

A Course Material on
TELEVISION AND VIDEO ENGINEERING



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Class : IV Year ECE

being prepared by me and it meets the knowledge requirement of the university curriculum.

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SEAL

EC2034 TELEVISION AND VIDEO ENGINEERING**UNIT I FUNDAMENTALS OF TELEVISION**

Aspect ratio-Image continuity-Number of scanning lines-Interlaced scanning-Picture resolution-Camera tubes-Image Orthicon-Vidicon- Plumbicon- Silicon Diode Array Vidicon- Solid-state Image scanners-Monochrome picture tubes- Composite video signal- video signal dimension-horizontal sync. Composition-vertical sync. Details functions of vertical pulse train- Scanning sequence details. Picture signal transmission positive and negative modulation- VSB transmission- Sound signal transmission- Standard channel bandwidth.

UNIT II MONOCHROME TELEVISION TRANSMITTER AND RECEIVER

TV transmitter-TV signal Propagation- Interference- TV Transmission Antennas-Monochrome TV receiver- RF tuner- UHF, VHF tuner-Digital tuning techniques-AFT- IF subsystems-AGC Noise cancellation-Video and Sound inter-carrier detection-Vision IF subsystem- DC re-insertion-Video amplifier circuits-Sync operation- typical sync processing circuits-Deflection current waveforms, Deflection oscillators- Frame deflection circuits- requirements- Line deflection circuits-EHT generation-Receiver antennas.

UNIT III ESSENTIALS OF COLOUR TELEVISION

Compatibility- Colour perception-Three colour theory- Luminance, Hue and saturation- Colour television cameras-Values of luminance and colour difference signals-Colour television display tubes-Delta-gun Precision-in-line and Trinitron colour picture tubes- Purity and convergence- Purity and static and Dynamic convergence adjustments- Pincushion-correction techniques-Automatic degaussing circuit- Gray scale tracking colour signal transmission- Bandwidth-Modulation of colour difference signals-Weighting factors-Formation of chrominance signal.

UNIT IV COLOUR TELEVISION SYSTEMS

NTSC colour TV systems-SECAM system- PAL colour TV systems- Cancellation of phase errors-PAL-D Colour system-PAL coder-PAL-Decoder receiver-Chromo signal amplifier-separation of U and V signals-colour burst separation-Burst phase Discriminator-ACC amplifier-Reference Oscillator-Ident and colour killer circuits-U and V demodulators- Colour signal matrixing. Sound in TV

UNIT V ADVANCED TELEVISION SYSTEMS

Satellite TV technology-Geo Stationary Satellites-Satellite Electronics-Domestic Broadcast System-Cable TV-Cable Signal Sources-Cable Signal Processing, Distribution & Scrambling- Video Recording-VCR Electronics-Video Home Formats- Video Disc recording and playback-DVD Players-Tele Text Signal coding and broadcast receiver- Digital television-Transmission and reception –Projection television-Flat panel display TV receivers-LCD and Plasma screen receivers-3DTV-EDTV.

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UNIT I

FUNDAMENTALS OF TELEVISION

1.1.ASPECT RATIO

- The frame adopted in all television systems is rectangular with width/height ratio, *i.e.*, aspect ratio = 4/3. There are many reasons for this choice. In human affairs most of the motion occurs in the horizontal plane and so a larger width is desirable.
- The eyes can view with more ease and comfort when the width of a picture is more than its height. The usage of rectangular frame in motion pictures with a width/height ratio of 4/3 is another important reason for adopting this shape and aspect ratio.
- This enables direct television transmission of film programmes without wastage of any film area.
- It is not necessary that the size of the picture produced on the receiver screen be same as that being televised but it is essential that the aspect ratio of the two be same, otherwise the scene details would look too thin or too wide.
- This is achieved by setting the magnitudes of the current in the deflection coils to correct values, both at the TV camera and receiving picture tube.
- Another important requirement is that the same coordinates should be scanned at any instant both by the camera tube beam and the picture tube beam in the receiver. Synchronizing pulses are transmitted along with the picture information to achieve exact congruence between transmitter and receiver scanning systems.

1.2.IMAGE CONTINUITY

- While televising picture elements of the frame by means of the scanning process, it is necessary to present the picture to the eye in such a way that an illusion of continuity is created and any motion in the scene appears on the picture tube screen as a smooth and continuous change.
- To achieve this, advantage is taken of 'persistence of vision' or storage characteristics of the human eye. This arises from the fact that the sensation produced when nerves of the eye's retina are stimulated by incident light does not cease immediately after the light is removed but persists for about 1/16th of a second.
- Thus if the scanning rate per second is made greater than sixteen, or the number of pictures shown per second is more than sixteen, the eye is able to integrate the changing levels of brightness in the scene. So when the picture elements are scanned rapidly enough, they appear to the eye as a complete picture unit, with none of the individual elements visible separately.
- In present day motion pictures twenty-four still pictures of the scene are taken per second and later projected on the screen at the same rate. Each picture or frame is projected individually as a still picture, but they are shown one after the other in rapid succession to produce the illusion of continuous motion of the scene being shown.

- A shutter in the projector rotates in front of the light source and allows the film to be projected on the screen when the film frame is still, but blanks out any light from the screen during the time when the next film frame is being moved into position.
- As a result, a rapid succession of still-film frames is seen on the screen. With all light removed during the change from one frame to the next, the eye sees a rapid sequence of still pictures that provides the illusion of continuous motion. Scanning. A similar process is carried out in the television system.

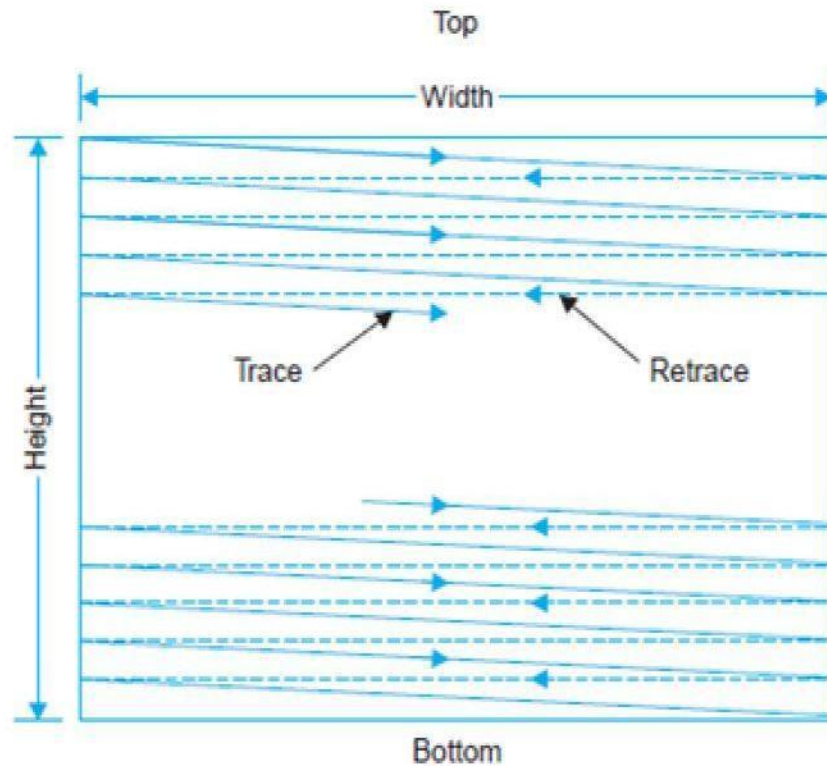


Figure. Path of scanning beam in covering picture area

- The scene is scanned rapidly both in the horizontal and vertical directions simultaneously to provide sufficient number of complete pictures or frames per second to give the illusion of continuous motion. Instead of the 24 as in commercial motion picture practice, the frame repetition rate is 25 per second in most television systems.
- Horizontal scanning. Fig. (a) shows the trace and retrace of several horizontal lines. The linear rise of current in the horizontal deflection coils (Fig. (b)) deflects the beam across the screen with a continuous, uniform motion for the trace from left to right.
- At the peak of the rise, the sawtooth wave reverses direction and decreases rapidly to its initial value.

- This fast reversal produces the retrace or flyback. The start of the horizontal trace is at the left edge of raster. The finish is at the right edge, where the flyback produces retrace back to the left edge. Note, that 'up' on the sawtooth wave corresponds to horizontal deflection to the right. The heavy lines in Fig. (a) indicate the useful scanning time and the dashed lines correspond to the retrace time.
- Vertical scanning. The sawtooth current in the vertical deflection coils (see Fig.) moves the electron beam from top to bottom of the raster at a uniform speed while the electron beam is being deflected horizontally.
- Thus the beam produces complete horizontal lines one below the other while moving from top to bottom. As shown in Fig. (c), the trace part of the sawtooth wave for vertical scanning deflects the beam to the bottom of the raster. Then the rapid vertical retrace returns the beam to the top.
- Note that the maximum amplitude of the vertical sweep current brings the beam to the bottom of the raster. As shown in Fig. (b) during vertical retrace the horizontal scanning continues and several lines get scanned during this period. Because of motion in the scene being televised, the information or brightness at the top of the target plate or picture tube screen normally changes by the time the beam returns to the top to recommence the whole process.
- This information is picked up during the next scanning cycle and the whole process is repeated 25 times to cause an illusion of continuity. The actual scanning sequence is however a little more complex than that just described and is explained in a later section of this chapter. It must however be noted, that both during horizontal retrace and vertical retrace intervals the scanning beams at the camera tube and picture tube are blanked and no picture information is either picked up or reproduced.
- Instead, on a time division basis, these short retrace intervals are utilized for transmitting distinct narrow pulses to keep the sweep oscillators of the picture tube deflection circuits of the receiver in synchronism with those of the camera at the transmitter.
- This ensures exact correspondence in scanning at the two ends and results in distortion less reproduction of the picture details.

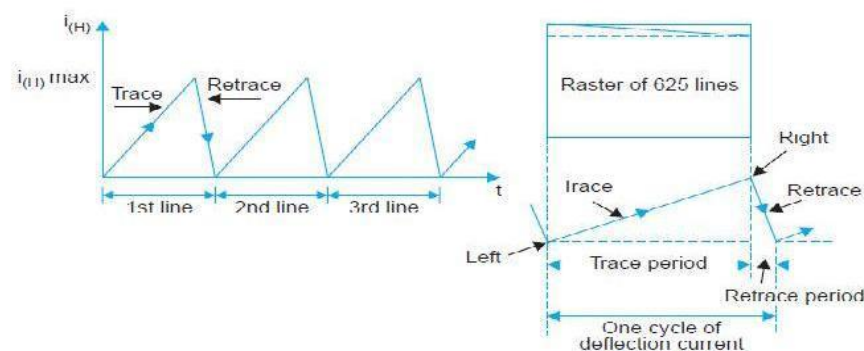
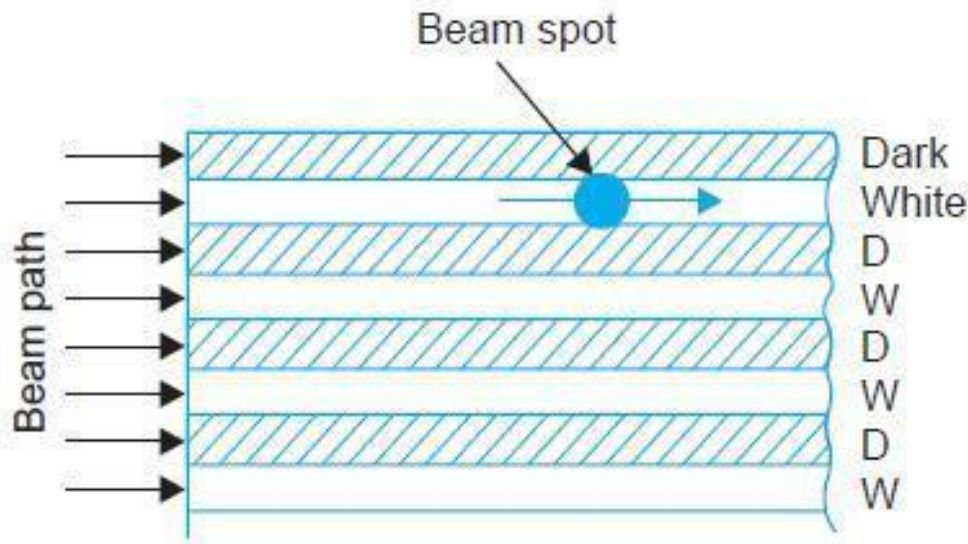


Figure. Waveform of current in the horizontal deflection coils producing linear (constant velocity) scanning in the horizontal direction.

1.3. NUMBER OF SCANNING LINES

- Most scenes have brightness gradations in the vertical direction. The ability of the scanning beam to allow reproduction of electrical signals according to these variations and the capability of the human eye to resolve these distinctly, while viewing the reproduced picture, depends on the total number of lines employed for scanning.
- It is possible to arrive at some estimates of the number of lines necessary by considering the bar pattern shown in Fig. (a), where alternate lines are black and white. If the thickness of the scanning beam is equal to the width of each white and black bar, and the number of scanning lines is chosen equal to the number of bars, the electrical information corresponding to the brightness of each bar will be correctly reproduced during the scanning process.
- Obviously the greater the number of lines into which the picture is divided in the vertical plane, the better will be the resolution. However, the total number of lines that need be employed is limited by the resolving capability of the human eye at the minimum viewing distance.
- The maximum number of alternate light and dark elements (lines) which can be resolved by the eye is given by $N_v = \frac{1}{\theta}$ where N_v = total number of lines (elements) to be resolved in the vertical direction, θ = minimum resolving angle of the eye expressed in radians, and $\theta = D/H$ = viewing-distance/picture height.
- For the eye this resolution is determined by the structure of the retina, and the brightness level of the picture. It has been determined experimentally that with reasonable brightness variations and a minimum viewing distance of four times the picture height ($D/H = 4$), the angle that any two adjacent elements must subtend at the eye for distinct resolution is approximately one minute ($1/60$ degree). This is illustrated in Fig (b). Substituting these values of θ and D/H we get $N_v = \frac{1}{\theta} = \frac{1}{1/180 \times 1/60} \times 4$
- Thus if the total number of scanning lines is chosen close to 860 and the scanning beam as illustrated in Fig. (a) just passes over each bar (line) separately while scanning all the lines from top to bottom of the picture frame, a distinct pick up of the picture information results and this is the best that can be expected from the system.
- This perhaps explains the use of 819 lines in the original French TV system. In practice however, the picture elements are not arranged as equally spaced segments but have random distribution of black, grey and white depending on the nature of the picture details or the scene under consideration.
- Statistical analysis and subjective tests carried out to determine the average number of effective lines suggest that about 70 per cent of the total lines or segments get separately scanned in the vertical direction and the remaining 30 per cent get merged with other elements due to the beam spot falling equally on two consecutive lines.
- This is illustrated in Fig.(c). Thus the effective number of lines distinctly resolved, i.e., $N_r = N_v \times k$, where k is the resolution factor whose value lies between 0.65 to 0.75. Assuming the value of $k = 0.7$ we get, $N_r = N_v \times k = 860 \times 0.7 = 602$.



Scanning spot perfectly aligned with black and white lines

- However, there are other factors which also influence the choice of total number of lines in a TV system.
- Tests conducted with many observers have shown that though the eye can detect the effective sharpness provided by about 800 scanning lines, but the improvement is not very significant with line numbers greater than 500 while viewing pictures having motion. Also the channel bandwidth increases with increase in number of lines and this not only adds to the cost of the system but also reduces the number of television channels that can be provided in a given VHF or UHF transmission band.
- Thus as a compromise between quality and cost, the total number of lines inclusive of those lost during vertical retrace has been chosen to be 625 in the 625-B monochrome TV system. In the 525 line American system, the total number of lines has been fixed at 525 because of a somewhat higher scanning rate employed in this system.

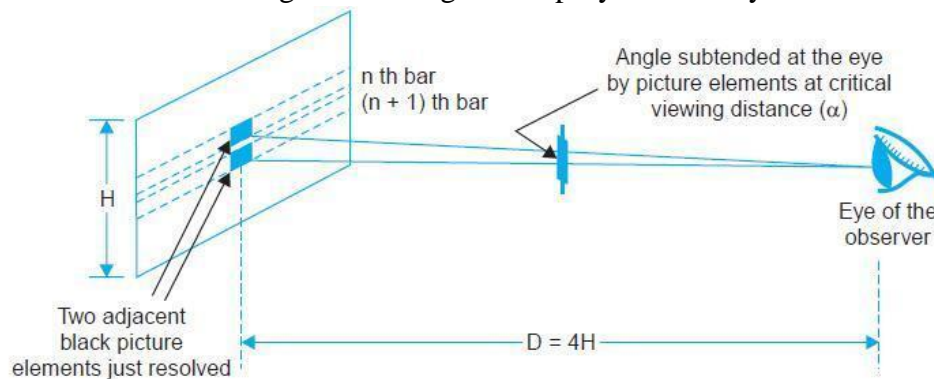


Figure. Critical viewing distance as determined by the ability of the eye to resolve two separate picture elements

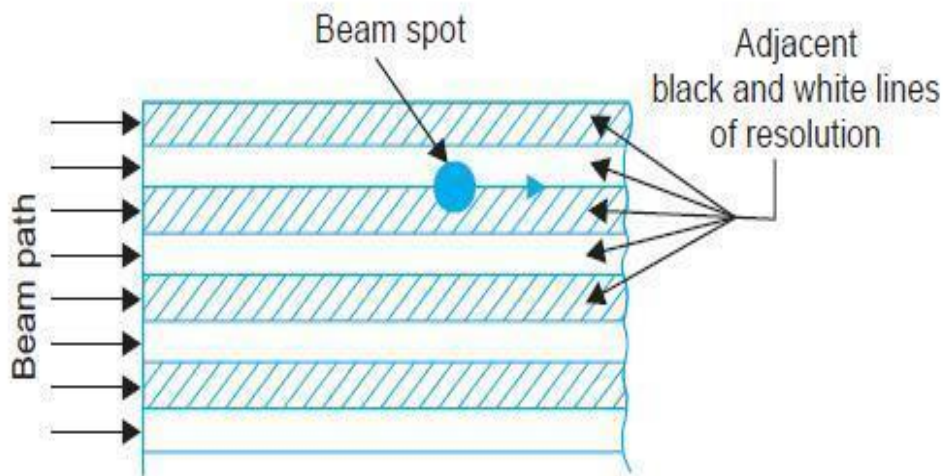


Figure. Scanning beam focused on the junction of black and white lines.

1.4. INTERLACED SCANNING

- Interlaced scanning. In television pictures an effective rate of 50 vertical scans per second is utilized to reduce flicker. This is accomplished by increasing the downward rate of travel of the scanning electron beam, so that every alternate line gets scanned instead of every successive line.
- Then, when the beam reaches the bottom of the picture frame, it quickly returns to the top to scan those lines that were missed in the previous scanning. Thus the total number of lines are divided into two groups called 'fields'. Each field is scanned alternately. This method of scanning is known as interlaced scanning and is illustrated in Fig. It reduces flicker to an acceptable level since the area of the screen is covered at twice the rate.
- This is like reading alternate lines of a page from top to bottom once and then going back to read the remaining lines down to the bottom. In the 625 line monochrome system, for successful interlaced scanning, the 625 lines of each frame or picture are divided into sets of 312.5 lines and each set is scanned alternately to cover the entire picture area.
- To achieve this the horizontal sweep oscillator is made to work at a frequency of 15625 Hz ($312.5 \times 50 = 15625$) to scan the same number of lines per frame ($15625/25 = 625$ lines), but the vertical sweep circuit is run at a frequency of 50 instead of 25 Hz.
- Note that since the beam is now deflected from top to bottom in half the time and the horizontal oscillator is still operating at 15625 Hz, only half the total lines, i.e., 312.5 ($625/2 = 312.5$) get scanned during each vertical sweep.

- Since the first field ends in a half line and the second field commences at middle of the line on the top of the target plate or screen (see Fig), the beam is able to scan the remaining 312.5 alternate lines during its downward journey. In all then, the beam scans 625 lines ($312.5 \times 2 = 625$) per frame at the same rate of 15625 lines ($312.5 \times 50 = 15625$) per second. Therefore, with interlaced scanning the flicker effect is eliminated without increasing the speed of scanning, which in turn does not need any increase in the channel bandwidth. It may be noted that the frame repetition rate of 25 (rather than 24 as used in motion pictures) was chosen to make the field frequency equal to the power line frequency of 50 Hz.
- This helps in reducing the undesired effects of hum due to pick up from the mains, because then such effects in the picture stay still, instead of drifting up or down on the screen.
- In the American TV system, a field frequency of 60 was adopted because the supply frequency is 60 Hz in USA. This brings the total number of lines scanned per second ($(525/2) \times 60 = 15750$) lines to practically the same as in the 625 line system. Scanning periods.
- The wave shapes of both horizontal and vertical sweep currents are shown in Fig. As shown there the retrace times involved (both horizontal and vertical) are due to physical limitations of practical scanning systems and are not utilized for transmitting or receiving any video signal.
- The nominal duration of the horizontal line as shown in Fig. (a) is $64 \mu\text{s}$ ($10^6/15625 = 64 \mu\text{s}$), out of which the active line period is $52 \mu\text{s}$ and the remaining $12 \mu\text{s}$ is the line blanking period. The beam returns during this short interval to the extreme left side of the frame to start tracing the next line.
- Similarly with the field frequency set at 50 Hz, the nominal duration of the vertical trace (see Fig (b)) is 20 ms ($1/50 = 20 \text{ ms}$). Out of this period of 20 ms, 18.720 ms are spent in bringing the beam from top to bottom and the remaining 1.280 ms is taken by the beam to return back to the top to commence the next cycle.
- Since the horizontal and vertical sweep oscillators operate continuously to achieve the fast sequence of interlaced scanning, 20 horizontal lines $F G 1280 \mu\text{s} = 20 \text{ lines I J}$ get traced during each vertical retrace interval.
- Thus 40 scanning $H 64 \mu\text{s} K$ lines are lost per frame, as blanked lines during the retrace interval of two fields. This leaves the active number of lines, N_a , for scanning the picture details equal to $625 - 40 = 585$, instead of the 625 lines actually scanned per frame. Scanning sequence.
- The complete geometry of the standard interlaced scanning pattern is illustrated in Fig. Note that the lines are numbered in the sequence in which these are actually scanned. During the first vertical trace actually 292.5 lines are scanned.

