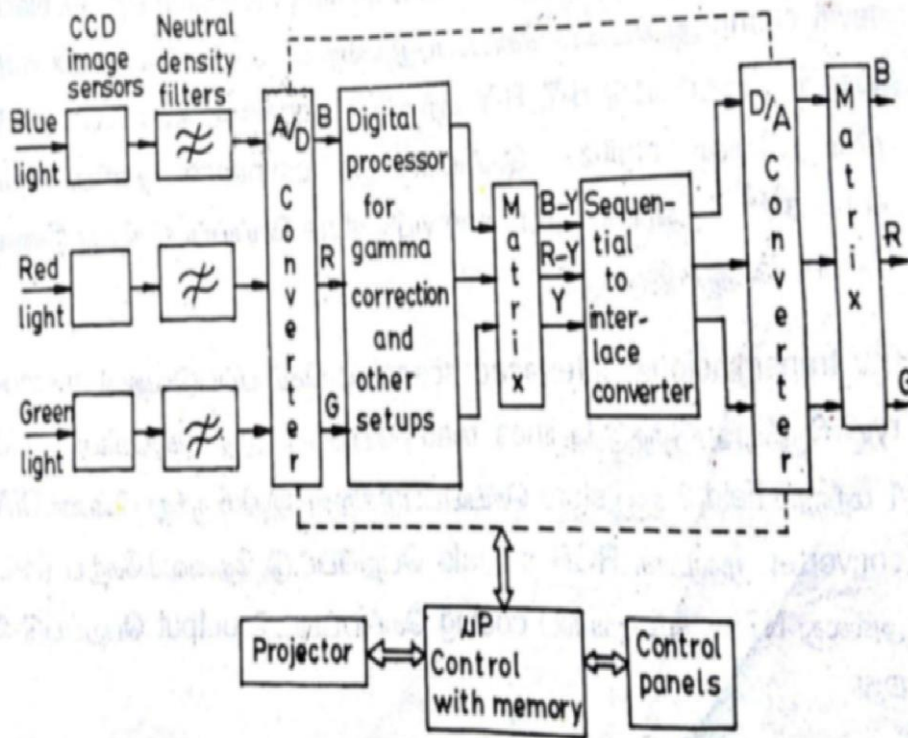
- Channel signal in the pilot signal is separated by the tuned amplifier. Pilot filter, filters the sync details from the pilot carrier. AM detector demodulates this. In the demodulated signal timing information needed for synchronization is available. For proper shaping, pulse shaping is provided. Keyed RF alternator is provided for mixing the sync signal with channel signal. Alternator is represented by resistor R_a . Keying by pass action is provided by diode. This is represented by 's'.

5.9 Telecine equipment:

In cinema cameras 24 frames per second is used. But for television 25 frames / second is used. So the pictures taken by movie camera is used for TV broadcast means, then it should be first converted to TV standards. The equipment used for this purpose is called telecine equipment.

5.10 Digital CCD telecine equipment:

Telecine equipment using CCD sensors that operate digitally is called as digital CCD telecine equipment. Block diagram is shown below.



Cine film is illuminated by slit of light. This represents H- line in TV scanning. By using dichroic prismatic splitters this light is separated to basic colors R,G and B. then it is given to separate CCD image sensors.

To correct the RGB sensitivity from the three CCD sensors, neutral density filters are used. The linear array in each CCD sensors contains 1024 elements. This represents H-line. By charge transfer method, the information's are moved in H – direction. Then H- scanning takes place. Then this is given to A/D converter and converted to digital signal.

Then by digital processing gamma correction and black level clamp is done. Then this is given to matrix network to produce B-Y, R-Y, and Y signals. Then it is digitized and separated to luminance and chrominance signal and stored in memory. This will be in sequential.

In TV transmission interlaced scanning is used. So from memory lines are read and stored in field 1 and field 2. Then this is given to D/A convertor, then the RGB signals are got and coded to required system (PAL and NTSC) and the output is got.

5.11 Introduction to high definition TV:

High definition television (HDTV) provides a resolution that is substantially higher than that of standard definition television. In HDTV, recent digital techniques are used for processing television signals. The aim of this HDTV are given below,

- I. Improvement in both vertical and horizontal resolution of the reproduced picture by approximately 2:1 over existing standards.
- II. Much improved color reproduction.
- III. Higher speed ratio at least 5:3 and
- IV. Stereophonic sound

Their implementation result is a picture quality as clear as obtained from 35mm cine films and sound as good as from digital audio discs.

HDTV may be transmitted in various formats.

- i. 1080p → 1920 x 1080p : - 2.1 megapixel (MPx) per frame
- ii. 1080i → 1920 x 1080i : - 2.1 megapixel (MPx) per frame
→1440 x 1080i: - 1.6 megapixel (MPx) per frame
- iii. 720p → 1280 x 720p : - 0.9 megapixel (MPx) per frame

The letter 'P' stands for progressive scan while 'I' indicates interlaced. Interlaced is fine for still and slow moving images. Progressive is fine for high speed video.

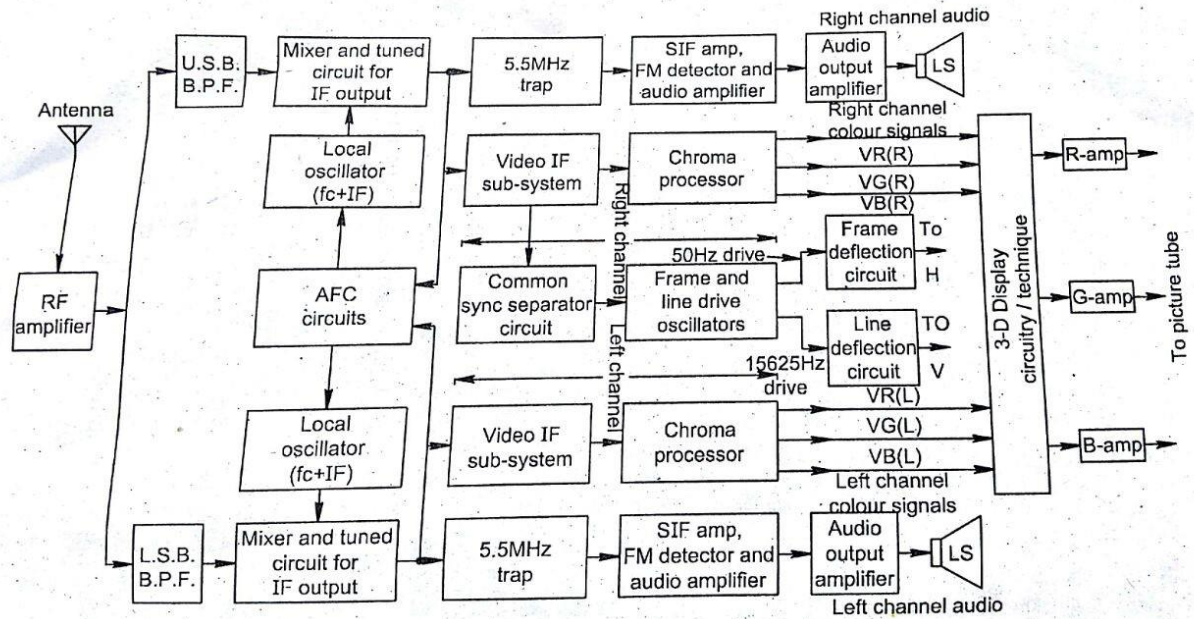
5.12 3D TV:

The two dimensional (length and breadth) pictures as we see on the television receiver screen look flat because these lack depth. However in three dimensional (3-D) appears to have all the qualities of a live scenes as viewed with natural vision. The 3-D picture scenes to extend beyond the screen at its back and also in the front.

The block schematic of a possible 3D picture and stereo sound receiver is shown in figure.

The RF amplifier in the tuner has a bandwidth of over 12 MHz and enough gain to feed sufficient amplitude of RF signal to the mixer (converter) circuits for easy separation of USB and LSB modulation components. The two RF sideband signals are separated by BP filters for feeding to corresponding mixer circuits. The USB IF signal is derived from the RF LSB signal by beating with the carrier equal to $(f_c - IF)$ MHz. From this stage onwards the two IF signals are processed separately, as in a conventional colour TV receiver to obtain the right and left channel RGB video signals.

The sync pulses are obtained from the composite video signal produced through video IF subsystems. On clipping and processing, these are fed to the vertical and horizontal (line) oscillator circuits for synchronizing, to obtain a steady raster. The right and left channel 5.5 MHz SIF signals are separated by trap circuits and demodulated in the usual way to feed the two stereo sound loudspeakers.