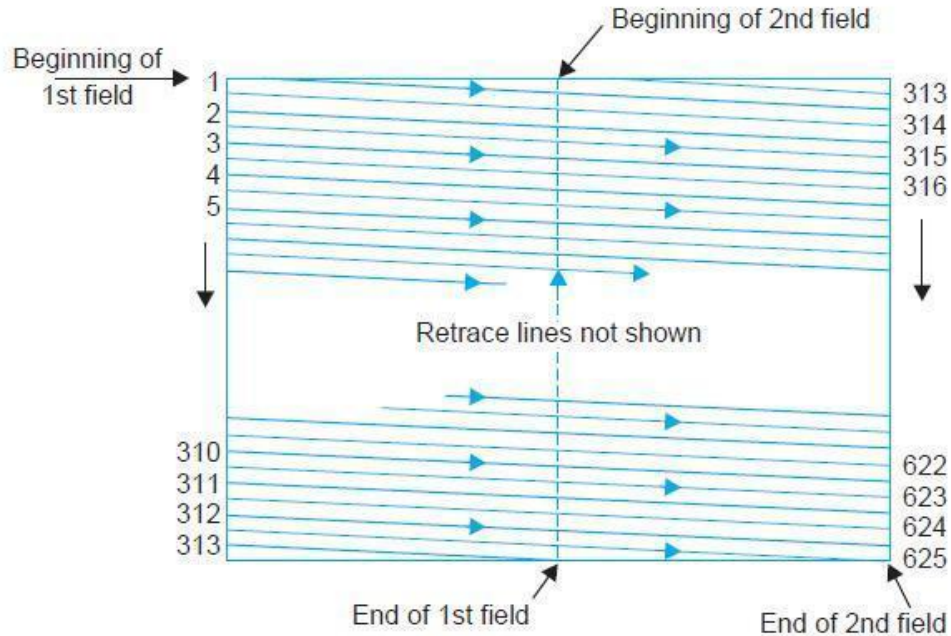


Figure. Principle of interlaced scanning. Note that the vertical retrace time has been assumed to be zero

- The beam starts at A, and sweeps across the frame with uniform velocity to cover all the picture elements in one horizontal line. At the end of this trace the beam then retraces rapidly to the left side of the frame as shown by the dashed line in the illustration to begin the next horizontal line.
- Note that the horizontal lines slope downwards in the direction of scanning because the vertical deflecting current simultaneously produces a vertical scanning motion, which is very slow compared with horizontal scanning. The slope of the horizontal trace from left to right is greater than during retrace from right to left.
- The reason is that the faster retrace does not allow the beam so much time to be deflected vertically. After line one, the beam is at the left side ready to scan line 3, omitting the second line.
- However, as mentioned earlier it is convenient to number the lines as they are scanned and so the next scanned line skipping one line, is numbered two and not three. This process continues till the last line gets scanned half when the vertical motion reaches the bottom of the raster or frame.
- As explained earlier skipping of lines is accomplished by doubling the vertical scanning frequency from the frame or picture repetition rate of 25 to the field frequency of 50 Hz. With the field frequency of 50 Hz the height of the raster is so set that 292.5 lines get scanned as the beam travels from top to bottom and reaches point B.

- Now the retrace starts and takes a period equal to 20 horizontal line periods to reach the top marked C.

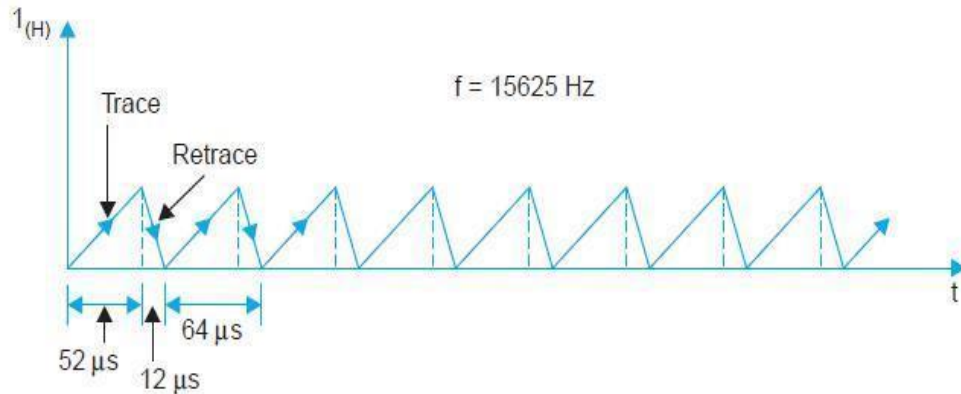


Figure. Horizontal deflection current

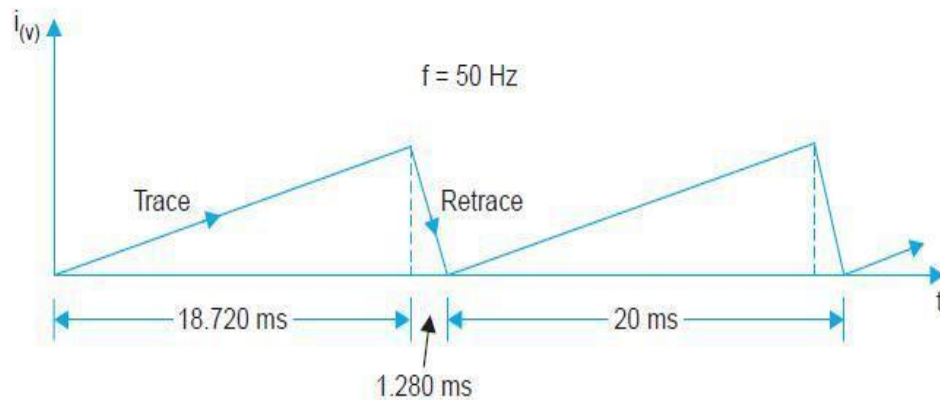


Figure. Vertical deflection current

- These 20 lines are known as inactive lines, as the scanning beam is cut-off during this period. Thus the second field starts at the middle of the raster and the first line scanned is the 2nd half of line number 313.
- The scanning of second field, starting at the middle of the raster automatically enables the beam to scan the alternative lines left un-scanned during the first field. The vertical scanning motion otherwise is exactly the same as in the previous field giving all the horizontal lines the same slope downwards in the direction of scanning.
- As a result 292.5 lines again get scanned and the beam reaches the bottom of the frame when it has completed full scanning of line number 605.
- The inactive vertical retrace again begins and brings the beam back to the top at point A in a period during which 20 blanked horizontal lines (605 to 625) get scanned. Back at point A, the scanning beam has just completed two fields or one frame and is ready to start the third field covering the same area (no. of lines) as scanned during the first field. This process (of scanning fields) is continued at a fast rate of 50 times a second, which

not only creates an illusion of continuity but also solves the problem of flicker satisfactorily.

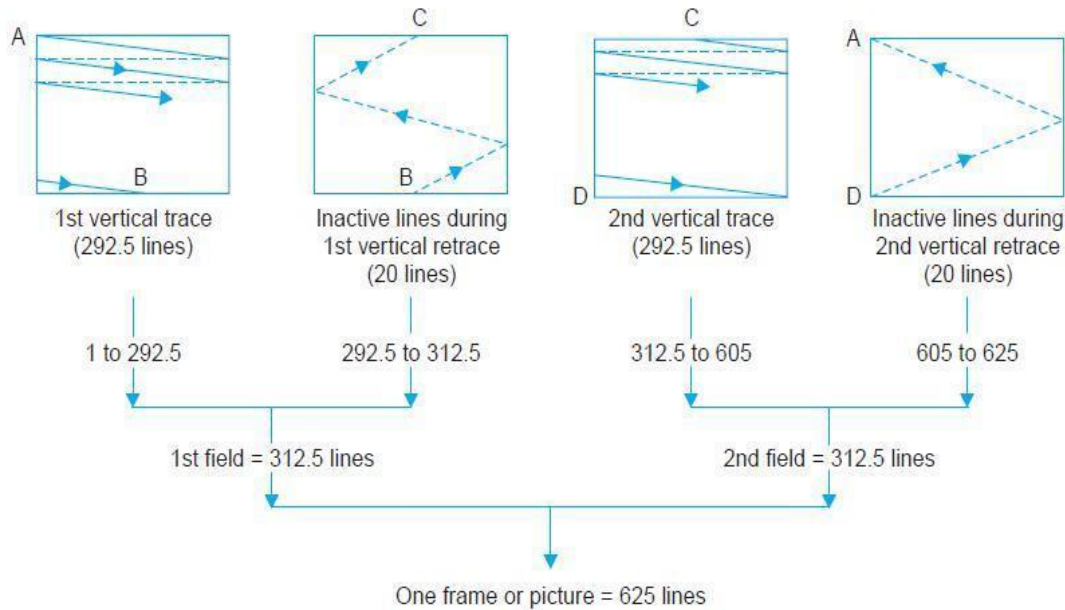


Figure. Odd line interlaced scanning procedure.

1.6. TELEVISION CAMERA TUBES

- A TV camera tube may be called the eye of a TV system. For such an analogy to be correct the tube must possess characteristic that are similar to its human counterpart. Some of the more important functions must be,
 - (i) sensitivity to visible light, (ii) wide dynamic range with respect to light intensity, and
 - (iii) ability to resolve details while viewing a multi-element scene.
- During the development of television, the limiting factor on the ultimate performance had always been the optical-electrical conversion device, i.e., the pick-up tube.
- Most types developed have suffered to a greater or lesser extent from (i) poor sensitivity, (ii) poor resolution, (iii) high noise level, (iv) undesirable spectral response, (v) instability, (vi) poor contrast range and (vii) difficulties of processing. However, development work during the past fifty years or so, has enabled scientists and engineers to develop image pick-up tubes, which not only meet the desired requirements but in fact excel the human eye in certain respects.
- Such sensitive tubes have now been developed which deliver output even where our eyes see complete darkness. Spectral response has been so perfected, that pick-up outside the visible range (in infra-red and ultraviolet regions) has become possible. In fact, now there is a tube available for any special application.

BASIC PRINCIPLE

- When minute details of a picture are taken into account, any picture appears to be composed of small elementary areas of light or shade, which are known as picture elements. The elements thus contain the visual image of the scene.
- The purpose of a TV pick-up tube is to sense each element independently and develop a signal in electrical form proportional to the brightness of each element. As already explained in Chapter 1, light from the scene is focused on a photosensitive surface known as the image plate, and the optical image thus formed with a lens system represents light intensity variations of the scene.
- The photoelectric properties of the image plate then convert different light intensities into corresponding electrical variations.
- In addition to this photoelectric conversion whereby the optical information is transduced to electrical charge distribution on the photosensitive image plate, it is necessary to pick-up this information as fast as possible. Since simultaneous pick-up is not possible, scanning by an electron beam is resorted to.
- The electron beam moves across the image plate line by line, and field by field to provide signal variations in a successive order. This scanning process divides the image into its basic picture elements. Through the entire image plate is photoelectric, its construction isolates the picture elements so that each discrete small area can produce its own signal variations.

Photoelectric Effects

- The two photoelectric effects used for converting variations of light intensity into electrical variations are (i) photoemission and (ii) photoconductivity. Certain metals emit electrons when light falls on their surface.
- These emitted electrons are called photoelectrons and the emitting surface a photocathode. Light consists of small bundles of energy called photons. When light is made incident on a photocathode, the photons give away their energy to the outer valence electrons to allow them to overcome the potential-energy barrier at the surface.
- The number of electrons which can overcome the potential barrier and get emitted, depends on the light intensity. Alkali metals are used as photocathode because they have very low work-function.
- Cesium-silver or bismuth-silver-cesium oxides are preferred as photo emissive surfaces because they are sensitive to incandescent light and have spectral response very close to the human eye. The second method of producing an electrical image is by photoconduction, where the conductivity or resistivity of the photosensitive surface varies in proportion to the intensity of light focused on it.
- In general the semiconductor metals including selenium, tellurium and lead with their oxides have this property known as photoconductivity. The variations in resistance at each point across the surface of the material is utilized to develop a varying signal by scanning it uniformly with an electron beam. Image Storage Principle Television cameras developed during the initial stages of development were of the non-storage type, where

the signal output from the camera for the light on each picture element is produced only at the instant it is scanned.

- Most of the illumination is wasted. Since the effect of light on the image plate cannot be stored, any instantaneous pick-up has low sensitivity. Image dissector and flying-spot camera are examples of non-storage type of tubes. These are no longer in use and will not be discussed.
- High camera sensitivity is necessary to televise scenes at low light levels and to achieve this, storage type tubes have been developed. In storage type camera tubes the effect of illumination on every picture element is allowed to accumulate between the times it is scanned in successive frames. With light storage tubes the amount of photoelectric signal can be increased 10,000 times approximately compared with the earlier non-storage type.

The Electron Scanning Beam

- As in the case of picture tubes an electron gun produces a narrow beam of electrons for scanning. In camera tubes magnetic focusing is normally employed. The electrons must be focused to a very narrow and thin beam because this is what determines the resolving capability of the camera.
- The diameter of the beam determines the size of the smallest picture element and hence the finest detail of the scene to which it can be resolved. Any movement of electric charge is a flow of current and thus the electron beam constitutes a very small current which leaves the cathode in the electron gun and scans the target plate.
- The scanning is done by deflecting the beam with the help of magnetic fields produced by horizontal and vertical coils in the deflection yoke put around the tubes. The beam scans 312.5 lines per field and 50 such fields are scanned per second.

Video Signal

- In tubes employing photo emissive target plates the electron beam deposits some charge on the target plate, which is proportional to the light intensity variations in the scene being televised.
- The beam motion is so controlled by electric and magnetic fields, that it is decelerated before it reaches the target and lands on it with almost zero velocity to avoid any secondary emission.
- Because of the negative acceleration the beam is made to move back from the target and on its return journey, which is very accurately controlled by the focusing and deflection coils, it strikes an electrode which is located very close to the cathode from where it started. The number of electrons in the returning beam will thus vary in accordance with the charge deposited on the target plate.
- This in turn implies that the current which enters the collecting electrode varies in amplitude and represents brightness variations of the picture. This current is finally made to flow through a resistance and the varying voltage developed across this resistance constitutes the video signal. Figure (a) illustrates the essentials of this technique of developing video signal. In camera tubes employing photoconductive cathodes the scanning electron beam causes a flow of current through the photoconductive material.

- The amplitude of this current varies in accordance with the resistance offered by the surface at different points. Since the conductivity of the material varies in accordance with the light falling on it, the magnitude of the current represents the brightness variations of the scene.
- This varying current completes its path under the influence of an applied dc voltage through a load resistance connected in series with path of the current. The instantaneous voltage developed across the load resistance is the video signal which, after due amplification and processing is amplitude modulated and transmitted.
- Figure (b) shows a simplified illustration of this method of developing video signal. **Electron Multiplier** When the surface of a metal is bombarded by incident electrons having high velocities, secondary emission takes place.
- Aluminium, as an example, can release several secondary electrons for each incident primary electron. Camera tubes often include an electron multiplier structure, making use of the secondary emission effect to amplify the small amount of photoelectric current that is later employed to develop video signal.
- The electron multiplier is a series of cold anode-cathode electrodes called dynodes mounted internally, with each at a progressively higher positive potential as illustrated in Fig. The few electrons emitted by the photocathode are accelerated to a more positive dynode.
- The primary electrons can then force the ejection of secondary emission electrons when the velocity of the incident electrons is large enough. The secondary emission ratio is normally three or four, depending on the surface and the potential applied.

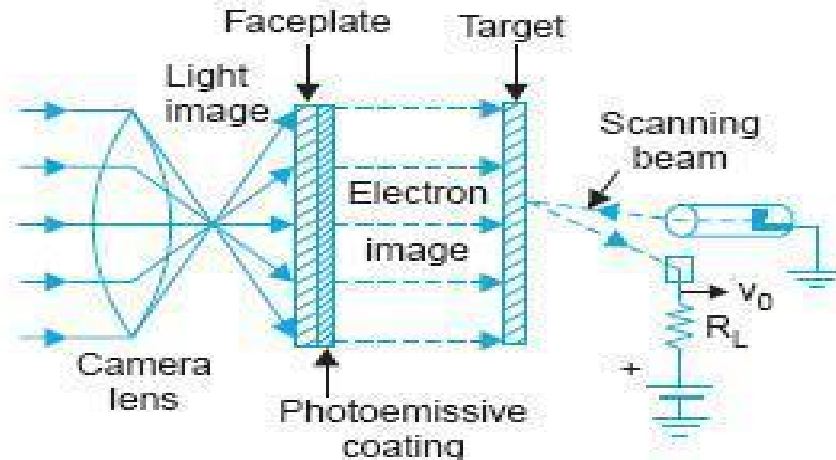


Figure. Production of video signal by photoemission

- The number of electrons available is multiplied each time the secondary electrons strike the emitting surface of the next more positive dynode. The current amplification thus obtained is noise free because the electron multiplier does not have any active device or resistors.

- Since the signal amplitude is very low any conventional amplifier, if used instead of the electron multiplier, would cause serious S/N ratio problems

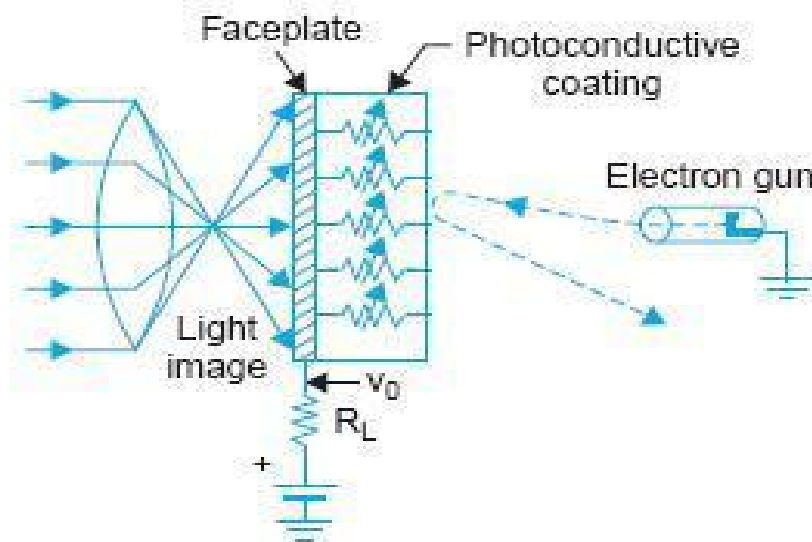


Figure. Production of video signal by photoconduction.

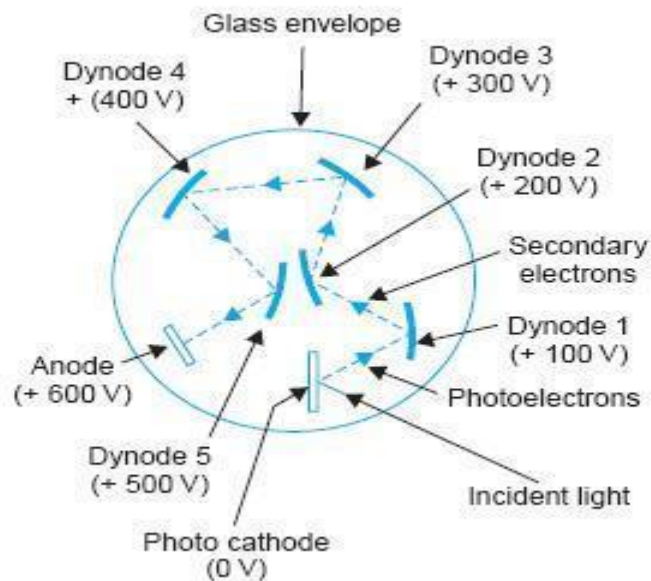
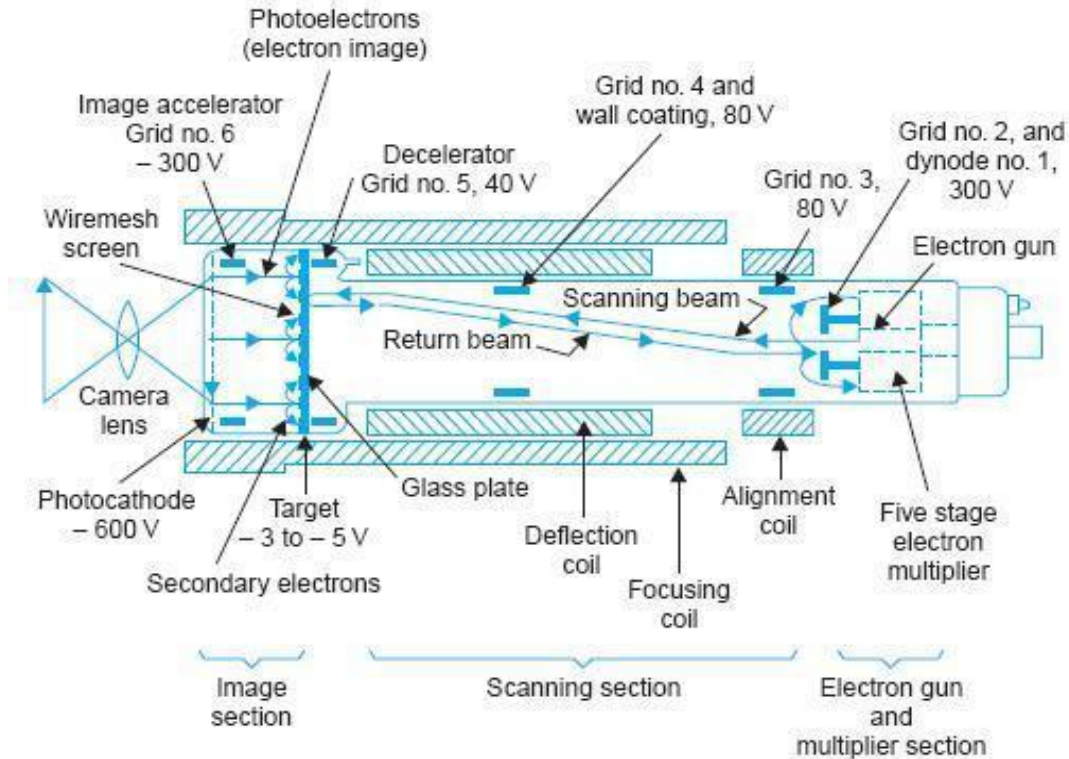


Figure. Illustration of an electron-multiplier structure.

1.7. IMAGE ORTHICON

- This tube makes use of the high photo emissive sensitivity obtainable from photocathodes, image multiplication at the target caused by secondary emission and an electron multiplier.
- A sectional view of an image orthicon is shown in Fig. It has three main sections: image section, scanning section and electron gun-cum-multiplier section. (i) Image Section The inside of the glass face plate at the front is coated with a silver, antimony coating sensitized with cesium, to serve as photocathode.
- Light from the scene to be televised is focused on the photocathode surface by a lens system and the optical image thus formed results in the release of electrons from each point on the photocathode in proportion to the incident light intensity. Photocathode surface is semitransparent and the light rays penetrate it to reach its inner surface from where electron emission takes place.
- Since the number of electrons emitted at any point in the photocathode has a distribution corresponding to the brightness of the optical image, an electron image of the scene or picture gets formed on the target side of the photo coating and extends towards it. Through the conversion efficiency of the photocathode is quite high, it cannot store charge being a conductor.
- For this reason, the electron image produced at the photocathode is made to move towards the target plate located at a short distance from it. The target plate is made of a very thin sheet of glass and can store the charge received by it.
- This is maintained at about 400 volts more positive with respect to the photocathode, and the resultant electric field gives the desired acceleration and motion to the emitted electrons towards it. The electrons, while in motion, have a tendency to repel each other and this can result in distortion of the information now available as charge image. To prevent this divergence effect an axial magnetic field, generated in this region by the 'long focus coil' is employed.
- This magnetic field imparts helical motion of increasing pitch and focuses the emitted electrons on the target into a well-defined electron image of the original optical image. The image side of the target has a very small deposit of cesium and thus has a high secondary emission ratio.
- Because of the high velocity attained by the electrons while in motion from photocathode to the target plate, secondary emission results, as the electrons bombard the target surface.
- These secondary electrons are collected by a wire-mesh screen, which is located in front of the target on the image side and is maintained at a slightly higher potential with respect to the target.



- The wire-mesh screen has about 300 meshes per cm² with an open area of 50 to 75 per cent, so that the screen wires do not interfere with the electron image.
- The secondary electrons leave behind on the target plate surface, a positive charge distribution, corresponding to the light intensity distribution on the original photocathode. For storage action this charge on the target plate should not spread laterally over its surface, during the storage time, since this would destroy the resolution of the device.
- To achieve this the target is made out of extremely thin sheet of glass. The positive charge distribution builds up during the frame storage time (40 ms) and thus enhances the sensitivity of the tube. It should be clearly understood, that the light from the scene being televised continuously falls on the photocathode, and the resultant emitted electrons on reaching the target plate cause continuous secondary emission. This continuous release of electrons results in the building up of positive charge on the target plate.
- Because of the high secondary emission ratio, the intensity of the positive charge distribution is four to five times more as compared to the charge liberated by the photocathode.
- This increase in charge density relative to the charge liberated at the photocathode is known as 'image multiplication' and contributes to the increased sensitivity of image orthicon. As shown in Fig., the two-sided target has the charge image on one side while an electron beam scans the opposite side.
- Thus, while the target plate must have high resistivity laterally for storage action, it must have low resistivity along its thickness, to enable the positive charge to conduct to the other side which is scanned.

- It is for this reason that the target plate is very thin, with thickness close to 0.004 mm. Thus, whatever charge distribution builds up on one side of the target plate due to the focused image, appears on the other side, which is scanned, and it is from here that the video signal is obtained.

(ii) Scanning Section

- The electron gun structure produces a beam of electrons that is accelerated towards the target. As indicated in the figure, positive accelerating potentials of 80 to 330 volts are applied to grid 2, grid 3, and grid 4 which is connected internally to the metalized conductive coating on the inside wall of the tube. The electron beam is focused at the target by magnetic field of the external focus coil and by voltage supplied to grid 4. The alignment coil provides magnetic field that can be varied to adjust the scanning beam's position, if necessary, for correct location.
- Deflection of electron beams to scan the entire target plate is accomplished by magnetic fields of vertical and horizontal deflecting coils mounted on yoke external to the tube. These coils are fed from two oscillators, one working at 15625 Hz, for horizontal deflection, and the other operating at 50 Hz, for vertical deflection. The target plate is close to zero potential and therefore electrons in the scanning beam can be made to stop their forward motion at its surface and then return towards the gun structure.
- The grid 4 voltage is adjusted to produce uniform deceleration of electrons for the entire target area. As a result, electrons in the scanning beam are slowed down near the target. This eliminates any possibility of secondary emission from this side of the target plate.
- If a certain element area on the target plate reaches a potential of, say, 2 volts during the storage time, then as a result of its thinness the scanning beam 'sees' the charge deposited on it, part of which gets diffused to the scanned side and deposits an equal number of negative charges on the opposite side.
- Thus out of the total electrons in the beam, some get deposited on the target plate, while the remaining stop at its surface and turn back to go towards the first electrode of the electron multiplier. Because of low resistivity across the two sides of the target, the deposited negative charge neutralizes the existing positive charge in less than a frame time.
- The target can again become charged as a result of the incident picture information, to be scanned during the successive frames. As the target is scanned element by element, if there are no positive charges at certain points, all the electrons in the beam return towards the electron gun and none gets deposited on the target plate.
- The number of electrons, leaving cathode of the gun, is practically constant, and out of this, some get deposited and remaining electrons, which travel backwards provide signal current that varies in amplitude in accordance with the picture information.
- Obviously then, the signal current is maximum for black areas on the picture, because absence of light from black areas on the picture does not result in any emission on the photocathode, and there is no secondary emission at the corresponding points on the target, and no electrons are needed from the beam to neutralize them.
- On the contrary for high light areas, on the picture, there is maximum loss of electrons from the target plate, due to secondary emission, and this results in large deposits of electrons from the beam and this reduces the amplitude of the returning beam current. The resultant beam current that turns away from the target, is thus, maximum for black

areas and minimum for bright areas on the picture. High intensity light causes large charge imbalance on the glass target plate.

- The scanning beam is not able to completely neutralize it in one scan. Therefore the earlier impression persists for several scans. Image Resolution. It may be mentioned at this stage that since the beam is of low velocity type, being reduced to near zero velocity in the region of the target it is subjected to stray electric fields in its vicinity, which can cause defocusing and thus loss of resolution.
- Also on contact with the target, the electrons would normally glide along its surface tangentially for a short distance and the point of contact becomes ill defined. The beam must strike the target at right angle at all points of the target, for better resolution. These difficulties are overcome in the image-orthicon by the combined action of electrostatic field because of potential on grid 4, and magnetic field of the long focusing coil.
- The interaction of two fields gives rise to cyclical motion to the beam in the vicinity of target, which then hits it at right angle no matter which point is being scanned. This very much improves the resolving capability of the picture tube.

(iii) Electron Multiplier

- The returning stream of electrons arrive at the gun close to the aperture from which electron beam emerged. The aperture is a part of a metal disc covering the gun electrode. When the returning electrons strike the disc which is at a positive potential of about 300 volts, with respect to the target, they produce secondary emission.
- The disc serves as first stage of the electron multiplier. Successive stages of the electron multiplier are arranged symmetrically around and back of the first stage. Therefore secondary electrons are attracted to the dynodes at progressively higher positive potentials. Five stages of multiplication are used, details of which are shown in Fig. Each multiplier stage provides a gain of approximately 4 and thus a total gain of $(4)^5 = 1000$ is obtained at the electron multiplier. This is known as signal multiplication.
- The multiplication so obtained maintains a high signal to noise ratio. The secondary electrons are finally collected by the anode, which is connected to the highest supply voltage of + 1500 volts in series with a load resistance R_L . The anode current through R_L has the same variations that are present in the return beam from the target and amplified by the electron multiplier.
- Therefore voltage across R_L is the desired video signal; the amplitude of which varies in accordance with light intensity variations of scene being televised. The output across R_L is capacitive coupled to the camera signal amplifier. With $R_L = 20 \text{ K-ohms}$ and typical dark and high light currents of magnitudes $30 \mu\text{A}$ and $5 \mu\text{A}$ respectively, the camera output signal will have an amplitude of 500 mV peak-to-peak.
- Field Mesh Image Orthicon. The tube described above is a non-field mesh image orthicon. In some designs an additional pancake-shaped magnetic coil is provided in front of the face plate. This is connected in series with the main focusing coil.
- The location of the coil results in a graded magnetic field such that the optically focused photocathode image is magnified by about 1.5 times. Thus the charge image produced on the target plate is bigger in size and this results in improved resolution and better overall performance. Such a camera tube is known as a field mesh Image Orthicon.

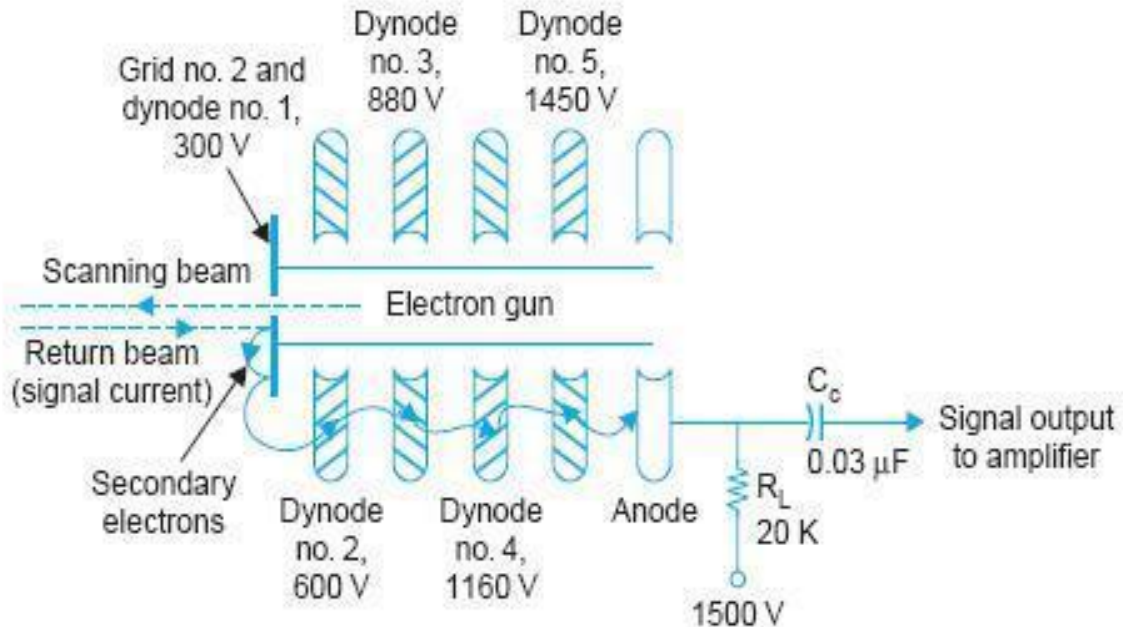


Figure. Electron-multiplier section of the Image Orthicon.

Light Transfer Characteristics and Applications

- During the evolution of image orthicon tubes, two separate types were developed, one with a very close target-mesh spacing (less than 0.001 cm) and the other with somewhat wider spacing.
- The tube, with very close target mesh spacing, has very high signal to noise ratio but this is obtained at the expense of sensitivity and contrast ratio.
- This is a worthwhile exchange where lighting conditions can be controlled and picture quality is of primary importance. This is generally used for live shows in the studios.
- The other type with wider target-mesh spacing has high sensitivity and contrast ratio with more desirable spectral response.
- This tube has wider application for outdoor or other remote pickups where a wide range of lighting conditions have to be accommodated. More recent tubes with improved photocathodes have sensitivities several times those of previous tubes and much improved spectral response.
- Overall transfer characteristics of such tubes are drawn in Fig. Tube 'A' is intended primarily for outdoor pick-ups where as tube 'B' is much suited for studio use and requires strong illumination.
- The knee of the transfer characteristics is reached when the illumination causes the target to be fully charged with respect to the mesh between successive scans by the electron beam.

- The tube is sometimes operated slightly above the knee, to obtain the black border effect (also known as Halo effect) around the high light areas of the target.

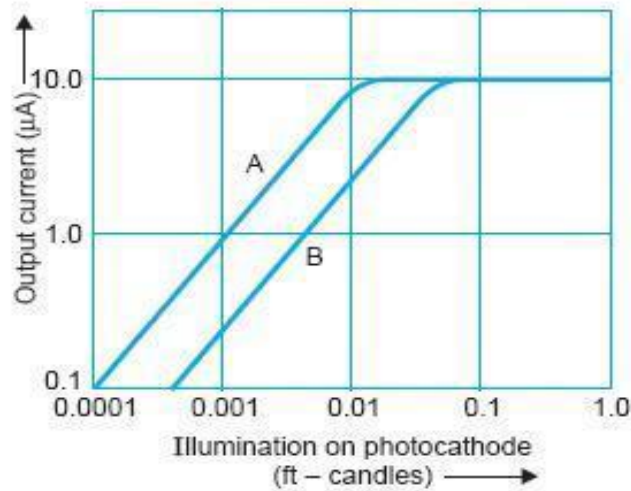


Figure. Light transfer characteristics of two different Image Orthicons.

1.8. VIDICON

- The Vidicon came into general use in the early 50’s and gained immediate popularity because of its small size and ease of operation. It functions on the principle of photoconductivity, where the resistance of the target material shows a marked decrease when exposed to light. illustrates the structural configuration of a typical vidicon, and Fig.

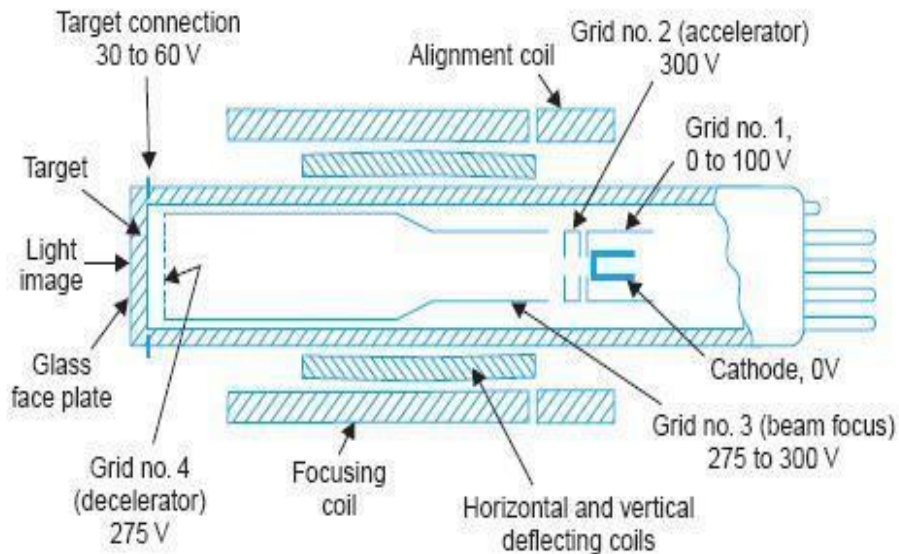


Figure. Vidicon camera tube cross-section.

- Shows the circuit arrangement for developing camera signal output. As shown there, the target consists of a thin photo conductive layer of either selenium or anti-mony compounds.
- This is deposited on a transparent conducting film, coated on the inner surface of the face plate. This conductive coating is known as signal electrode or plate. Image side of the photolayer, which is in contact with the signal electrode, is connected to DC supply through the load resistance R_L .
- The beam that emerges from the electron gun is focused on surface of the photo conductive layer by combined action of uniform magnetic field of an external coil and electrostatic field of grid No 3. Grid No. 4 provides a uniform decelerating field between itself, and the photo conductive layer, so that the electron beam approaches the layer with a low velocity to prevent any secondary emission.
- Deflection of the beam, for scanning the target, is obtained by vertical and horizontal deflecting coils, placed around the tube.

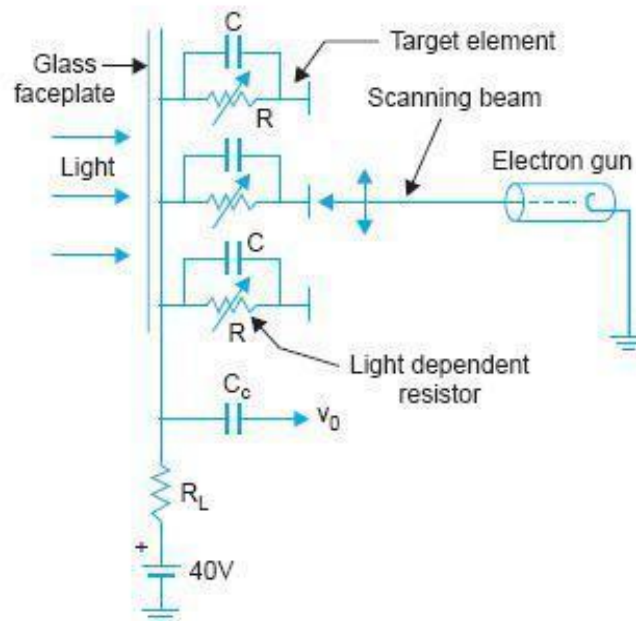


Figure. Schematic representation of a Vidicon target area.

Charge Image

- The photo layer has a thickness of about 0.0001 cm, and behaves like an insulator with a resistance of approximately 20 M Ω when in dark. With light focused on it, the photon energy enables more electrons to go to the conduction band and this reduces its resistivity.
- When bright light falls on any area of the photoconductive coating, resistance across the thickness of that portion gets reduced to about 2 M Ω . Thus, with an image on the target,

each point on the gun side of the photo layer assumes a certain potential with respect to the DC supply, depending on its resistance to the signal plate.

- For example, with a B + source of 40 V (see Fig), an area with high illumination may attain a potential of about + 39 V on the beam side. Similarly dark areas, on account of high resistance of the photo layer may rise to only about + 35 volts.
- Thus, a pattern of positive potentials appears, on the gun side of the photo layer, producing a charge image, that corresponds to the incident optical image.

Storage Action

- Though light from the scene falls continuously on the target, each element of the photo coating is scanned at intervals equal to the frame time. This results in storage action and the net change in resistance, at any point or element on the photoconductive layer, depends on the time, which elapses between two successive scanning and the intensity of incident light.
- Since storage time for all points on the target plate is same, the net change in resistance of all elementary areas is proportional to light intensity variations in the scene being televised. **Signal Current** As the beam scans the target plate, it encounters different positive potentials on the side of the photo layer that faces the gun.
- Sufficient number of electrons from the beam are then deposited on the photo layer surface to reduce the potential of each element towards the zero cathode potential. The remaining electrons, not deposited on the target, return back and are not utilized in the vidicon.
- However, the sudden change in potential on each element while the beam scans, causes a current flow in the signal electrode circuit producing a varying voltage across the load resistance R L. Obviously, the amplitude of current and the consequent output voltage across R L are directly proportional to the light intensity variations on the scene.
- Note that, since, a large current would cause a higher voltage drop across R L , the output voltage is most negative for white areas. The video output voltage, that thus develops across the load resistance (50 K-ohms) is adequate and does not need any image or signal multiplication as in an image orthicon.
- The output signal is further amplified by conventional amplifiers before it leaves the camera unit. This makes the vidicon a much simpler picture tube. **Leaky Capacitor Concept** Another way of explaining the development of 'charge image' on the photo layer is to consider it as an array of individual target elements, each consisting of a capacitor paralleled with a light dependent resistor. A number of such representations are shown in Fig.

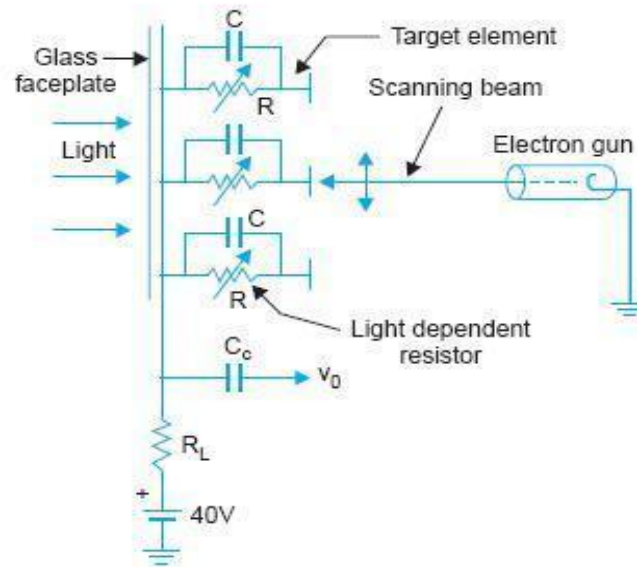


Figure. Schematic representation of a Vidicon target area.

- As seen there, one end of these target elements is connected to the signal electrode and the other end is unterminated facing the beam. In the absence of any light image, the capacitors attain a charge almost equal to the $B + (40\text{ V})$ voltage in due course of time.
- However, when an image is focused on the target the resistors in parallel with the capacitors change in value depending on the intensity of light on each unit element.
- For a high light element, the resistance across the capacitor drops to a fairly low value, and this permits lot of charge from the capacitor to leak away. At the time of scanning, more electrons are deposited, on the unterminated end of this capacitor to recharge it to the full supply voltage of $+40\text{ V}$. The consequent flow of current that completes its path through R_L develops a signal voltage across it.
- Similarly for black areas of the picture, the resistance across the capacitors remains fairly high, and not much charge is allowed to leak from the corresponding capacitors. This in turn needs fewer number of electrons from the beam to recharge the capacitors. The resultant small current that flows, develops a lower voltage across the load resistance.
- The electron beam thus 'sees' the charge on each capacitor, while scanning the target, and delivers more or less number of electrons to recharge them to the supply voltage. This process is repeated every 40 ms to provide the necessary video signal corresponding to the picture details at the upper end of the load resistor.
- The video signal is fed through a blocking capacitor to an amplifier for necessary amplification.

Light Transfer Characteristics

- Vidicon output characteristics are shown in Fig. Each curve is for a specific value of 'dark' current, which is the output with no light. The 'dark' current is set by adjusting the target voltage.

- Sensitivity and dark current both increase as the target voltage is increased.
- Typical output for the vidicon is $0.4 \mu\text{A}$ for bright light with a dark current of $0.02 \mu\text{A}$. The photoconductive layer has a time lag, which can cause smear with a trail following fast moving objects.
- The photoconductive lag increases at high target voltages, where the vidicon has its highest sensitivity.

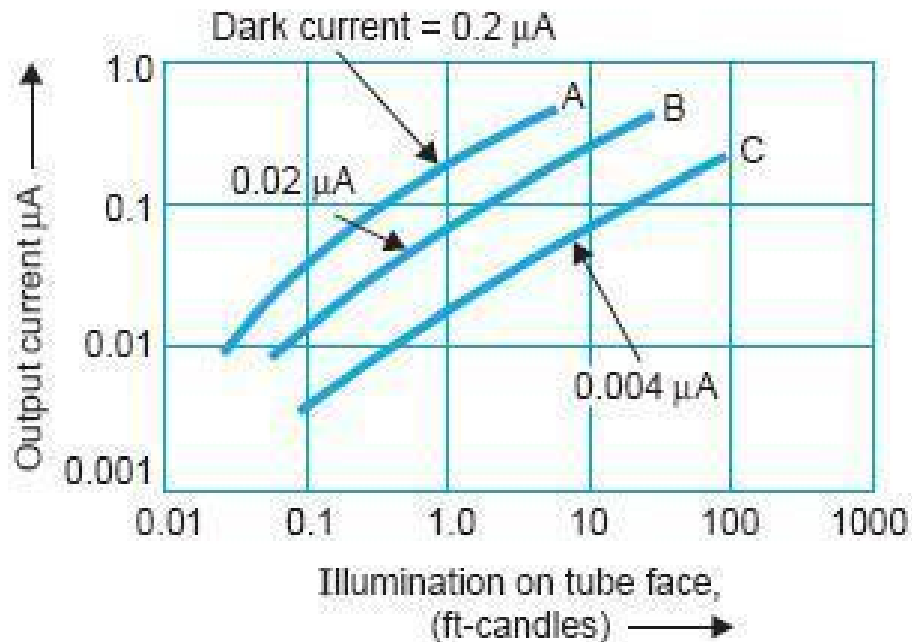


Figure. Light transfer characteristics of Vidicon

Applications

- Earlier types of vidicons were used only where there was no fast movement, because of inherent lag. These applications included slides, pictures, closed circuit TV etc. The present day improved vidicon finds wide applications in education, medicine, industry, aerospace and oceanography.
- It is, perhaps, the most popular tube in the television industry. Vidicon is a short tube with a length of 12 to 20 cm and diameter between 1.5 and 4 cm. Its life is estimated to be between 5000 and 20,000 hours.

1.9. PLUMBICON

- This picture tube has overcome many of the less favorable features of standard vidicon. It has fast response and produces high quality pictures at low light levels. Its smaller size and light weight, together with low-power operating characteristics, makes it an ideal tube for transistorized television cameras. Except for the target, plumbicon is very similar to the standard vidicon. Focus and deflection are both obtained magnetically. Its target operates effectively as a P-I-N semi-conductor diode.

- The inner surface of the faceplate is coated with a thin transparent conductive layer of tin oxide (SnO_2). This forms a strong N type (N^+) layer and serves as the signal plate of the target. On the scanning side of this layer is deposited a photoconductive layer of pure lead monoxide (PbO) which is intrinsic or 'I' type. Finally the pure PbO is doped to form a P type semiconductor on which the scanning beam lands.