5.13 BLUE RAY:

5.13.1 Introduction:

Blue ray (or) Blue Ray disc is a next generation digital video disc. It is optical disc storage medium. It was introduced in 1996. It can, record, store, rewrite and play back high definition(HD) video and digital audio as well as large amounts of data.

A single layer BD can store up to 25GB of data and a double layer can store up to 50GB of data.

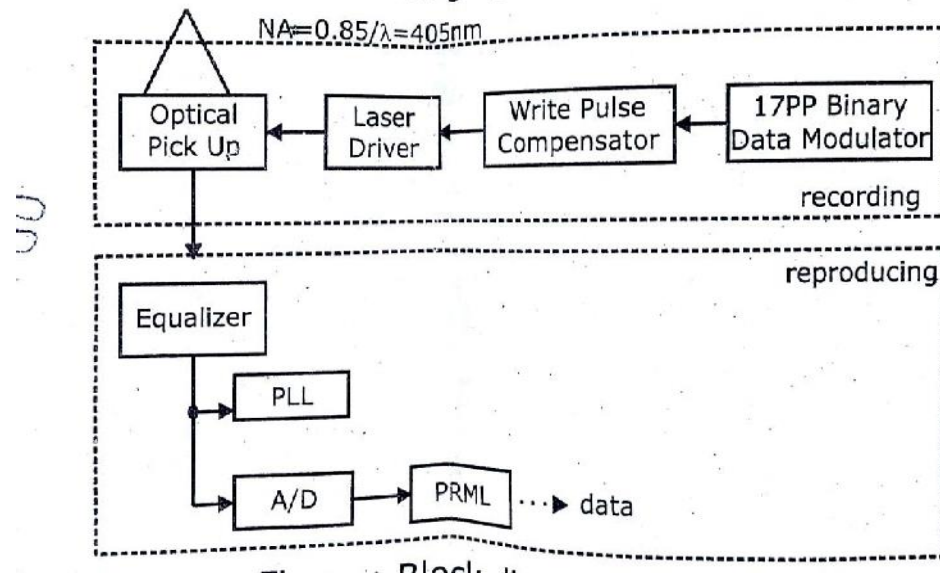
5.13.2 Disc parameter:

The following table shows the characteristics of BD.

Parameters	
Disk diameter	120 mm
Disk thickness	1.2 mm
Laser wavelength	405 nm
Numerical aperture	0.85
Minimum pit length	0.138 μ m
Data rate	36 Mb/sec
Number of sides	One or two
Number of data layers	One or two
Data capacity	Single layer : 25 GB
	Double layer : 50 GB