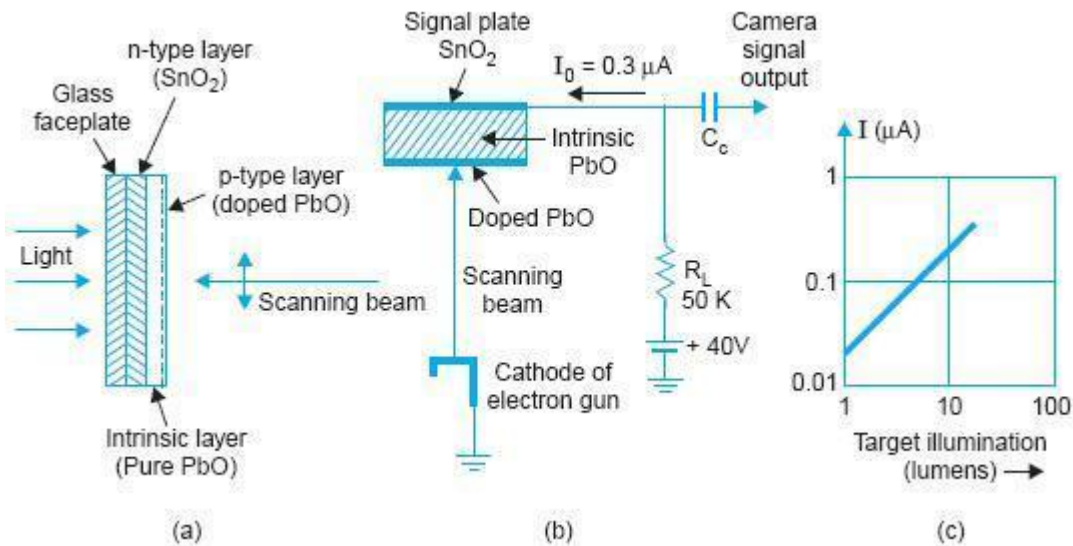


Figure. Plumbicon camera tube (a) target details (b) output signal current and (c) characteristics.

- The photoconductive target of the plumbicon functions similar to the photoconductive target in the vidicon, except for the method of discharging each storage element.
- In the standard vidicon, each element acts as a leaky capacitor, with the leakage resistance decreasing with increasing light intensity. In the plumbicon, however, each element serves as a capacitor in series with a reverse biased light controlled diode.
- In the signal circuit, the conductive film of tin oxide (SnO_2), is connected to the target supply of 40 volts through an external load resistance R_L to develop the camera output signal voltage.
- Light from the scene being televised is focussed through the transparent layer of tin-oxide on the photoconductive lead monoxide. Without light the target prevents any conduction because of absence of any charge carriers and so there is little or no output current. A typical value of dark current is around 4 nA ($4 \times 10^{-9} \text{ Amp}$).
- The incidence of light on the target results in photo excitation of semiconductor junction between the pure PbO and doped layer. The resultant decrease in resistance causes signal current flow which is proportional to the incident light on each photo element. The overall thickness of the target is 10 to 20 μm .

Light Transfer Characteristics

- The current output versus target illumination response of a plumbicon is shown in Fig (c). It is a straight line with a higher slope as compared to the response curve of a vidicon. The higher value of current output, i.e., higher sensitivity, is due to much reduced recombination of photo generated electrons and holes in the intrinsic layer which contains very few discontinuities.
- For target voltages higher than about 20 volts, all the generated carriers are swept quickly across the target without much re-combinations and thus the tube operates in a photo saturated mode. The spectral response of the plumbicon is closer to that of the human eye except in the red color region.

1.10. SILICON DIODE ARRAY VIDICON

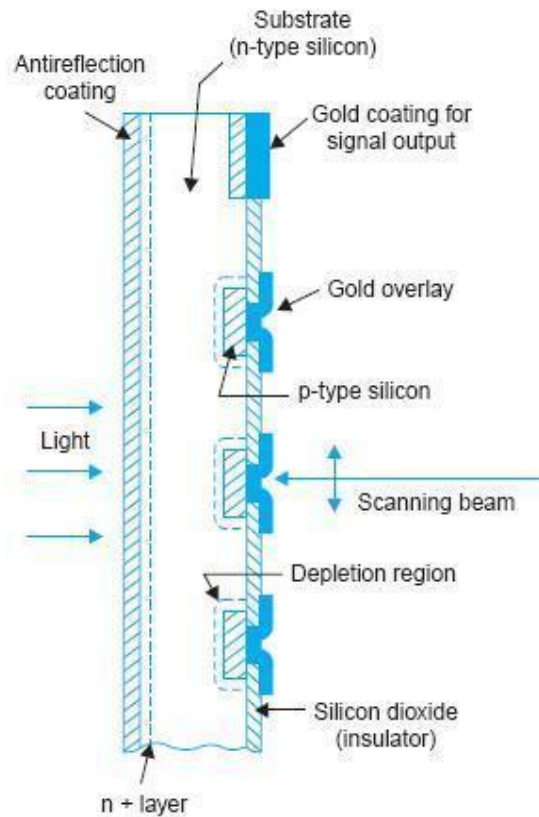
- This is another variation of vidicon where the target is prepared from a thin n-type silicon wafer instead of deposited layers on the glass faceplate. The final result is an array of silicon photodiodes for the target plate. Figure shows constructional details of such a target. As shown there, one side of the substrate (n-type silicon) is oxidized to form a film of silicon dioxide (SiO_2) which is an insulator.
- Then by photo masking and etching processes, an array of fine openings is made in the oxide layer. These openings are used as a diffusion mask for producing corresponding number of individual photodiodes.
- Boron, as a dopant is vaporized through the array of holes, forming islands of p-type silicon on one side of the n-type silicon substrate. Finally a very thin layer of gold is deposited on each p-type opening to form contacts for signal output.
- The other side of the substrate is given an antireflection coating. The resulting p-n photodiodes are about $8 \mu\text{m}$ in diameter. The silicon target plate thus formed is typically 0.003 cm thick, 1.5 cm square having an array of 540×540 photodiodes. This target plate is mounted in a vidicon type of camera tube.

Scanning and Operation

- The photodiodes are reverse biased by applying $+10 \text{ V}$ or so to the n + layer on the substrate. This side is illuminated by the light focused on to it from the image. The incidence of light generates electron-hole pairs in the substrate. Under influence of the applied electric field, holes are swept over to the 'p' side of the depletion region thus reducing reverse bias on the diodes.
- This process continues to produce storage action till the scanning beam of electron gun scans the photodiode side of the substrate. The scanning beam deposits electrons on the p-side thus returning the diodes to their original reverse bias.
- The consequent sudden increase in current across each diode caused by the scanning beam represents the video signal. The current flows through a load resistance in the battery circuit and develops a video signal proportional to the intensity of light falling on the array of photodiodes.
- A typical value of peak signal current is $7 \mu\text{A}$ for bright white light. The vidicon employing such a multi diode silicon target is less susceptible to damage or burns due to

excessive high lights. It also has low lag time and high sensitivity to visible light which can be extended to the infrared region.

- A particular make of such a vidicon has the trade name of 'Epicon'. Such camera tubes have wide applications in industrial, educational and CCTV (closed circuit television) services.



Constructional details (enlarged) of a silicon diode array target plate.

1.11. SOLID STATE IMAGE SCANNERS

- The operation of solid state image scanners is based on the functioning of charge coupled devices (CCDs) which is a new concept in metal-oxide-semiconductor (MOS) circuitry. The CCD may be thought of to be a shift register formed by a string of very closely spaced MOS capacitors. It can store and transfer analog charge signals—either electrons or holes—that may be introduced electrically or optically. The constructional details and the manner in which storing and transferring of charge occurs is illustrated in Fig.
- The chip consists of a p-type substrate, the one side of which is oxidized to form a film of silicon dioxide, which is an insulator. Then by photolithographic processes, similar to

those used in miniature integrated circuits an array of metal electrodes, known as gates, are deposited on the insulator film.

- This results in the creation of a very large number of tiny MOS capacitors on the entire surface of the chip. The application of small positive potentials to the gate electrodes results in the development of depletion regions just below them.
- These are called potential wells. The depth of each well (depletion region) varies with the magnitude of the applied potential. As shown in Fig. (a),

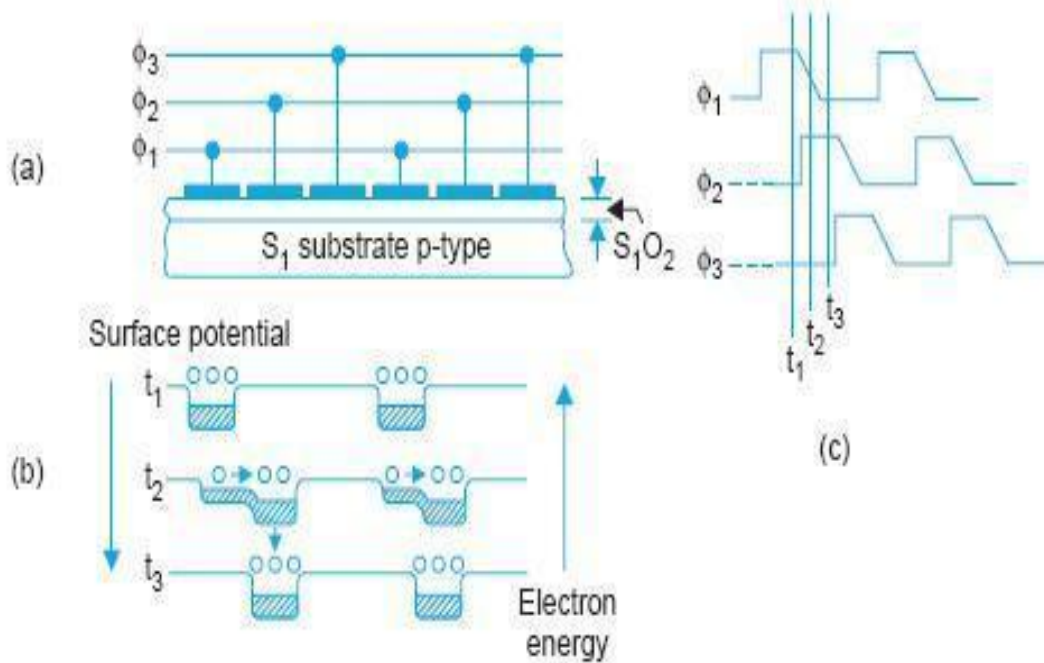


Figure. A three phase n-channel MOS charge coupled device. (a) Construction (b) transfer of electrons between potential wells (c) different phases of clocking voltage waveform.

- The gate electrodes operate in groups of three, with every third electrode connected to a common conductor. The spots under them serve as light sensitive elements.
- When any image is focused onto the silicon chip, electrons are generated within it, but very close to the surface. The number of electrons depends on the intensity of incident light. Once produced they collect in the nearby potential wells. As a result the pattern of collected charges represents the optical image.

Charge Transfer

- The charge of one element is transferred along the surface of the silicon chip by applying a more positive voltage to the adjacent electrode or gate, while reducing the voltage on it. The minority carriers (electrons in this case) while accumulating in the so called wells reduce their depths much like the way a fluid fills up in a container.

- The accumulation of charge carriers under the first potential wells of two consecutive trios is shown in Fig. (b) Where at instant t_1 a potential V_1 exists at the corresponding gate electrodes. In practice the charge transfer is effected by multiphase clock voltage pulses (see Fig. 6.12 (c)) which are applied to the gates in a suitable sequence.
- The manner in which the transition takes place from potential wells under V_1 to those under V_2 is illustrated in Fig. (b). A similar transfer moves charges from V_2 to V_3 and then from V_3 to V_1 under the influence of continuing clock pulses.
- Thus, after one complete clock cycle, the charge pattern moves one stage (three gates) to the right. The clocking sequence continues and the charge finally reaches the end of the array where it is collected to form the signal current.

Scanning of Television Pictures

- A large number of CCD arrays are packed together to form the image plate. It does not need an electron gun, scanning beam, high voltage or vacuum envelope of a conventional camera tube.
- The potential required to move the charge is only 5 to 10 volt. The spot under each trio serves as the resolution cell. When light image is focused on the chip, electrons are generated in proportion to the intensity of light falling on each cell.

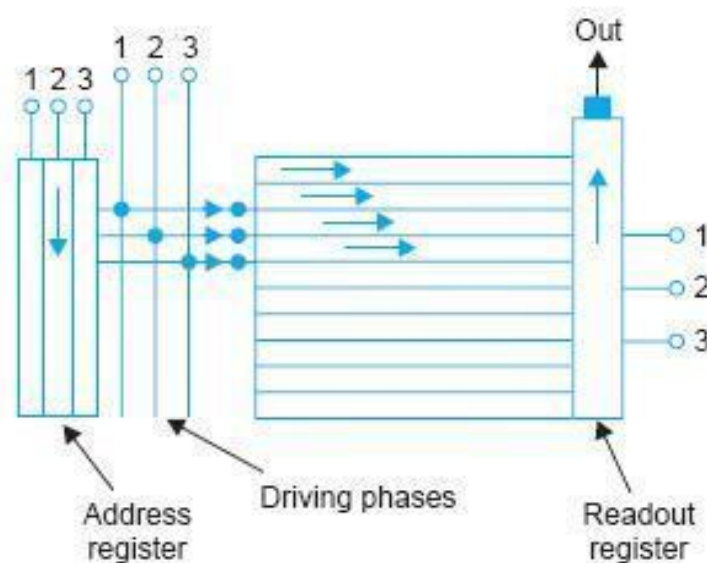


Figure. Basic organization of line addressed charge transfer area imaging devices.

- The principle of one-dimensional charge transfer as explained above can be integrated in various ways to render a solid-state area image device. The straightforward approach consists of arranging a set of linear imaging structures so that each one corresponds to a scan line in the display.
- The lines are then independently addressed and read into a common output diode by application of driving pulses through a set of switches controlled by an address register as

shown in Fig To reduce capacitance, the output can be simply a small diffused diode in one corner of the array.

- The charge packets emerging from any line are carried to this diode by an additional vertical output register. In such a line addressed structure (Fig.) where the sequence of addressing the lines is determined by the driving circuitry, interlacing can be accomplished in a natural way.

Cameras Employing Solid-State Scanners

- CCDs have a bright future in the field of solid state imaging. Full TV line-scan arrays have already been constructed for TV cameras. However, the quality of such sensors is not yet suitable for normal TV studio use.
- RCA SID 51232 is one such 24 lead dual-in-line image sensor. It is a self-scanned sensor intended primarily for use in generating standard interlaced 525 line television pictures. The device contains 512×320 elements and is constructed with a 3 phase n-channel, vertical frame transfer organization using a sealed silicon gate structure.
- Its block diagrams is shown in Fig. (a). The image scanner’s overall picture performance is comparable to that 2/3 inch vidicon camera tubes but undesirable characteristics such as lag and micro phonics are eliminated. The SID 51232 is supplied in a hermetic, edge contacted, 24-connection ceramic dual-inline package. The package contains an optical glass window (see Fig. (b)) which allows an image to be focused into sensor’s 12.2 mm image diagonal.

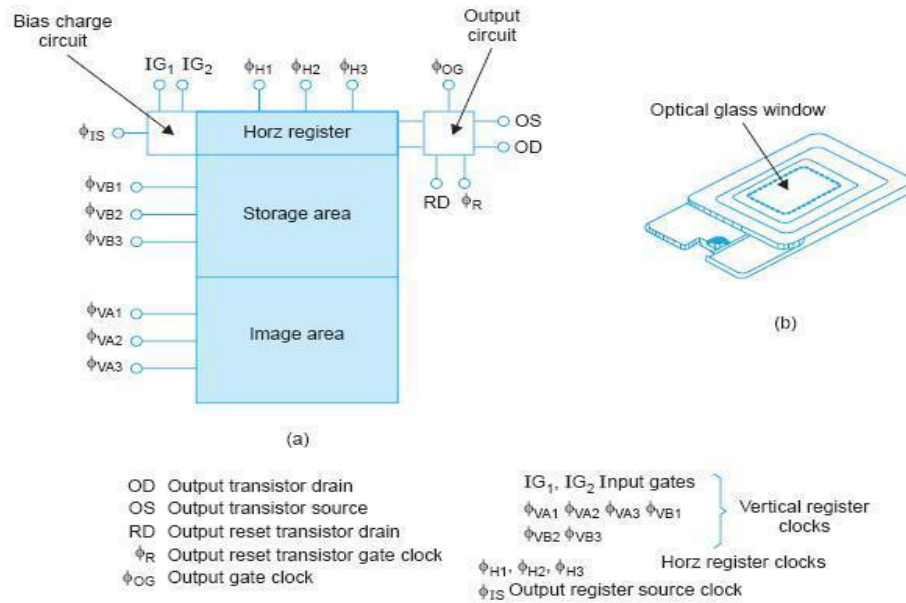


Figure. 512×320 element sensor (RCA SID 51232) for very compact TV cameras,(a) chip’s block diagram, (b) view with optical glass window.

1.12. MONOCHROME PICTURE TUBE

- Modern monochrome picture tubes employ electrostatic focusing and electromagnetic deflection. A typical black and white picture tube is shown in Fig. The deflection coils are mounted externally in a specially designed yoke that is fixed close to the neck of the tube.
- The coils when fed simultaneously with vertical and horizontal scanning currents deflect the beam at a fast rate to produce the raster. The composite video signal that is injected either at the grid or cathode of the tube, modulates the electron beam to produce brightness variations of the tube, modulates the electron beam to produce brightness variations on the screen.
- This results in reconstruction of the picture on the raster, bit by bit, as a function of time. However, the information thus obtained on the screen is perceived by the eye as a complete and continuous scene because of the rapid rate of scanning.

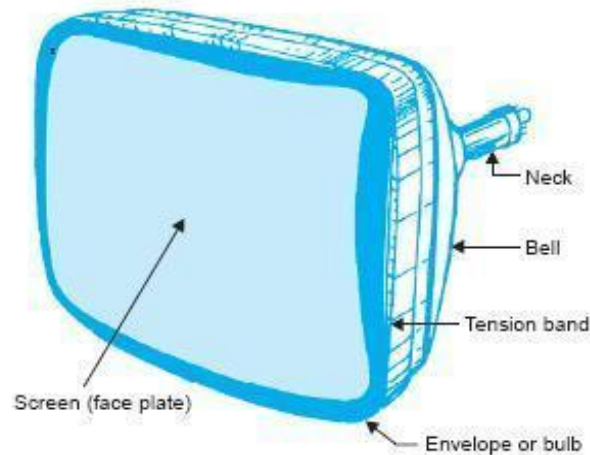


Figure. A rectangular picture tube.

Electron Gun

- The various electrodes that constitute the electron gun are shown in Fig. The cathode is indirectly heated and consists of a cylinder of nickel that is coated at its end with thoriated tungsten or barium and strontium oxides.
- These emitting materials have low work-function Base within the tube. The control grid (Grid No. 1) is maintained at a negative potential with respect to cathode and controls the flow of electrons from the cathode.
- However, instead of a wire mesh structure, as in a conventional amplifier tube, it is a cylinder with a small circular opening to confine the electron stream to a small area. The grids that follow the control grid are the accelerating or screen grid (Grid No. 2) and the focusing grid (Grid No. 3).

- These are maintained at different positive potentials with respect to the cathode that vary between + 200 V to + 600 V. All the elements of the electron gun are connected to the base pins and receive their rated voltages from the tube socket that is wired to the various sections of the receiver.

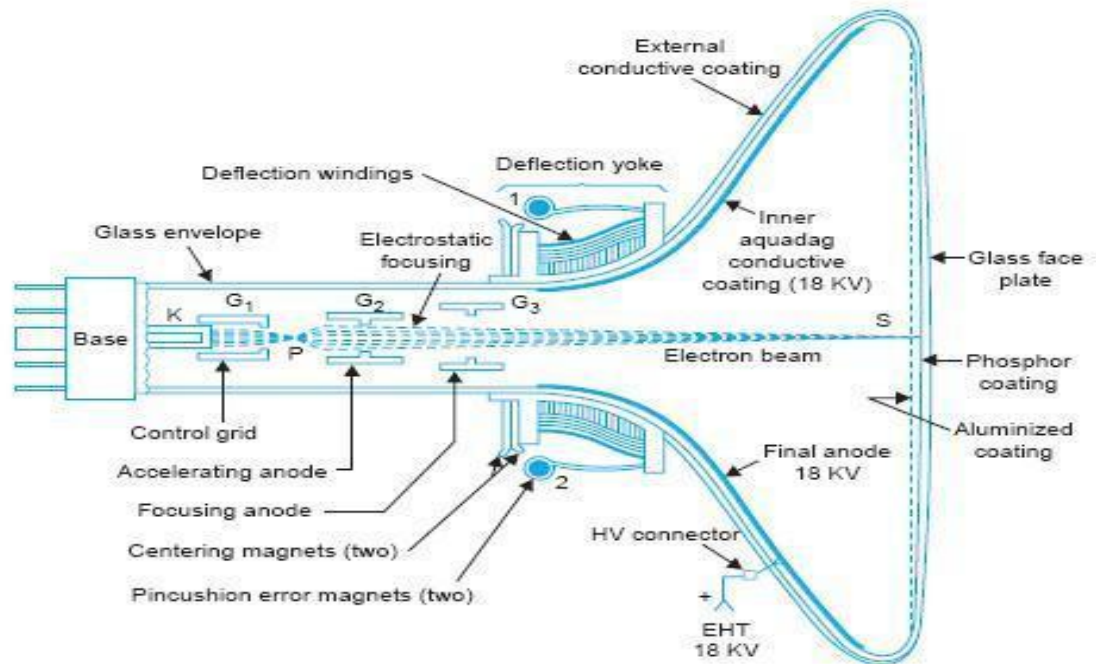


Figure. Elements of a picture tube employing low voltage electrostatic focusing and magnetic deflection.

Electrostatic Focussing

- The electric field due to the positive potential at the accelerating grid (also known as 1st anode) extends through the opening of the control grid right to the cathode surface. The orientation of this field is such that besides accelerating the electrons down the tube, it also brings all the electrons in the stream into a tiny spot called the crossover.
- This is known as the first electrostatic lens action. The resultant convergence of the beam is shown in Fig. The second lens system that consists of the screen grid and focus electrode draws electrons from the crossover point and brings them to a focus at the viewing screen.
- The focus anode is larger in diameter and is operated at a higher potential than the first anode. The resulting field configuration between the two anodes is such that the electrons leaving the crossover point at various angles are subjected to both convergent and divergent forces as they move along the axis of the tube.
- This in turn alters the path of the electrons in such a way that they meet at another point on the axis. The electrode voltages are so chosen or the electric field is so varied that the second point where all the electrons get focused is the screen of the picture tube. Electrostatic focusing is preferred over magnetic focusing because it is not affected very much by changes in the line voltage and needs no ion-spot correction.

Beam Velocity

- In order to give the electron stream sufficient velocity to reach the screen material with proper energy to cause it to fluoresce, a second anode is included within the tube.
- This is a conductive coating with colloidal graphite on the inside of the wide bell of the tube. This coating, called aquadag, usually extends from almost half-way into the narrow neck to within 3 cm of the fluorescent screen as shown in Fig.
- It is connected through a specially provided pin at the top or side of the glass bell to a very high potential of over 15 kV. The exact voltage depends on the tube size and is about 18 kV for a 48 cm monochrome tube.
- The electrons that get accelerated under the influence of the high voltage anode area, attain very high velocities before they hit the screen.
- Most of these electrons go straight and are not collected by the positive coating because its circular structure provides a symmetrical accelerating field around all sides of the beam.
- The kinetic energy gained by the electrons while in motion is delivered to the atoms of the phosphor coating when the beam hits the screen. This energy is actually gained by the outer valence electrons of the atoms and they move to higher energy levels.
- While returning to their original levels they give out energy in the form of electromagnetic radiation, the frequency of which lies in the spectral region and is thus perceived by the eye as spots of light of varying intensity depending on the strength of the electron beam bombarding the screen.
- Because of very high velocities of the electrons which hit the screen, secondary emission takes place. If these secondary emitted electrons are not collected, a negative space charge gets formed near the screen which prevents the primary beam from arriving at the screen.
- The conductive coating being at a very high positive potential collects the secondary emitted electrons and thus serves the dual purpose of increasing the beam velocity and removing unwanted secondary electrons.
- The path of the electron current flow is thus from cathode to screen, to the conductive coating through the secondary emitted electrons and back to the cathode through the high voltage supply.
- A typical value of beam current is about 0.6 mA with 20 kV applied at the aquadag coating.

1.13. COMPOSITE VIDEO SIGNAL

- Composite video signal consists of a camera signal corresponding to the desired picture information, blanking pulses to make the retrace invisible, and synchronizing pulses to synchronize the transmitter and receiver scanning.
- A horizontal synchronizing (sync) pulse is needed at the end of each active line period whereas a vertical sync pulse is required after each field is scanned. The amplitude of both horizontal and vertical sync pulses is kept the same to obtain higher efficiency of picture signal transmission but their duration (width) is chosen to be different for separating them at the receiver.

- Since sync pulses are needed consecutively and not simultaneously with the picture signal, these are sent on a time division basis and thus form a part of the composite video signal.

1.12. VIDEO SIGNAL DIMENSIONS

- Figure shows the composite video signal details of three different lines each corresponding to a different brightness level of the scene. As illustrated there, the video signal is constrained to vary between certain amplitude limits.
- The level of the video signal when the picture detail being transmitted corresponds to the maximum whiteness to be handled, is referred to as peak-white level. This is fixed at 10 to 12.5 percent of the maximum value of the signal while the black level corresponds to approximately 72 percent.
- The sync pulses are added at 75 percent level called the blanking level. The difference between the black level and blanking level is known as the 'Pedestal'. However, in actual practice, these two levels, being very close, tend to merge with each other as shown in the figure.
- Thus the picture information may vary between 10 percent to about 75 percent of the composite video signal depending on the relative brightness of the picture at any instant. The darker the picture the higher will be the voltage within those limits.
- Note that the lowest 10 percent of the voltage range (whiter than white range) is not used to minimize noise effects. This also ensures enough margin for excessive bright spots to be accommodated without causing amplitude distortion at the modulator.
- At the receiver the picture tube is biased to ensure that a received video voltage corresponding to about 10 percent modulation yields complete whiteness at that particular point on the screen, and an analogous arrangement is made for the black level. Besides this, the television receivers are provided with 'brightness' and 'contrast' controls to enable the viewer to make final adjustments as he thinks fit.

D.C. component of the video signal.

- In addition to continuous amplitude variations for individual picture elements, the video signal has an average value or dc component corresponding to the average brightness of the scene.
- In the absence of dc component the receiver cannot follow changes in brightness, as the ac camera signal, say for grey picture elements on a black background will then be the same as a signal for white area on a grey back-ground.
- In Fig, dc components of the signal for three lines have been identified, each representing a different level of average brightness in the scene. It may be noted that the break shown in the illustration after each line signal is to emphasize that dc component of the video signal is the average value for complete frames rather than lines since the background information of the picture indicates the brightness of the scene.
- Thus Fig. illustrates the concept of change in the average brightness of the scene with the help of three lines in separate frames because the average brightness can change only from frame to frame and not from line to line.

Pedestal height.

- As noted in Fig the pedestal height is the distance between the pedestal level and the average value (dc level) axis of the video signal. This indicates average brightness since it measures how much the average value differs from the black level.
- Even when the signal loses its dc value when passed through a capacitor-coupled circuit the distance between the pedestal and the dc level stays the same and thus it is convenient to use the pedestal level as the reference level to indicate average brightness of the scene.

Setting the pedestal level.

- The output signal from the TV camera is of very small amplitude and is passed through several stages of ac coupled high gain amplifiers before being coupled to a control amplifier.
- Here sync pulses and blanking pulses are added and then clipped at the correct level to form the pedestals. Since the pedestal height determines the average brightness of the scene, any smaller value than the correct one will make the scene darker while a larger Pedestal height will result in higher average brightness.
- The video control operator who observes the scene at the studio sets the level for the desired brightness in the reproduced picture which he is viewing on a monitor receiver. This is known as dc insertion because this amounts to adding a dc component to the ac signal.
- Once the dc insertion has been accomplished the pedestal Level becomes the black reference and the pedestal height indicates correct relative brightness for the reproduced picture. However, the dc level inserted in the control amplifier is usually Lost in succeeding stages because of capacitive coupling, but still the correct dc component can be reinserted when necessary because the pedestal height remains the same.

The blanking pulses.

- The composite video signal contains blanking pulses to make the retrace lines invisible by raising the signal amplitude slightly above the black level (75 percent) during the time the scanning circuits produce retraces.
- As illustrated in Fig. the composite video signal contains horizontal and vertical blanking pulses to blank the corresponding retrace intervals. The repetition rate of horizontal blanking pulses is therefore equal to the line scanning frequency of 15625 Hz.
- Similarly the frequency of the vertical blanking pulses is equal to the field-scanning frequency of 50 Hz. It may be noted that though the level of the blanking pulses is distinctly above the picture signal information, these are not used as sync pulses.
- The reason is that any occasional signal corresponding to any extreme black portion in the picture may rise above the blanking level and might conceivably interfere with the synchronization of the scanning generators.
- Therefore, the sync pulses, specially designed for triggering the sweep oscillators are placed in the upper 25 per cent (75 per cent to 100 per cent of the carrier amplitude) of the video signal, and are transmitted along with the picture signal.

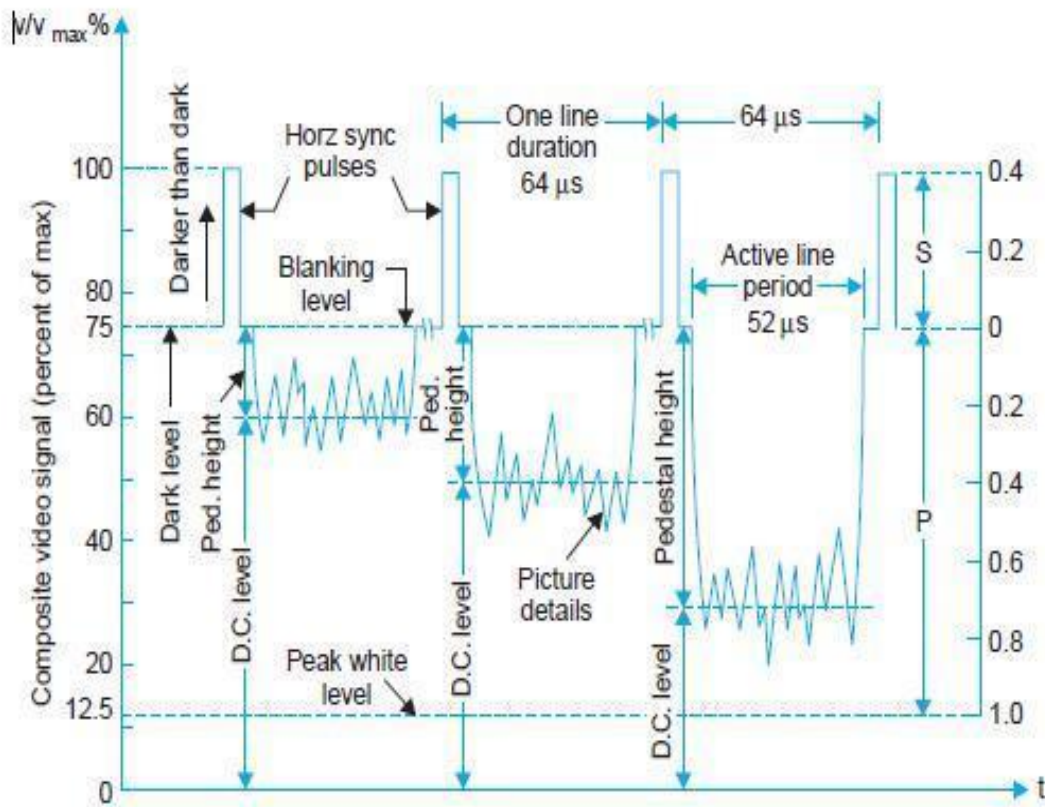


Figure. Arbitrary picture signal details of three scanning lines with different average brightness levels. Note that picture to sync ratio $P/S = 10/4$.

Sync pulse and video signal amplitude ratio.

- The overall arrangement of combining the picture signal and sync pulses may be thought of as a kind of voltage division multiplexing where about 65 per cent of the carrier amplitude is occupied by the video signal and the upper 25 per cent by the sync pulses.
- Thus, as shown in Fig. 3.1, the final radiated signal has a picture to sync signal ratio (P/S) equal to $10/4$.
- This ratio has been found most satisfactory because if the picture signal amplitude is increased at the expense of sync pulses, then when the signal to noise ratio of the received signal falls, a point is reached when the sync pulse amplitude becomes insufficient to keep the picture locked even though the picture voltage is still of adequate amplitude to yield an acceptable picture.
- On the other hand if sync pulse height is increased at the expense of the picture detail, then under similar conditions the raster remains locked but the picture content is of too low an amplitude to set up a worthwhile picture.

- A ratio of P/S = 10/4, or thereabout, results in a situation such that when the signal to noise ratio reaches a certain low level, the sync amplitude becomes insufficient, *i.e.*, the sync fails at the same time as the picture ceases to be of entertainment value. This represents the most efficient use of the television system

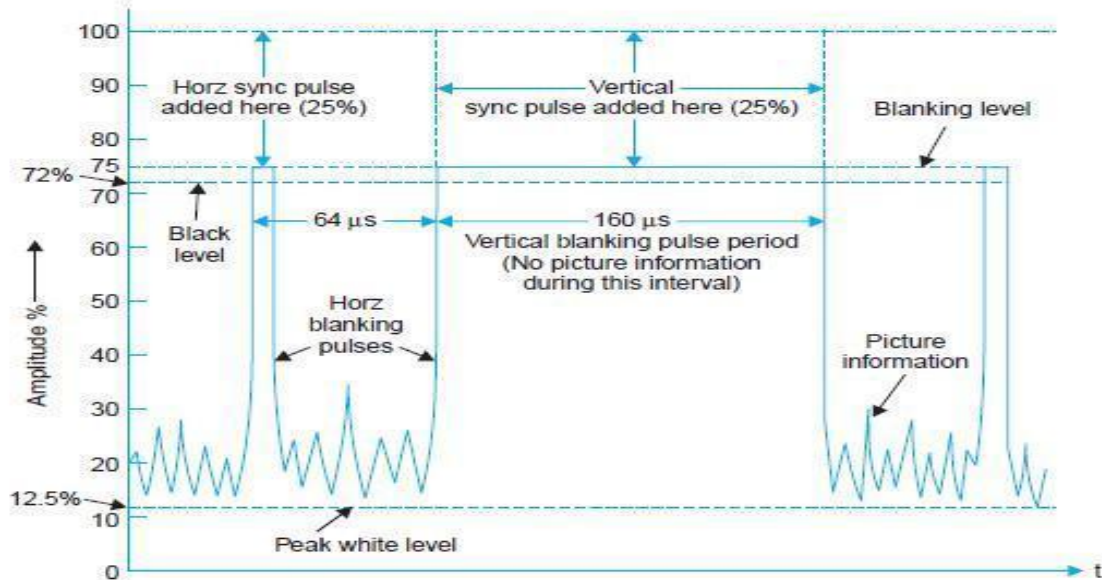


Figure. Horizontal and vertical blanking pulses in video signal. Sync pulses are added above the blanking level and occupy upper 25% of the composite video signal amplitude

1.15. HORIZONTAL SYNC DETAILS

The horizontal blanking period and sync pulse details are illustrated in Fig. The interval between horizontal scanning lines is indicated by *H*. As explained earlier, out of a total line period of 64 μ s, the line blanking period is 12 μ s. During this interval a line synchronizing pulse is inserted. The pulses corresponding to the differentiated leading edges of the sync pulses are actually used to synchronize the horizontal scanning oscillator. This is the reason why in Fig and other figures to follow, all time intervals are shown between sync pulse leading edges.

The line blanking period is divided into three sections. These are the ‘front porch’, the ‘line sync’ pulse and the ‘back porch’. The time intervals allowed to each part are summarized below and their location and effect on the raster is illustrated in Fig.

Details of Horizontal Scanning

<i>Period Time</i>	(μ s)
Total line (<i>H</i>)	64
Horz blanking	12 \pm .3
Horz sync pulse	4.7 \pm 0.2
Front porch	1.5 \pm .3
Back porch	5.8 \pm .3
Visible line time	52

Front porch.

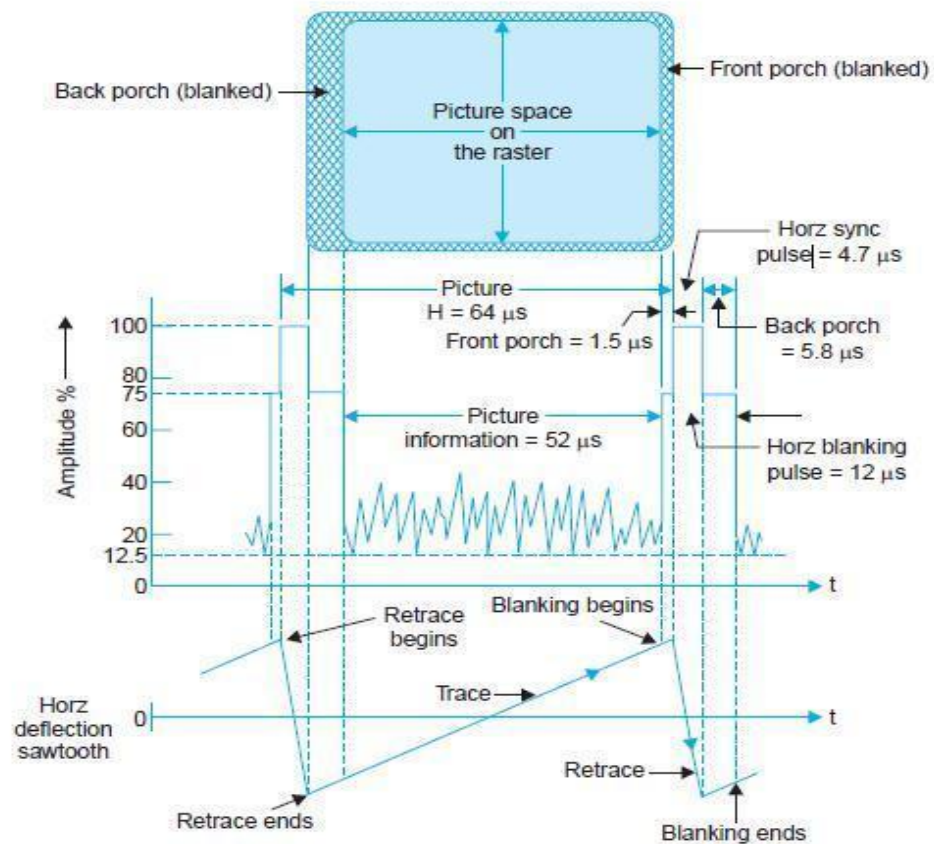
- This is a brief cushioning period of $1.5 \mu\text{s}$ inserted between the end of the picture detail for that line and the leading edge of the line sync pulse. This interval allows the receiver video circuit to settle down from whatever picture voltage level exists at the end of the picture line to the blanking level before the sync pulse occurs.
- Thus sync circuits at the receiver are isolated from the influence of end of the line picture details. The most stringent demand is made on the video circuits when peak white detail occurs at the end of a line.
- Despite the existence of the front porch when the line ends in an extreme white detail, and the signal amplitude touches almost zero level, the video voltage level fails to decay to the blanking level before the leading-edge of the line sync pulse occurs.
- This results in late triggering of the time base circuit thus upsetting the 'horz' line sync circuit. As a result the spot (beam) is late in arriving at the left of the screen and picture information on the next line is displaced to the left.
- This effect is known as 'pulling-on-whites'.

Line sync pulse.

- After the front porch of blanking, horizontal retrace is produced when the sync pulse starts. The flyback is definitely blanked out because the sync level is blacker than black.
- Line sync pulses are separated at the receiver and utilized to keep the receiver line time base in precise synchronism with the distant transmitter.
- The nominal time duration for the line sync pulses is $4.7 \mu\text{s}$. During this period the beam on the raster almost completes its back stroke (retrace) and arrives at the extreme left end of the raster.

Back porch.

- This period of $5.8 \mu\text{s}$ at the blanking level allows plenty of time for line flyback to be completed. It also permits time for the horizontal time-base circuit to reverse direction of current for the initiation of the scanning of next line.
- In fact, the relative timings are so set that small black bars (see Fig) are formed at both the ends of the raster in the horizontal plane.
- These blanked bars at the sides have no effect on the picture details reproduced during the active line period.
- The back porch also provides the necessary amplitude equal to the blanking level (reference level) and enables to preserve the dc content of the picture information at the transmitter.
- At the receiver this level which is independent of the picture details is utilized in the AGC (automatic gain control) circuits to develop true AGC voltage proportional to the signal strength picked up at the antenna



1.16. VERTICAL SYNC DETAILS

- The vertical sync pulse train added after each field is somewhat complex in nature. The reason for this stems from the fact that it has to meet several exacting requirements.
- Therefore, in order to fully appreciate the various constituents of the pulse train, the vertical sync details are explored step by step while explaining the need for its various components.
- The basic vertical sync added at the end of both even and odd fields is shown in Fig. Its width has to be kept much larger than the horizontal sync pulse, in order to derive a suitable field sync pulse at the receiver to trigger the field sweep oscillator. The standards specify that the vertical sync period should be 2.5 to 3 times the horizontal line period. If the width is less than this, it becomes difficult to distinguish between horizontal and vertical pulses at the receiver.
- In color TV transmission a short sample (8 to 10 cycles) of the color subcarrier oscillator output is sent to the receiver for proper detection of color signal sidebands.
- This is known as color burst and is located at the back porch of the horizontal blanking pedestal. If the width is greater than this, the transmitter must operate at peak power for an unnecessarily long interval of time. In the 625 line system 2.5 line period ($2.5 \times 64 = 160 \mu s$) has been allotted for the vertical sync pulses.

- Thus a vertical sync pulse commences at the end of 1st half of 313th line (end of first field) and terminates at the end of 315th line. Similarly after an exact interval of 20 ms (one field period) the next sync pulse occupies line numbers 1st, 2nd and 1st half of third, just after the second field is over.
- Note that the beginning of these pulses has been aligned in the figure to signify that these must occur after the end of vertical stroke of the beam in each field, *i.e.*, after each $1/50$ th of a second.
- This alignment of vertical sync pulses, one at the end of a half-line period and the other after a full line period (see Fig.) results in a relative misalignment of the horizontal sync pulses and they do not appear one above the other but occur at half-line intervals with respect to each other.
- However, a detailed examination of the pulse trains in the two fields would show that horizontal sync pulses continue to occur exactly at $64 \mu\text{s}$ intervals (except during the vertical sync pulse periods) throughout the scanning period from frame to frame and the apparent shift of $32 \mu\text{s}$ is only due to the alignment of vertical sync instances in the figure.
- As already mentioned the horizontal sync information is extracted from the sync pulse train by differentiation, *i.e.*, by passing the pulse train through a high-pass filter. Indeed pulses corresponding to the differentiated leading edges of sync pulses are used to synchronize the horizontal scanning oscillator.
- The process of deriving these pulses is illustrated in Fig. Furthermore, receivers often use mono stable multi-vibrators to generate horizontal scan, and so a pulse is required to initiate each and every cycle of the horizontal oscillator in the receiver. This brings out the first and most obvious shortcoming of the waveforms shown in Fig.

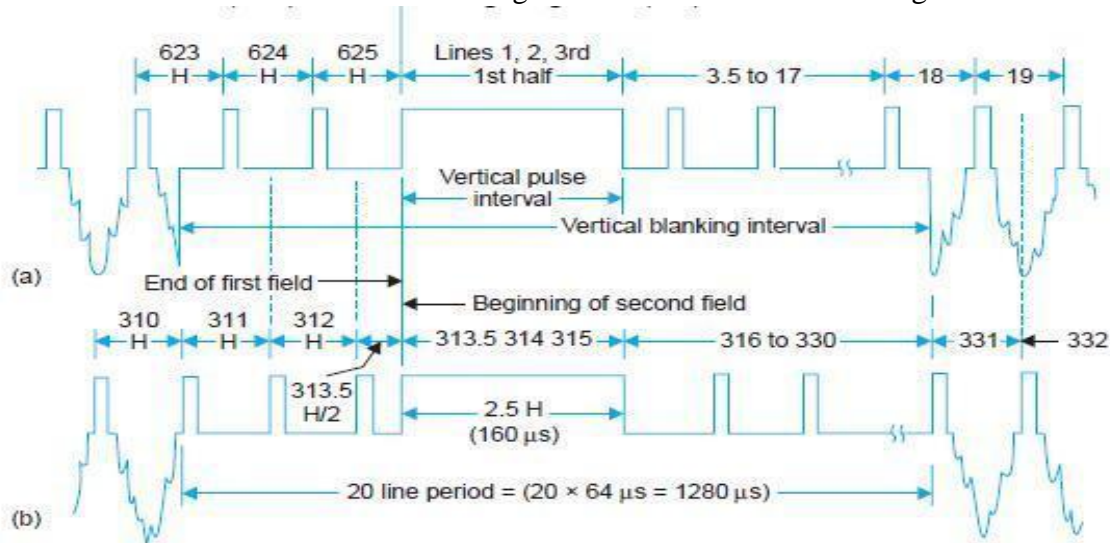
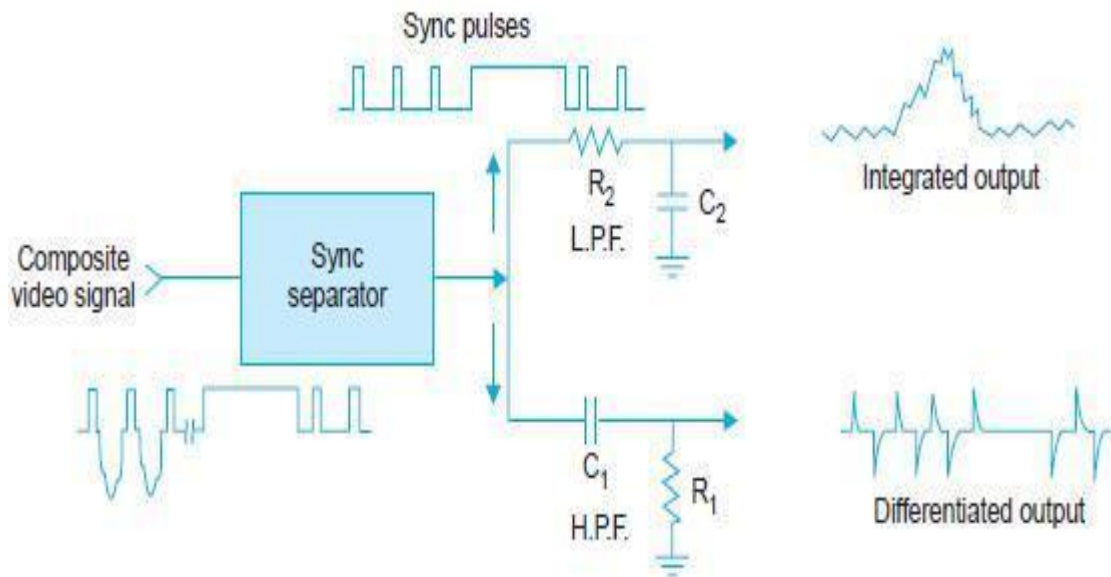


Figure. Composite video waveforms showing horizontal and basic vertical sync pulses at the end of (a) second (even) field, (b) first (odd) field. Note, the widths of horizontal blanking intervals and sync pulses are exaggerated.