5.13.3 RECORDING AND PLAY BACK PRINCIPLES:

The recording and play back principle is described in the following figure



- **Recording:**

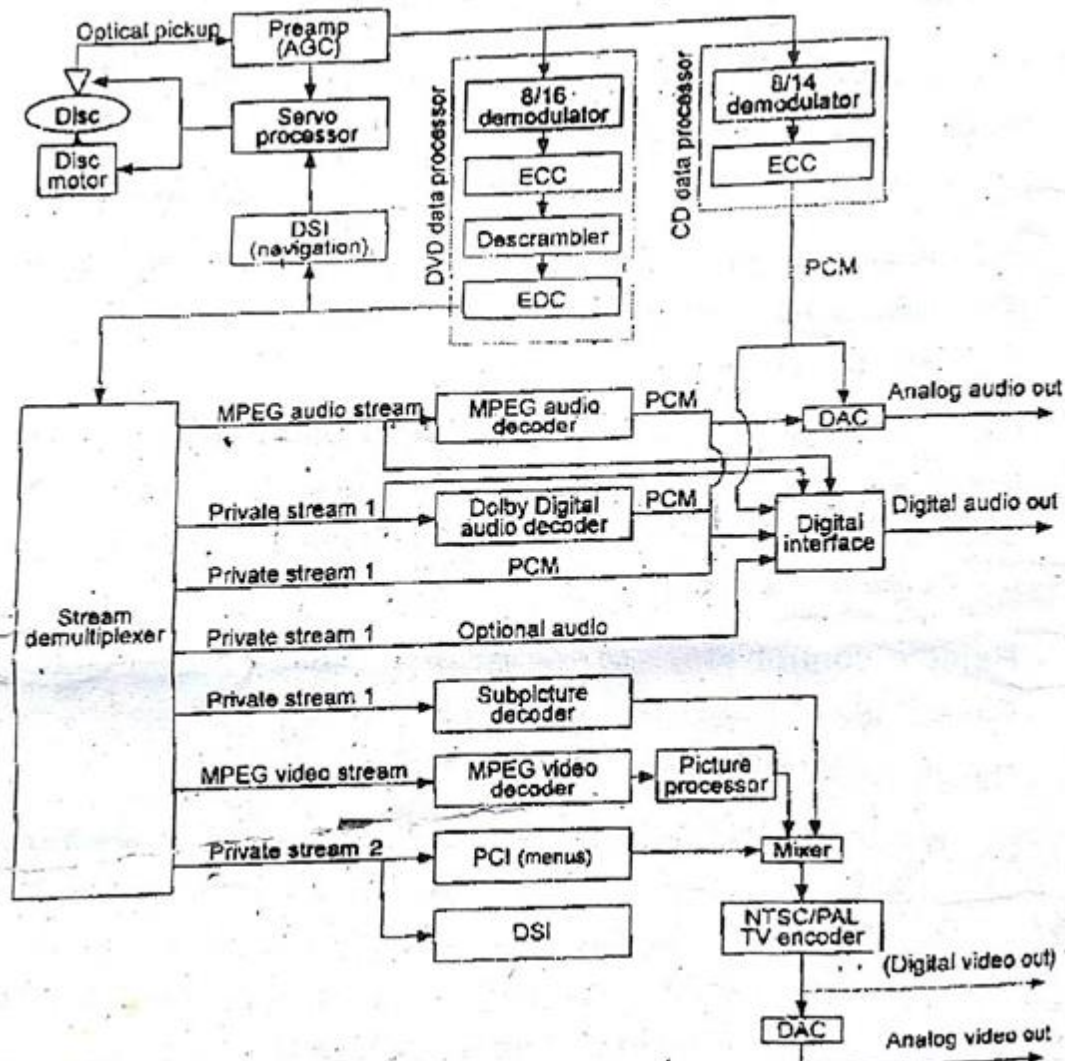
The binary data modulator encodes the NRZI signal according to the 17PP rule. The encoded signal is sent to a write pulse compensator. In which the signal is modulated to multi-pulse. The modulated pulse waveform is sent to a laser driver circuit. The laser driver circuit modulates the power of laser beam to record data on Blue – Ray disc.

- **Playback:**

To playback the recorded data, the reproduced signal through an equalizer is given to the Phase Locked Loop (PLL). The output of the equalizer is also given to the analog to digital (A/D) converter. The (A/D) converter converts the signal to digital. It is at the clock timing of PLL. Then the signal is passed through a PRML channel to correct the initial bit error. The output is the NRZI signal. It is sent to the subsequent digital signal processing unit.

5.14 Block diagram of DVD player:

Important sections and their working is explained below.



5.14.1 Optical pickup section:

Using disc motor, DVD rotates. Laser pickup assembly identifies the pits and lands in the tracks of rotating disc and gives the corresponding output voltage. DSI (data search information) navigate according to user requirement and gives servo signals for motor rotation according to read data.

5.14.2 DVD data processor:

DVD is modulated with 8 to 16 coding. This is demodulated and compared with details in ECC (Error Correction Code) and it is corrected if there is any error.

After that this is descrambled and verified using EDC(Error Detection Code)

While recording datas are multiplexed and stored. For demultiplexing, it is sent to stream demultiplexer.

5.14.3 CD Data Processor:

DVD player can read CD also. In CD data is modulated by 8 to 14 methods. After demodulation by using ECC. It is verified and the output data is sent to analog and digital output.

Stream demultiplexer:

In DVD at end of each sector EDC will be there. Using this, data is verified and sent to stream demultiplexer. Here all data (audio, video, subtitles) are multiplexed.

Here except MPEG audio / video others are marked as private stream.

By using remote control particular data is selected by using navigation manager data is operated. That selected data is sent to the respective decoders.

5.14.4 Decoding Section:

For each stream there will be distinctive decoders. By using decoders decoding is completed. If digital output is needed it is directly taken as digital and if analog output is needed by using DAC, analog output is taken.

5.14.5 Abbreviations used in block diagram:

ECC:Error Correction Code.

EDC: Error Detection Code

PCM: Pulse Code Modulation

PCI: Presenting Control Information

DSI: Data Search Information

5.15 Desirable features and output of DVD player:

- Since there is no physical content with the disc as it revolves the quality of pictures and sound in DVD.
- Movies on DVD can be seen in wide screen format and we can get an experience of watching in a cinema theatre.