- The horizontal sync pulses are available both during the active and blanked line periods but there are no sync pulses (leading edges) available during the 2.5 line vertical sync period.
- Thus the horizontal sweep oscillator that operates at 15625 Hz, would tend to step out of synchronism during each vertical sync period. The situation after an odd field is even worse.
- As shown in Fig. the vertical blanking period at the end of an odd field begins midway through a horizontal line. Consequently, looking further along this waveform, we see that the leading edge of the vertical sync pulse comes at the wrong time to provide synchronization for the horizontal oscillator.
- Therefore, it becomes necessary to cut slots in the vertical sync pulse at half-line-intervals to provide horizontal sync pulses at the correct instances both after even and odd fields.
- The technique is to take the video signal amplitude back to the blanking level $4.7 \mu\text{s}$ before the line pulses are needed. The waveform is then returned back to the maximum level at the moment the line sweep circuit needs synchronization.
- Thus five narrow slots of $4.7 \mu\text{s}$ width get formed in each vertical sync pulse at intervals of $32 \mu\text{s}$. The trailing but rising edges of these pulses are actually used to trigger the horizontal oscillator.
- The resulting waveforms together with line numbers and the differentiated output of both the field trains is illustrated in Fig.



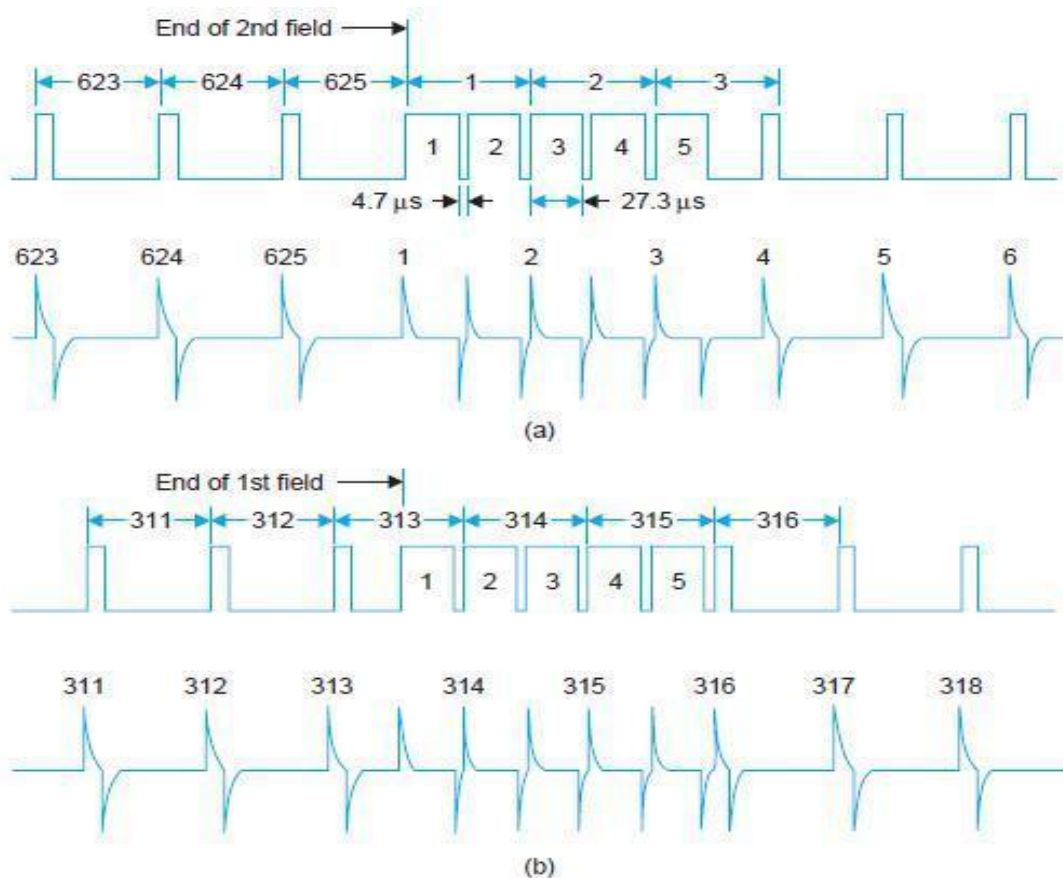


Figure. Differentiating waveforms (a) pulses at the end of even (2nd) field and the corresponding output of the differentiator (H.P.F.) (b) pulses at the end of odd (1st) field and the corresponding output of the differentiator (H.P.F.) Note, the differentiated pulses bearing line numbers are the only ones needed at the end of each field.

- This insertion of short pulses is known as notching or serration of the broad field pulses. Note that though the vertical pulse has been broken to yield horizontal sync pulses, the effect on the vertical pulse is substantially unchanged.
- It still remains above the blanking voltage level all of the time it is acting. The pulse width is still much wider than the horizontal pulse width and thus can be easily separated at the receiver.
- Returning to Fig. it is seen that each horizontal sync pulse yields a positive spiked output from its leading edge and a negative spiked pulse from its trailing edge. Time-constant of the differentiating circuit is so chosen, that by the time a trailing edge arrives, the pulse due to the leading edge has just about decayed.

- The negative-going triggering pulses may be removed with a diode since only the positive going pulses are effective in locking the horizontal oscillator. However, the pulses actually utilized are the ones that occur sequentially at $64 \mu s$ intervals. Such pulses are marked with line numbers for both the fields. Note that during the intervals of serrated vertical pulse trains, alternate vertical spikes are utilized.
- The pulses not used in one field are the ones utilized during the second field. This happens because of the half-line difference at the commencement of each field and the fact that notched vertical sync pulses occur at intervals of $32 \mu s$ and not $64 \mu s$ as required by the horizontal sweep oscillator.
- The pulses that come at a time when they cannot trigger the oscillator are ignored. Thus the requirement of keeping the horizontal sweep circuit locked despite insertion of vertical sync pulses is realized.
- Now we turn to the second shortcoming of the waveform of Fig. First it must be mentioned that synchronization of the vertical sweep oscillator in the receiver is obtained from vertical sync pulses by integration.
- This is illustrated in Fig. where the time-constant $R2C2$ is chosen to be large compared to the duration of horizontal pulses but not with respect to width of the vertical sync pulses.
- The integrating circuit may equally be looked upon as a low pass filter, with a cut-off frequency such that the horizontal sync pulses produce very little output, while the vertical pulses have a frequency that falls in the pass-band of the filter.
- The voltage built across the capacitor of the low-pass filter (integrating circuit) corresponding to the sync pulse trains of both the fields is shown in Fig. Note that each horizontal pulse causes a slight rise in voltage across the capacitor but this is reduced to zero by the time the next pulse arrives.
- This is so, because the charging period for the capacitor is only $4.7 \mu s$ and the voltage at the input to the integrator remains at zero for the rest of the period of $59.3 \mu s$.
- Hence there is no residual voltage across the vertical filter (L.P. filter) due to horizontal sync pulses. Once the broad serrated vertical pulse arrives the voltage across the output of the filter starts increasing. However, the built up voltage differs for each field.
- The reason is not difficult to find. At the beginning of the first field (odd field) the last horz sync pulse corresponding to the beginning of 625th line is separated from the 1st vertical pulse by full one line and any voltage developed across the filter will have enough time to return to zero before the arrival of the first vertical pulse, and thus the filter output voltage builds up from zero in response to the five successive broad vertical sync pulses.
- The voltage builds up because the capacitor has more time to charge and only $4.7 \mu s$ to discharge. The situation, however, is not the same for the beginning of the 2nd (even) field. Here the last horizontal pulse corresponding to the beginning of 313th line is separated from the first vertical pulse by only half-a-line.
- The voltage developed across the vertical filter will thus not have enough time to reach zero before the arrival of the first vertical pulse, which means that the voltage build-up does not start from zero, as in the case of the 1st field. The residual voltage on account of the half line discrepancy gets added to the voltage developed on account of the broad

vertical pulses and thus the voltage developed across the output filter is some what higher at each instant as compared to the voltage developed at the beginning of the first-field.

- This is shown in dotted chain line in Fig. The vertical oscillator trigger potential level marked as trigger level in the diagram (Fig.) intersects the two filter output profiles at different points which indicates that in the case of second field the oscillator will get triggered a fraction of a second too soon as compared to the first field. Note that this inequality in potential levels for the two fields continues during the period of discharge of the capacitor once the vertical sync pulses are over and the horizontal sync pulses take-over.
- Though the actual time difference is quite short it does prove sufficient to upset the desired interlacing sequence. End of 2nd field 1st field *Equalizing pulses*. To take care of this drawback which occurs on account of the half-a-line discrepancy five narrow pulses are added on either side of the vertical sync pulses.
- These are known as pre-equalizing and post-equalizing pulses. Each set consists of five narrow pulses occupying 2.5 lines period on either side of the vertical sync pulses. Pre-equalizing and post equalizing pulse details with line numbers occupied by them in each field are given in Fig.
- The effect of these pulses is to shift the half-line discrepancy away both from the beginning and end of vertical sync pulses. Pre-equalizing pulses being of $2.3 \mu s$ duration result in the discharge of the capacitor to essentially zero voltage in both the fields, despite the half-line discrepancy before the voltage build-up starts with the arrival of vertical sync pulses.
- This is illustrated in Fig. Post-equalizing pulses are necessary for a fast discharge of the capacitor to ensure triggering of the vertical oscillator at proper time. If the decay of voltage across the capacitor is slow as would happen in the absence of post-equalizing pulses, the oscillator may trigger at the trailing edge which may be far-away from the leading edge and this could lead to an error in triggering.
- Thus with the insertion of narrow pre and post equalizing pulses, the voltage rise and fall profile is essentially the same for both the field sequences (see Fig.) and the vertical oscillator is triggered at the proper instants, *i.e.*, exactly at an interval of 1/50th of a second.
- This problem could possibly also be solved by using an integrating circuit with a much larger time constant, to ensure that the capacitor remains virtually uncharged by the horizontal pulses. However, this would have the effect of significantly reducing the integrator output for vertical pulses so that a vertical sync amplifier would have to be used.
- In a broadcasting situation, there are thousands of receivers for every transmitter. Consequently it is much more efficient and economical to cure this problem in one transmitter than in thousands of receivers. This, as explained above, is achieved by the use of pre and post equalizing pulses.
- The complete pulse trains for both the fields incorporating equalizing pulses are shown in . From the comparison of the horizontal and vertical output pulse forms shown in Fig and it appears that the vertical trigger pulse (output of the low-pass filter) is not very sharp but actually it is not so. The scale hosen exaggerates the extent of the vertical pulses. The voltage build-up period is only $160 \mu s$ and so far as the vertical synchronizing oscillator

is concerned this pulse occurs rapidly and represents a sudden change in voltage which decays very fast.

- The polarity of the pulses as obtained at the outputs of their respective fields may not be suitable for direct application in the controlled synchronizing oscillator and might need inversion.

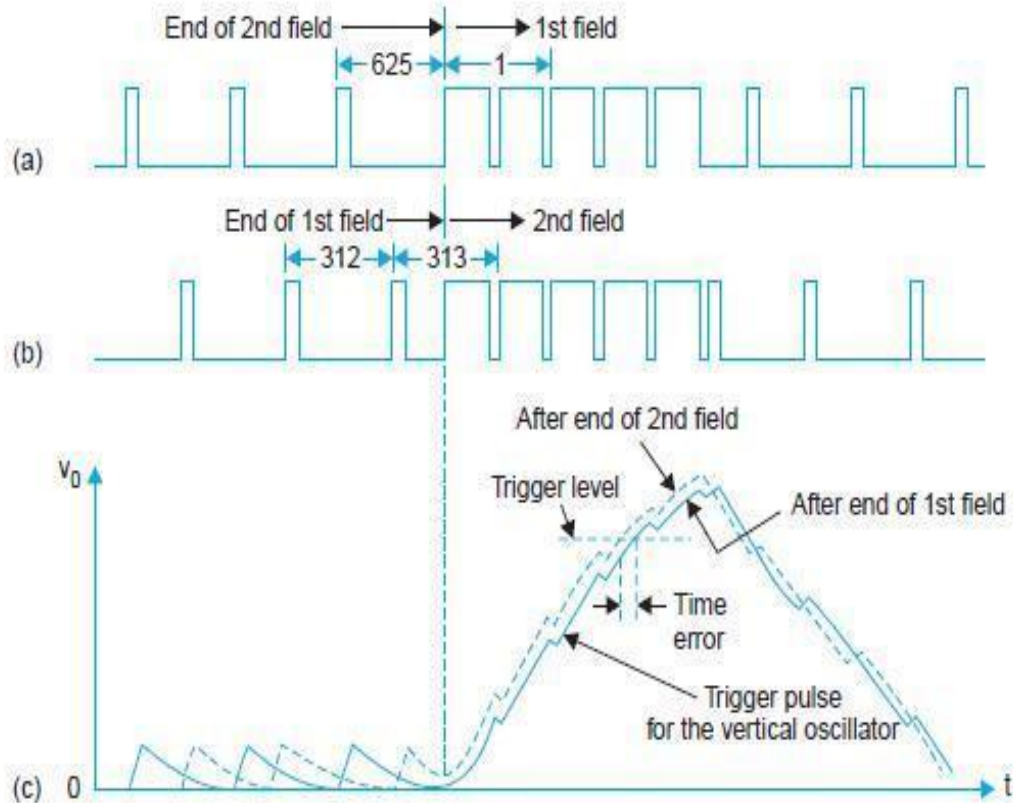
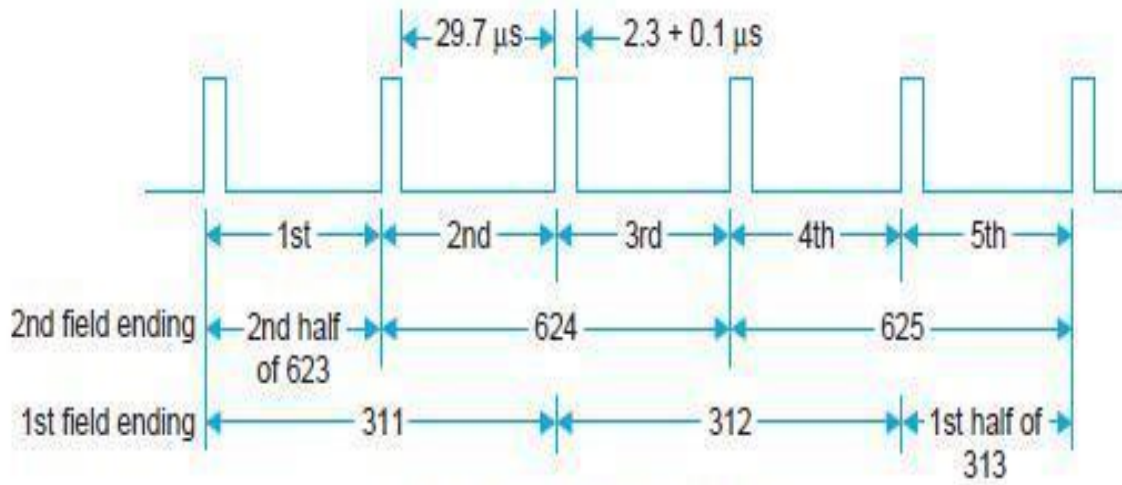
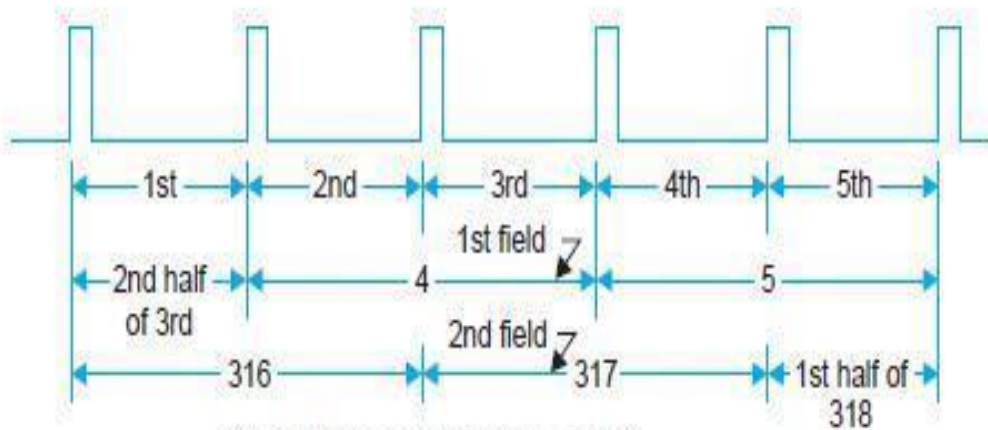


Figure. Integrating waveforms (a) pulses at the end of 2nd (even) field (b) pulses at the end of 1st (odd) field (c) integrator output. Note the above sync pulses have purposely been drawn without equalizing pulses

I



(a) Pre-sync equalizing pulses (five)



(b) Post-sync equalizing pulses (five)

Figure. Pre-sync equalizing and Post-sync equalizing pulses.

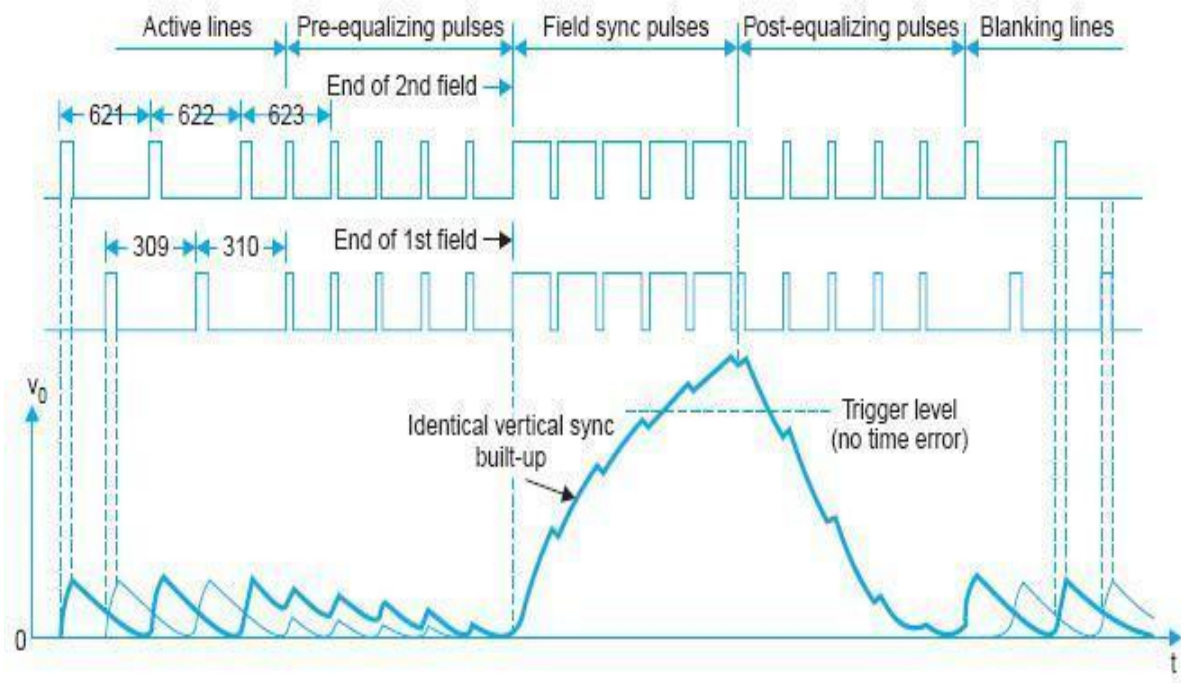


Figure. Identical vertical sync voltage built-up across the integrating capacitor.

1.17. SCANNING SEQUENCE DETAILS

- A complete chart giving line numbers and pulse designations for both the fields (corresponding to Fig) is given below :

First Field (odd field)

Line numbers :	one to 1st-half of 313th line (312.5 lines)
1, 2 and 3rd 1st-half, lines 2.5 lines	— Vertical sync pulses
3rd 2nd-half, 4, and 5 2.5 lines	— Post-vertical sync equalizing pulses.
6 to 17, and 18th 1st-half 12.5 lines	— blanking retrace pulses
18th 2nd-half to 310 292.5 lines	— Picture details
311, 312, and 313th 1st-half 2.5 lines	— Pre-vertical sync equalizing pulses for the 2nd field.
Total number of lines	= 312.5

Second field (even field)

Line numbers :	313th 2nd-half to 625 (312.5 lines)
313th 2nd-half, 314, 315 2.5 lines	— Vertical sync pulses
316, 317, 318th 1st-half 2.5 lines	— Post-vertical sync equalizing pulses
318th 2nd-half-to 330 12.5 lines	— Blanking retrace pulses
331 to 1st-half of 623rd 292.5 line	— Picture details
623 2nd-half, 624 and 625 2.5 lines	— Pre-vertical sync equalizing pulses for the
	1st field
Total number of lines	= 312.5
<i>Total Number of Lines per Frame</i>	= 625

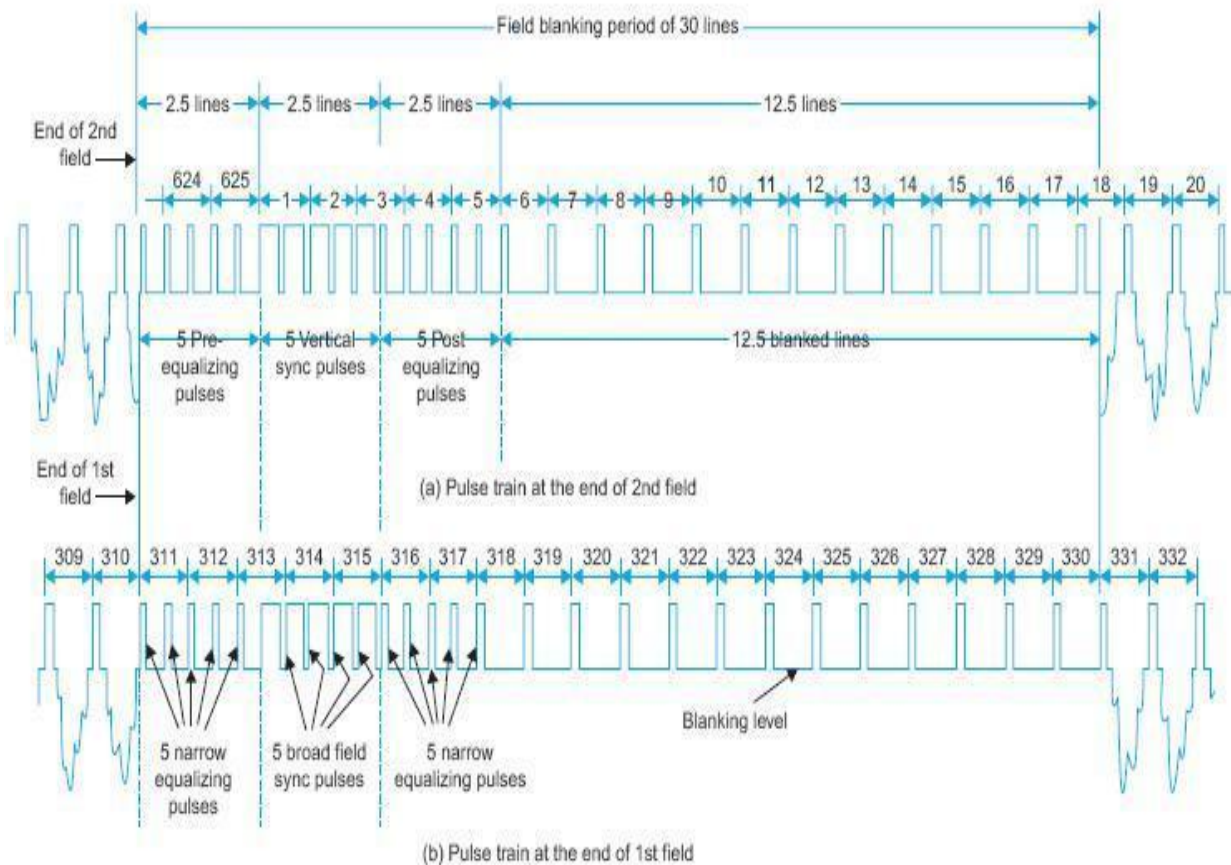


Figure. Field synchronizing pulse trains of the 625 lines TV system.

COMPOSITE VIDEO SIGNAL

- Approximate location of line numbers. The serrated vertical sync pulse forces the vertical deflection circuitry to start the flyback. However, the flyback generally does not begin with the start of vertical sync because the sync pulse must build up a minimum voltage across the capacitor to trigger the scanning oscillator.
- If it is assumed that vertical flyback starts with the leading edge of the fourth serration, a time of 1.5 lines passes during vertical sync before vertical flyback starts. Also five equalizing pulses occur before vertical sync pulse train starts.
- Then four lines ($2.5 + 1.5 = 4$) are blanked at the bottom of the picture before vertical retrace begins. A typical vertical retrace time is five lines. Thus the remaining eleven ($20 - (4 + 5) = 11$) lines are blanked at the top of the raster. These lines provide the sweep

oscillator enough time to adjust to a linear rise for uniform pick-up and reproduction of the picture.

FUNCTIONS OF VERTICAL PULSE TRAIN

- By serrating the vertical sync pulses and the providing pre- and post-equalizing pulses the following basic requirements necessary for successful interlaced scanning are ensured.
- (a) A suitable field sync pulse is derived for triggering the field oscillator.
- (b) The line oscillator continues to receive triggering pulses at correct intervals while the process of initiation and completion of the field time-base stroke is going on.
- (c) It becomes possible to insert vertical sync pulses at the end of a line after the 2nd field and at the middle of a line at the end of the 1st field without causing any interlace error.
- (d) The vertical sync build up at the receiver has precisely the same shape and timing on odd and even fields.

PREFERENCE OF AM FOR PICTURE SIGNAL TRANSMISSION

- At the VHF and UHF carrier frequencies there is a displacement in time between the direct and reflected signals. The distortion which arises due to interference between multiple signals is more objectionable in FM than AM because the frequency of the FM signal continuously changes.
- If FM were used for picture transmission, the changing best frequency between the multiple paths, delayed with respect to each other, would produce a bar interference pattern in the image with a shimmering effect, since the bars continuously change as the beat frequency

POSITIVE AND NEGATIVE MODULATION

- When the intensity of picture brightness causes increase in amplitude of the modulated envelope, it is called 'positive' modulation.
- When the polarity of modulating video signal is so chosen that sync tips lie at the 100 per cent level of carrier amplitude and increasing brightness produces decrease in the modulation envelope, it is called 'negative modulation'.
- The two polarities of modulation are illustrated in Fig

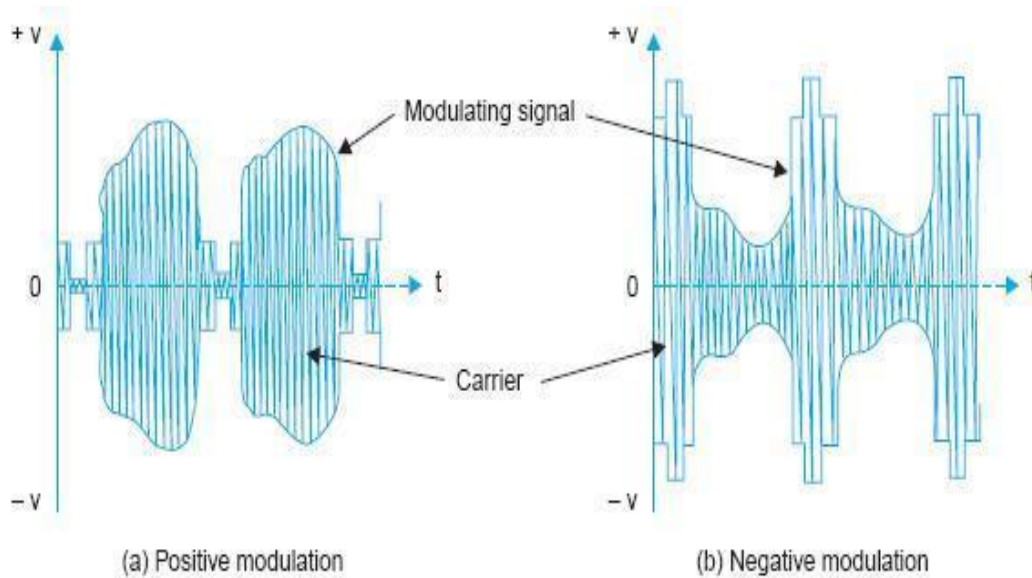


Figure. RF waveforms of an amplitude modulated composite video signal.

Comparison of Positive and Negative Modulation

- Effect of Noise Interference on Picture Signal. Noise pulses created by automobile ignition systems are most troublesome. The RF energy contained in such pulses is spread more or less uniformly over a wide frequency range and has a random distribution of phase and amplitude.
- When such RF pulses are added to sidebands of the desired signal, and sum of signal and noise is demodulated, the demodulated video signal contains pulses corresponding to RF noise peaks, which extend principally in the direction of increasing envelope amplitude. This is shown in Fig.
- Thus in negative system of modulation, noise pulse extends in black direction of the signal when they occur during the active scanning intervals. They extend in the direction of sync pulses when they occur during blanking intervals. In the positive system, the noise extends in the direction of the white during active scanning, *i.e.*, in the opposite direction from the sync pulse during blanking.
- Obviously the effect of noise on the picture itself is less pronounced when negative modulation is used. With positive modulation noise pulses will produce white blobs on the screen whereas in negative modulation the noise pulses would tend to produce black spots which are less noticeable against a grey background.
- This merit of lesser noise interference on picture information with negative modulation has led to its use in most TV systems. (b) Effect of Noise Interference on Synchronization. Sync pulses with positive modulation being at a lesser level of the modulated carrier envelope are not much affected by noise pulses.
- However, in the case of negatively modulated signal, it is sync pulses which exist at maximum carrier amplitude, and the effect of interference is both to mutilate some of

these, and to produce lot of spurious random pulses. This can completely upset the synchronization of the receiver time bases unless something is done about it.

- Because of almost universal use of negative modulation, special horizontal stabilizing circuits have been developed for use in receivers to overcome the adverse effect of noise on synchronization. (c) Peak Power Available from the Transmitter. With positive modulation, signal corresponding to white has maximum carrier amplitude.
- The RF modulator cannot be driven harder to extract more power because the non-linear distortion thus introduced would affect the amplitude scale of the picture signal and introduce brightness distortion in very bright areas of the picture.
- In negative modulation, the transmitter may be over-modulated during the sync pulses without adverse effects, since the non-linear distortion thereby introduced, does not very much affect the shape of sync pulses. Consequently, the negative polarity of modulation permits a large increase in peak power output and for a given setup in the final transmitter stage the output increases by about 40%. (d) Use of AGC (Automatic Gain Control) Circuits in the Receiver.
- Most AGC circuits in receivers measure the peak level of the incoming carrier signal and adjust the gain of the RF and IF amplifiers accordingly. To perform this measurement simply, a stable reference level must be available in the signal. In negative system of modulation, such a level is the peak of sync pulses which remains fixed at 100 per cent of signal amplitude and is not affected by picture details.
- This level may be selected simply by passing the composite video signal through a peak detector. In the positive system of modulation the corresponding stable level is zero amplitude at the carrier and obviously zero is no reference, and it has no relation to the signal strength.
- The maximum carrier amplitude in this case depends not only on the strength of the signal but also on the nature of picture modulation and hence cannot be utilized to develop true AGC voltage. Accordingly AGC circuits for positive modulation must select some other level (blanking level) and this being at low amplitude needs elaborate circuitry in the receiver.
- Thus negative modulation has a definite advantage over positive modulation in this respect. The merits of negative modulation over positive modulation, so far as picture signal distortion and AGC voltage source are concerned, have led to the use of negative modulation in almost all TV systems now in use.

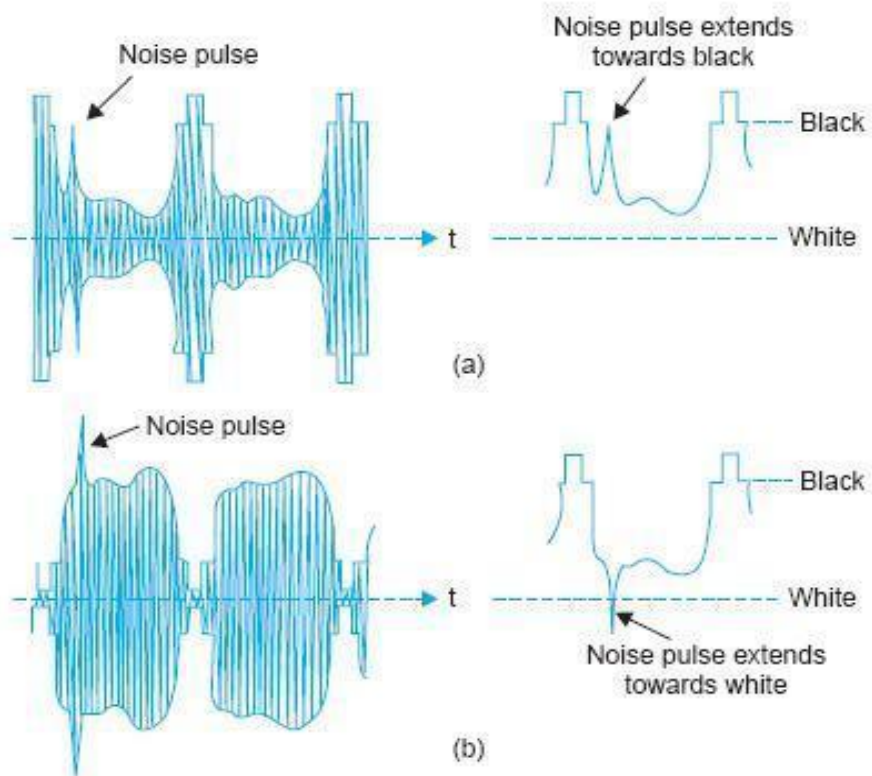


Figure. Effect of noise pulses (a) with negative modulation,(b) with positive modulation.

1.19. SOUND SIGNAL TRANSMISSION

- The outputs of all the microphones are terminated in sockets on the sound panel in the production control room. The audio signal is accorded enough amplification before feeding it to switchers and mixers for selecting and mixing outputs from different microphones.
- The sound engineer in the control room does so in consultation with the programme director. Some prerecorded music and special sound effects are also available on tapes and are mixed with sound output from the studio at the discretion of programme director.
- All this needs prior planning and a lot of rehearsing otherwise the desired effects cannot be produced. As in the case of picture transmission, audio monitors are provided at several stages along the audio channel to keep a check over the quality and volume of sound.

Preference of FM over AM for Sound Transmission

- Contrary to popular belief both FM and AM are capable of giving the same fidelity if the desired bandwidth is allotted. Because of crowding in the medium and short wave bands in radio transmission, the highest modulating audio frequency used is 5 kHz and not the full audio range which extends up to about 15 kHz.
- This limit of the highest modulating frequency results in channel bandwidth saving and only a bandwidth of 10 kHz is needed per channel. Thus, it becomes possible to

accommodate a large number of radio broadcast stations in the limited broadcast band. Since most of the sound signal energy is limited to lower audio frequencies, the sound reproduction is quite satisfactory.

- Frequency modulation, that is capable of providing almost noise free and high fidelity output needs a wider swing in frequency on either side of the carrier. This can be easily allowed in a TV channel, where, because of very high video frequencies a channel bandwidth of 7 MHz is allotted. In FM, where highest audio frequency allowed is 15 kHz, the sideband frequencies do not extend too far and can be easily accommodated around the sound carrier that lies 5.5 MHz away from the picture carrier.
- The bandwidth assigned to the FM sound signal is about 200 kHz of which not more than 100 kHz is occupied by sidebands of significant amplitude. The latter figure is only 1.4 per cent of the total channel bandwidth of 7 MHz. Thus, without encroaching much, in a relative sense, on the available band space for television transmission all the advantages of FM can be availed.

UNIT II

MONOCHROME TELEVISION TRANSMITTER AND RECEIVER

2.1. TELEVISION TRANSMITTER

- A simplified functional block diagram of a television transmitter is shown in Fig. Necessary details of video signal modulation with picture carrier of allotted channel are shown in picture transmitter section of the diagram. Note the inclusion of a dc restorer circuit (DC clamp) before the modulator.
- Also note that because of modulation at a relatively low power level, an amplifier is used after the modulated RF amplifier to raise the power level.
- Accordingly this amplifier must be a class-B push-pull linear RF amplifier. Both the modulator and power amplifier sections of the transmitter employ specially designed VHF triodes for VHF channels and klystrons in transmitters that operate in UHF channels.

Vestigial Sideband Filter

- The modulated output is fed to a filter designed to filter out part of the lower sideband frequencies. As already explained this results in saving of band space.

Antenna

- The filter output feeds into a combining network where the output from the FM sound transmitter is added to it.
- This network is designed in such a way that while combining, either signal does not interfere with the working of the other transmitter.
- A coaxial cable connects the combined output to the antenna system mounted on a high tower situated close to the transmitter.
- A turnstile antenna array is used to radiate equal power in all directions. The antenna is mounted horizontally for better signal to noise ratio

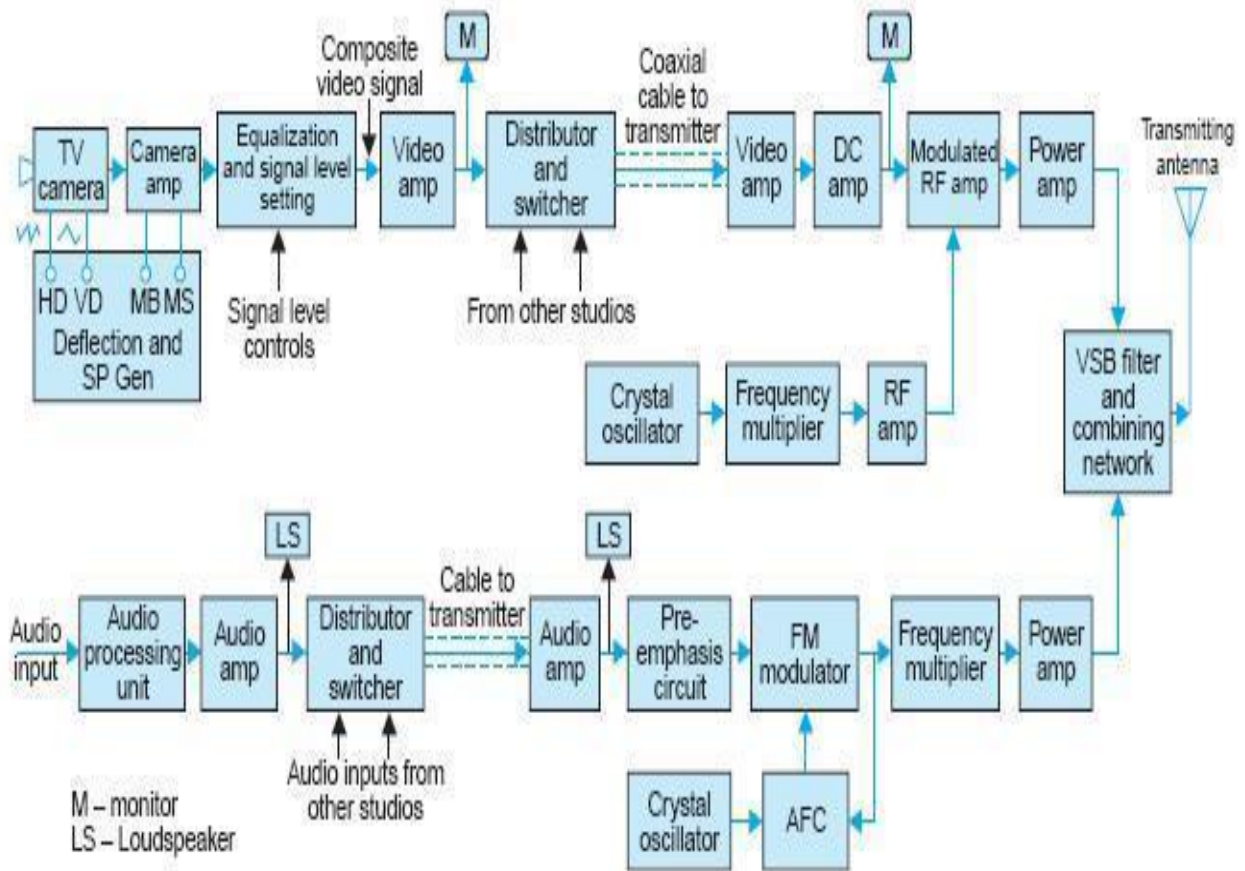


Figure. Simplified block diagram of a television transmitter.

2.4. TELEVISION TRANSMISSION ANTENNAS

- As already explained, television signals are transmitted by space wave propagation and so the height of antenna must be as high as possible in order to increase the line-of-sight distance.
- Horizontal polarization is standard for television broadcasting, as signal to noise ratio is favorable for horizontally polarized waves when antennas are placed quite high above the surface of the earth.

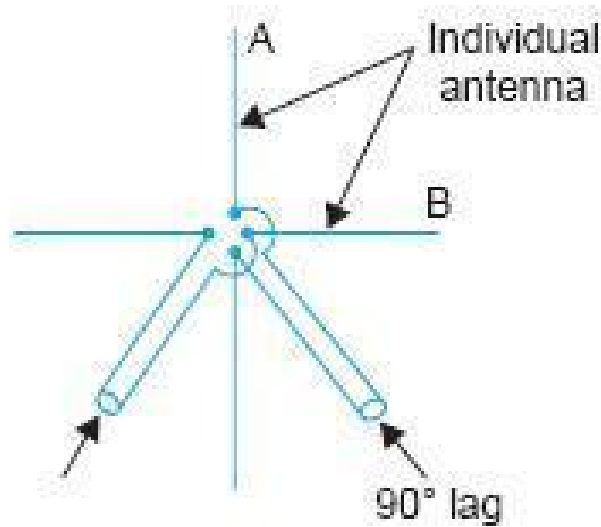


Figure. Turnstile array.

Turnstile Array

- To obtain an omnidirectional radiation pattern in the horizontal plane, for equal television signal radiation in all directions, an arrangement known as ‘turnstile array’ is often used.
- In this type of antenna two crossed dipoles are used in a turnstile arrangement as shown in Fig. These are fed in quadrature from the same source by means of an extra $\lambda/4$ line. Each dipole has a figure of eight pattern in the horizontal plane, but crossed with each other. The resultant field in all directions is equal to the square root of the sum of the squares of fields radiated by each conductor in that direction.
- Thus the resultant pattern as shown in Fig. is very nearly circular in the plane of the turnstile antenna. Fig. shows several turnstiles stacked one above the other for vertical directivity.

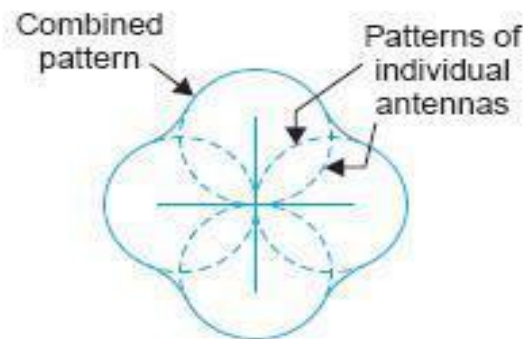


Figure. Directional pattern in the plane of turnstile.

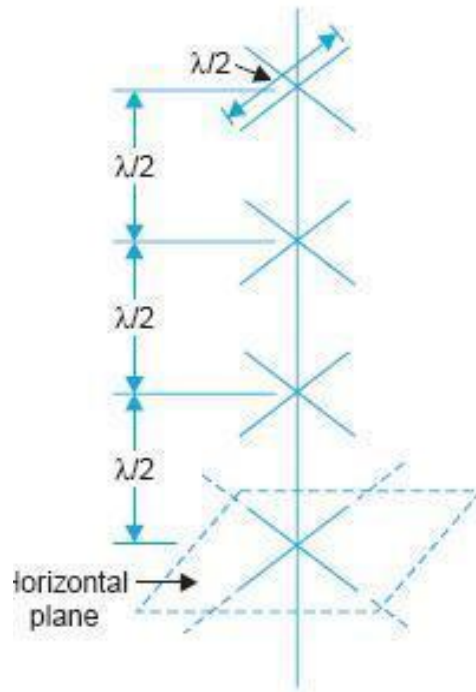


Figure. Stacked turnstile array.

Dipole Panel Antenna System

- Another antenna system that is often used for band I and band III transmitters consists of dipole panels mounted on the four sides at the top of the antenna tower as shown in Fig.
- Each panel consists of an array of full-wave dipoles mounted in front of reflectors. For obtaining unidirectional pattern the four panels mounted on the four sides of the tower are so fed that the current in each lags behind the previous by 90° .
- This is achieved by varying the field cable length by $\lambda/4$ to the two alternate panels and by reversal of polarity of the current.

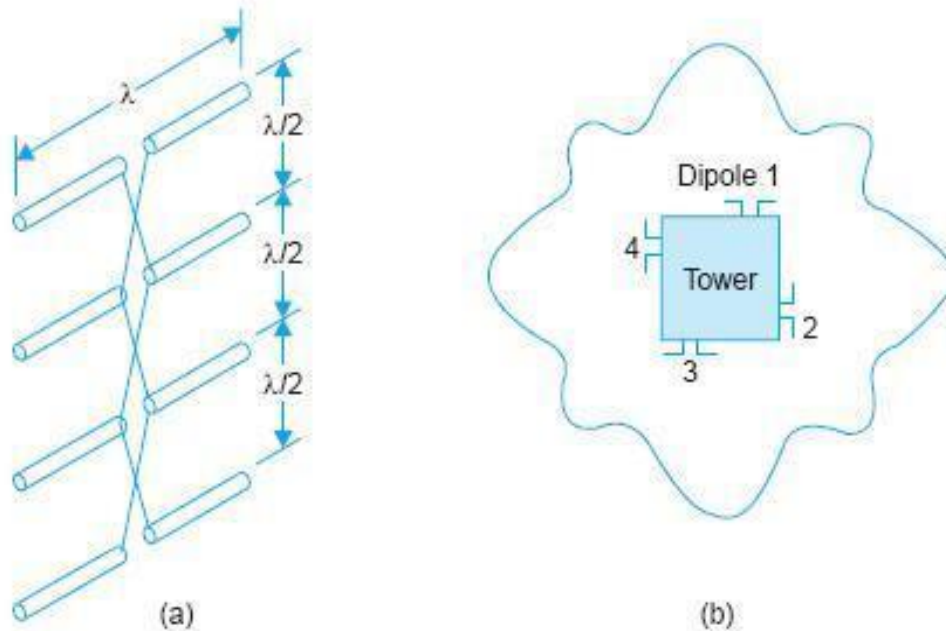


Figure. Dipole panel antenna system (a) panel of dipoles (b) radiation pattern of four tower mounted dipole antenna panels.