Capacity:

- Single layer DVD hold over a 2 hours and dual layer hold 4 hours over.
- Still picture accompanied by hundreds of hours of audio and next.

Noise

- Most of the LD player make a whirring noise

Video

- DVD use digital video technique

Availability:

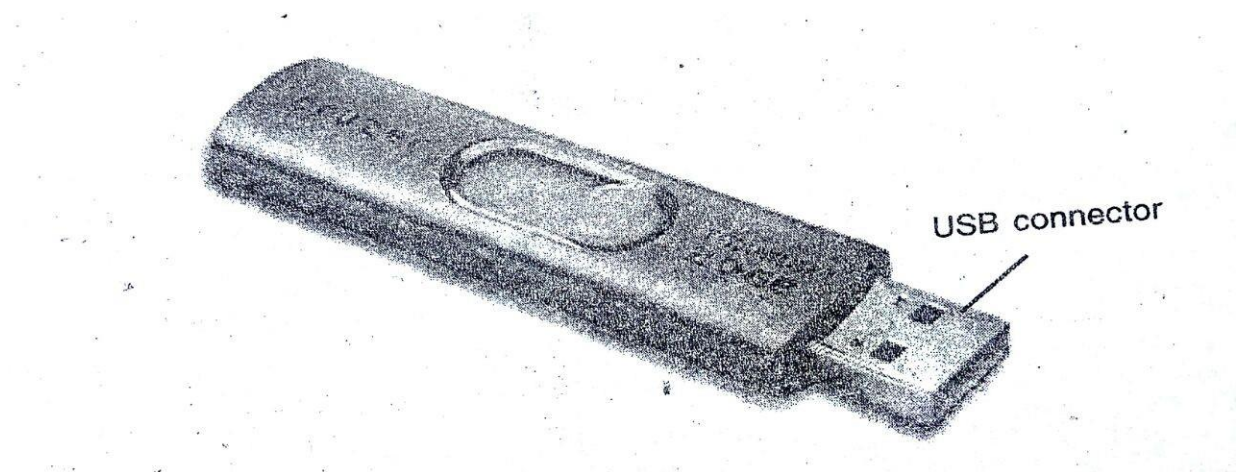
- DVD player and disc are available for purchase and rental in thousand of output in internet.

Price:

- Low cost DVD player are cheaper than the cheapest LD player. Most movies on DVD less than on LD.

5.15 USB flash drive (PEN DRIVE)

USB flash drive is a small portable flash memory card. This can be plugged into computer USB ports and function like a portable hard drive. This drive is otherwise called thump drive or jump drive or pen drive or key drives. These drives were introduced by IBM in December 2000. The figure given below show the structure of a flash drive.



A flash drive consists of a flash memory chip (EEPROM) protected inside a plastic metal. The USB connector is in one side and is protected by a removable cap. Most of the flash drives are preformatted with FAT or FAT 32 file systems. Each sector is of 512 bytes and the first sector contains a master boot record and partition table.

Therefore flash drive can be partitioned as hard drives. Flash drives are available in various capacities such as 1 GB, 2GB, 4GB etc.

5.15.1 Features:

- I. Flash drives are resistance to scratches and other mechanical damage.
- II. It is very small, so it can kept inside the user's pocket.
- III. Storage capacity is higher than a DVD.
- IV. It can be used as audio player.
- V. It uses less power than hard disk.
- VI. The user can insert the flash drive into the computer and use it immediately.

REVIEW QUESTION

PART – A

1. What is scrambling?
2. What is descrambling?
3. What is CCTV?
4. List out some models of DVD.
5. Expand HDTV, CCTV and DVD.
6. List out the types of scrambling method.

PART-B

1. List out some applications of CCTV.
2. Explain the types of scrambling.
3. List out some features of DVD.
4. Explain CCTV in detail.
5. What is telecine equipment?

PART-C

1. With neat block diagram explain the working of remote control IR transmitter.
2. With neat block diagram explain the working of remote control IR receiver.
3. With neat block diagram explain the working of descrambler.
4. With neat block diagram explain the working of digital CCD telecine equipment(System).
5. With neat block diagram explain the working of 3DTV.
6. With neat block diagram explain the working of DVD.
7. With neat block diagram explain the working of blue ray disc.
8. Explain in detail the USB flash drive (pen drive).
9. With neat block diagram explain the working of digital colour TV receiver.

1.