Combining Network

- The AM picture signal and FM sound signal from the corresponding transmitters are fed to the same antenna through a balancing unit called diplexer.
- As illustrated in Fig. the antenna combining system is a bridge configuration in which first two arms are formed by the two radiators of the turnstile antenna and the other two arms consist of two capacitive reactance.
- Under balanced conditions, video and sound signals though radiated by the same antenna, do not interfere with the functioning of the transmitter other than their own.

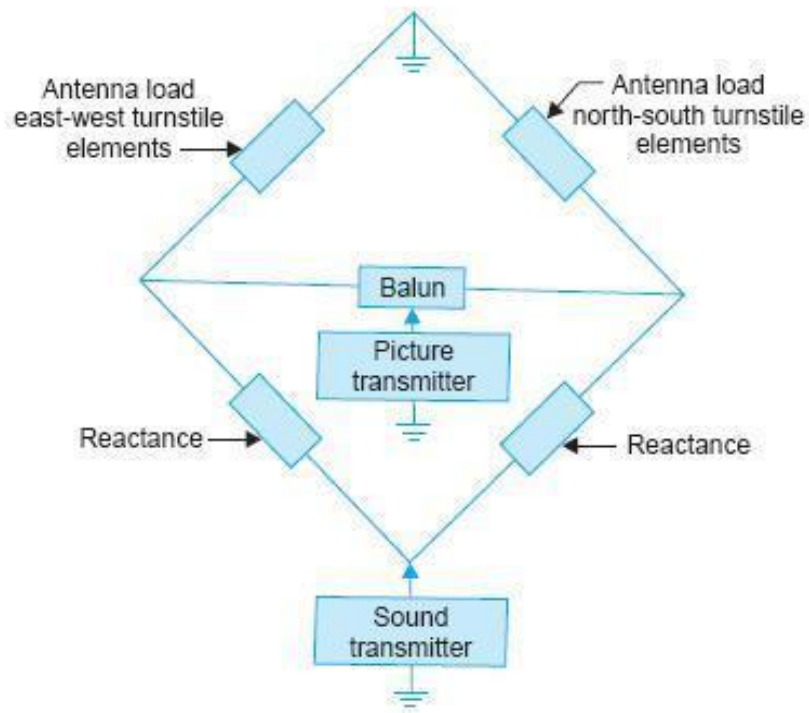


Figure. Equivalent bridge circuit of a diplexer for feeding picture and sound transmitters to a common turnstile array.

2.5. MONOCHROME TV RECEIVER CIRCUIT

- Out of the numerous receiver circuits that are in use, one developed by Bharat Electronics Ltd. (BEL) has been chosen for detailed discussion. It is a multichannel fully solid-state receiver conforming to CCIR 625-B system.
- It employs three ICs. The design of the receiver is so simple that it can be assembled* with a minimum of tooling and test facilities. Such an exercise can be very instructive for fully grasping alignment and servicing techniques of a television receiver. Fig. on the foldout page shows the circuit diagram of this receiver. A brief description of the circuit follows:

(a) Tuner

- The receiver employs a turret type tuner and provides all channels between 3 to 10 in the VHF range. A high pass filter with a cut-off frequency of 40 MHz is used at the input to reduce interference due to IF signals. The tuner operates from a + 12 V supply and has an effective AGC range of 50 db.

(b) Video IF Section

- The video IF sub-system consists of IC, BEL CA**3068 and other associated components housed in a modular box to avoid any possible RF interference.
- All interconnections to this module are *The technical manual of the receiver can be obtained on request from M/s Bharat Electronics Ltd. Jalahalli, P.O., Bangalore 560013 India.
- The manual gives all necessary circuit details, coil data, list of components, assembly and alignment details. either through feed through capacitors or insulated lead throughs.
- The IF sub-assembly provides (i) a gain around 75 db to the incoming signal from the tuner, (ii) required selectivity and bandwidth, (iii) attenuation to adjacent channel interfering frequencies, (iv) attenuation of 26 db to sound IF for intercarrier sound, (v) sound IF and video outputs and (vi) AGC voltage to the IF section and tuner.

(c) Sound IF Sub-system and Audio Section

The important functions performed by this sub-system are:

- (i) to amplify inter carrier IF signal available from the picture IF amplifier,
- (ii) to recover sound signal,
- (iii) to amplify the sound signal and deliver at least 2 watts of audio power to the loudspeaker.

The circuit of BEL CA*3065 IC consists of

- (i) a regulated power supply,
 - (ii) a sound IF amplifier-limiter,
 - (iii) an FM limiter,
 - (iv) an electronic attenuator and a buffer amplifier, and
 - (v) an audio driver.
- The sound section operates from a + 12 V supply. It employs transistor BC 148B as a boot-strapped driver and matched transistor pair, 2N5296 and 2N6110, at the output stage. The bandwidth of the audio amplifier is from 40 Hz to 15 KHz and can deliver 2 watts of useful audio power.

(d) Video Amplifier and Picture Tube Biasing

- This section of the receiver uses transistors BF 195 C as driver (buffer), BD115 as video amplifier and BC147B in the blanking circuit. The video amplifier delivers 90 V p-p signal to the cathode of picture tube 500-C1P4.
- The current limiting is provided by diode 0A79 and associated circuitry. Transistor Q 503 switches amplifier transistor Q502 only during the time when video signal is present and turns it off during horizontal and vertical sync periods.
- The horizontal blanking pulses of 60 V p-p and vertical blanking pulses of 40 V p-p are applied to the base of transistor Q503. High voltage output of 1.1 KV from the horizontal output circuit is rectified and fed to focusing grids of the picture tube through a potential

divider. Brightness control operates from a + 200 V supply. The contrast control functions by varying input signal amplified to the video amplifier transistor Q 502.

(e) Horizontal Oscillator Sub-system

- This section employs transistor Q 401 (BC 148 A), IC, CA 920 and associated passive components. Composite video signal from the IF section is applied to pin 8 of IC 401 (CA 920). The functions of the horizontal subsystem are:
 - (i) To generate a line frequency signal, the frequency of which can be current controlled,
 - (ii) To separate sync information from the composite signal,
 - (iii) To compare the phase of sync pulses with that of the oscillator output and generate a control voltage for automatic tuning of the oscillator.
 - (iv) Phase comparison between the oscillator waveform and middle of the line flyback Pulse, to generate a control voltage for correction of the switching delay time in the horizontal driving and output stages, and
 - (v) Shaping and amplification of the oscillator output to obtain pulses capable of driving the horizontal deflection driver circuit.

(f) Horizontal Output Circuit

- Output from the horizontal oscillator is applied to the base of horizontal driver transistor Q802 through a coupling capacitor (C 803). The transistor switches from cut-off to saturation when a pulse is applied to its base and provides the necessary drive for Q803 (BU 205).
- The output transistor (Q803) drives the line output transformer to provide deflection current to the yoke coils. In addition, the output circuit (i) generates flyback pulses for blanking, AFC and AGC keying, (ii) provides auxiliary power supplies and generates high voltage (+ 18 KV) for anode of the picture tube and (iii) produces 1.1 KV dc for the focusing grids. The heater supply of 6.3 V for the picture tube is taken across winding 10-11 of the line output transformer.

(g) Vertical Deflection Circuit

- As shown in Fig. 29.1, the circuit operates from a 40 V dc supply obtained through the line output transformer. This sub-system is a self-oscillatory synchronized oscillator with a matched pair of output transistors.
- Clipped vertical sync pulses are fed at the base of Q 70 (BC 148 C) to provide it with a stable drive. Resistor R 724 senses yoke current and feeds a voltage proportional to this current back to the base of Q 702 (BC148 B) for adjustment of the picture height. Coupling network between the collector of Q 701 and the base of Q 702 incorporates the necessary 'S' correction and provides linearity of the deflection current. Hold control forms part of the input circuit of transistor Q 701.

(h) Power Supply Circuit

- The power supply circuit is a conventional transformerless half-wave rectifier and filter circuit.

- It provides 200 V for feeding various sections of the receiver. Front panel control. Four controls i.e. on/off volume control, channel selector and fine tuning, contrast control and brightness control are brought out at the front panel of the receiver.
- In addition, vertical hold and horizontal hold controls are available on the side panel for occasional adjustments.

2.6. RF TUNER

- The RF amplifier, the local oscillator and the mixer stages form the RF tuning section. This is commonly known as '*Tuner*' or '*Front end*'.
- A simplified block diagram of the tuner is shown in Fig. It is the same for both monochrome and colour receivers except that automatic frequency tuning is provided in colour receivers only.
- The function of the tuner is to select a single channel signal from the many signals picked up by the antenna, amplify it and mix it with the CW (continuous wave) output of the local oscillator to convert the channel frequencies to a band around the intermediate frequency of the receiver.
- It is the local oscillator that tunes in the desired station. Its frequency is unique for each channel, which determines the RF signal frequencies to be received and converted to frequencies in the pass-band of the IF section.

TUNER OPERATION

- As shown in the tuner block diagram the function of channel selection is accomplished by simultaneously adjusting the tuned circuits of all the three stages that make up the tuner. This means that three or four tuned circuits must be switched while changing channels. The tuned circuits found in both vacuum tube and transistor tuners are as follows:
 - (i) Input tuned circuit to the RF amplifier
 - (ii) Output tuned circuit of the RF amplifier
 - (iii) Input tuned circuit to the mixer
 - (iv) Local oscillator tuned circuit
- In some tuners the mixer input tuned circuit is left out and thus they have only three tuned circuits. Each tuned circuit consists of a coil and a capacitor. The resonating capacitance consists of distributed capacitance of the circuit plus small fixed ceramic capacitors.
- The fine tuning control is varied to obtain exact picture and sound intermediate frequencies for which the receiver is designed. The correct setting of the local oscillator frequency is indicated by the best picture obtained on the screen.
- Physically, the tuner is wired as a sub-assembly on a separate chassis which is mounted on the main receiver chassis. The IF signal from the tuner is coupled to the first picture IF

amplifier through a short coaxial cable. The AGC line and B+ supply are connected from the main chassis to the tuner sub chassis.

- The tuner is enclosed in a compact shielded box and all connections are usually brought out at the top of the tuner via feed through capacitors. In tube-type receivers, the filament power to the tuner tubes is also supplied from the common power supply.
- Though the principle of selection in television receivers is the same as that in radio receivers the design of the tuner is very different from the heterodyning section of the radio receiver.
- This is because of large band width requirements and very high frequencies employed for TV transmission. In fact tuner design techniques differ so much at ultra-high frequencies that all true multichannel receivers employ separate tuners for the VHF and UHF channels. We will confine our discussion to channels with frequencies 47 to 223 MHz in the VHF band (30 to 300 MHz).

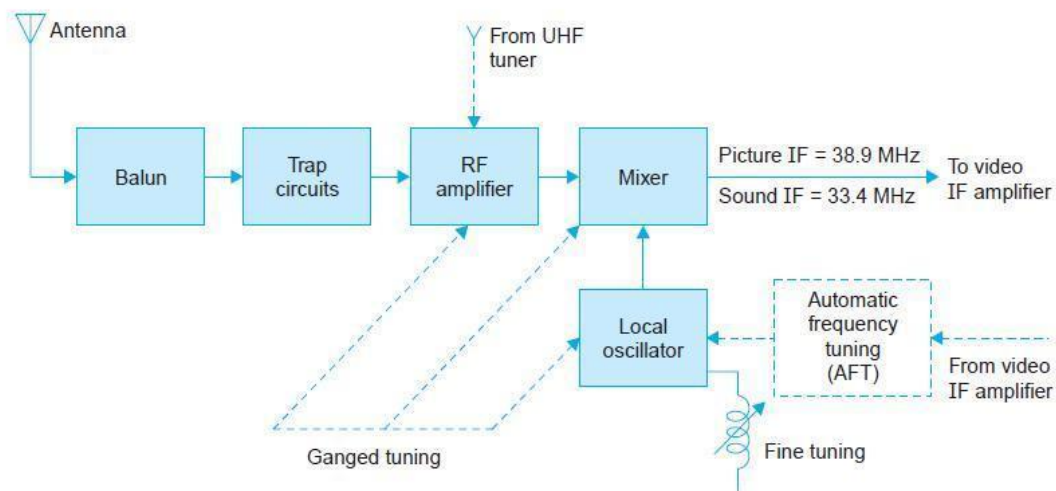


Figure. Block diagram of a VHF tuner. Note that AFT is provided in colour receivers only.

FACTORS AFFECTING TUNER DESIGN

The factors that must be considered before attempting to learn details of the tuner circuitry are:

(a) Choice of IF and Local Oscillator Frequencies

- high image rejection ratio,
 - reduced local oscillator radiation,
 - ease of detection and
 - good selectivity at the IF stages.
- The local oscillator frequency is kept higher than the channel carrier frequency since this results in a relatively narrow oscillator frequency range.
 - It is then easier to design an oscillator that is stable and delivers almost constant output voltage over its entire frequency range. Intermediate frequencies have been standardized

in accordance with the total bandwidth allotted to each channel in different TV systems. In the 625-B monochrome system, the picture IF = 38.9 MHz and sound IF = 33.4 MHz.

(b) Need for an RF Amplifier Stage

- In principle an RF amplifier is not necessary and the signal could be fed directly to the tuned input circuit of the mixer as is the normal practice in radio receivers.
- However, at very high frequencies the problems of image signals, radiation from the local oscillator through the antenna circuit and conversion loss at the mixer are such that a stage of amplification prior to the mixer is desirable.
- Another very important purpose of providing one stage of amplification is to feed enough RF signal into the mixer for a clean picture without snow.
- White speckles called snow are caused by excessive noise signals present in the video signal. The mixer circuit generates most of the noise because of heterodyning.
- Except in areas very close to the transmitter the signal level is moderate and a low noise RF amplifier stage with a gain of about 25 db becomes necessary to obtain the desired signal-to-noise ratio of 30 : 1.
- In fringe areas where the signal level is very low an additional RF amplifier known as *booster* is often employed to maintain a reasonable signal-to-noise ratio. In all tuner designs the gain of the RF amplifier is controlled by AGC voltage to counter any variations in the input signal to the receiver. A signal level of about 400 μ V at the input to the receiver is considered adequate for a snow free picture.

(c) Coupling Networks

- Parallel tuned networks are used to accomplish the desired selectivity in RF and IF sections of the receiver. For minimum power loss the coupling network should match the output impedance of one stage to the input impedance of the following stage.
- In circuits employing tubes this does not present any problem because the output and input impedance levels are not very different and the main criterion is to transfer maximum voltage to the next stage.
- However, in transistor amplifiers, where the input circuit also consume power, the inter stage coupling network must be designed to transfer maximum power from the output of one stage to the input of the following stage.
- The coupling design is further complicated by the fact that in transistors the output and input impedance levels are much different from each other. For example the input impedance of a common base configuration at very high frequencies is only a few tens of ohms, whereas its output impedance is of the order of several tens of kilo-ohms.

UHF TUNERS

- There are two types of UHF tuners. In one type the converter section of the UHF tuner converts the incoming signals from the UHF band (470 to 890 MHz) to the VHF band. Usually the UHF channels are converted to VHF channel numbers 5 or 6 and the VHF tuner, in turn, processes these signals in the usual way.
- Since the relative positions of video and sound IFs are specified, the converter oscillator of the UHF tuner is tuned to a frequency lower than the incoming UHF signal to take into account the double-heterodyning action involved. In the second type, the UHF signal is heterodyned with local oscillator output to translate the incoming channel directly to the IF band.
- The output thus obtained from the UHF tuner is coupled to the VHF tuner, where the RF amplifier and mixer stages operate as IF amplifiers, when the VHF station selector is set to the UHF position. In this position the VHF oscillator is disabled by cutting off its dc supply. The RF tuned circuits are also changed to IF tuned circuits. In present day tuners, this type is preferred. Figure illustrates the block schematic of this circuit. Separate antennas are used for VHF and UHF channels.
- The UHF tuner does not employ an RF amplifier because the input signal strength being very low is comparable to the noise generated in the RF amplifier. If used it lowers the signal-to-noise ratio and fails to boost the signal level above the noise level.
- Therefore, the incoming UHF signal is directly coupled to the mixer where a diode is used for heterodyning instead of a transistor or a special tube. The reason for using a diode is two-fold. Firstly, the local oscillator output at ultrahigh frequencies is too low to cause effective mixing with an active device whereas it is adequate when a diode is employed. Secondly the noise level with a diode is lower than when an active device is used. Since the diode is a non-linear device it can produce beating of the incoming channel frequencies with the local oscillator frequency to generate side-band frequencies.

Block diagram of a UHF-VHF tuner

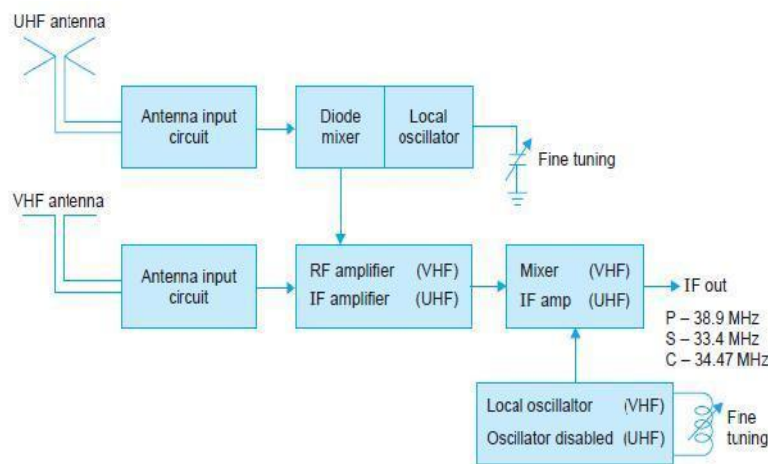


Figure. Block diagram of a UHF-VHF tuner

- The weak output from the UHF tuner is coupled to the VHF tuner where both the RF amplifier and mixer stages acts as IF amplifiers to boost the signal to the level normally obtained when a VHF channel is tuned.
- In conclusion the various functions performed by a television receiver tuner may be summarized as follows:
 1. It selects the desired station and rejects others.
 2. It converts all incoming channel frequencies to a common IF band.
 3. It provides gain to the weak input signal picked up by the antenna. This improves S/N ratio and reduces snow on the picture.
 4. It isolates the local oscillator from the feeder circuit to prevent undesired radiation through the antenna.
 5. It improves image rejection ratio and thus reduces interference from source operating at frequencies close to the image frequencies of various channels.
 6. It prevents spurious pick-ups from sources which operate in the IF band of the receiver.
 7. It provides matching between the antenna and input circuits of the receiver, thus eliminating the appearance of ghost images on the screen.
 8. It rejects any pick-up from stations operating in the FM band.
 9. It has provision to select any channel out of the various allotted in the VHF and UHF bands for TV transmission.
 10. It has a fine tuning control for accurate setting of the selected station.

2.8. AUTOMATIC FINE TUNING (AFT)

- The local oscillator frequency in the RF tuner is set to provide exact IF frequencies. However, despite many remedial measures to improve the stability of the oscillator circuit, some drift does occur on account of ambient temperature changes, component aging, and power supply voltage fluctuations and so on.
- For a monochrome receiver a moderate amount of change in the local oscillator frequency can be tolerated without much effect on the reproduced picture and sound output. The fine tuning control is adjusted occasionally to get a sharp picture. The sound output is automatically corrected because of the use of inter carrier sound system. However, requirements of frequency stability of the local oscillator in a colour TV receiver are much more stringent.
- This is so, because proper fine tuning of colour receivers is judged both by the sharpness of the picture and quality of colour. If the local oscillator frequency becomes higher than the correct value, the picture IF, subcarrier IF and sound IF frequencies will also become higher by the same amount and fall on incorrect positions on the IF response curve.
- This will result in poor picture quality because the amplitudes of low-frequency video sidebands clustered around the picture IF will decrease. At the same time chrominance signal sidebands clustered around the location of subcarrier will receive more gain and hence become stronger than normal.
- Similarly, if the local oscillator frequency changes to become less than the desired value opposite effects would result and colour reproduction will become weak.

- In case the decrease in frequency is more than 1 MHz, the colour burst may be lost and only a black and white picture will be seen on the screen.
- Similar troubles can also result in receivers that employ remote control tuning because of non-availability of fine tuning control and imperfections of the mechanical/electronic system employed for channel selection.

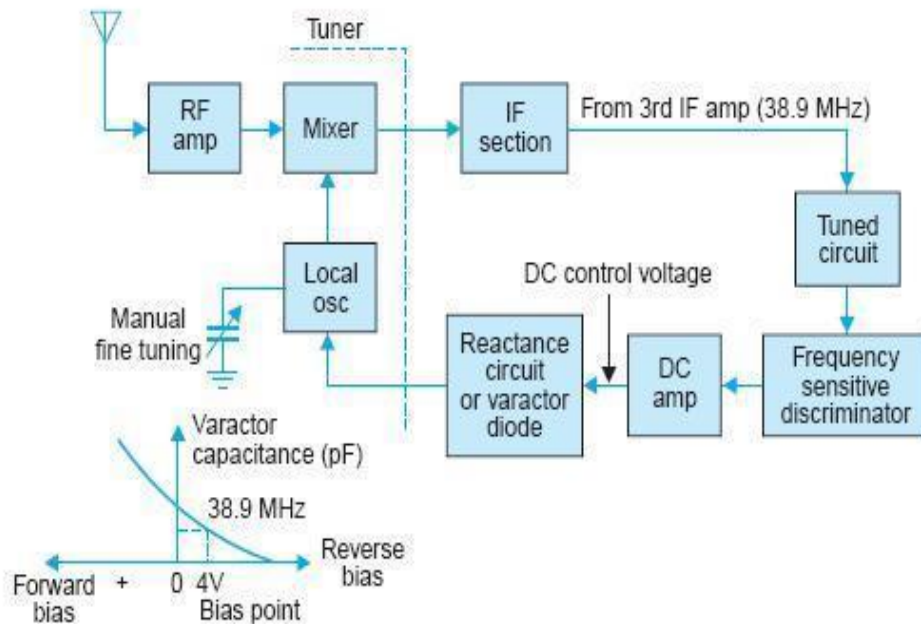


Figure. Block diagram of an AFT circuit.

2.9. AGC NOISE CANCELLING CIRCUIT

- Automatic gain control (AGC) circuit varies the gain of a receiver according to the strength of signal picked up by the antenna. The idea is the same as automatic volume control (AVC) in radio receivers.
- Useful signal strength at the receiver input terminals may vary from $50 \mu\text{V}$ to 0.1 V or more, depending on the channel being received and distance between the receiver and transmitter.
- The AGC bias is a dc voltage proportional to the input signal strength. It is obtained by rectifying the video signal as available after the video detector. The AGC bias is used to control the gain of RF and IF stages in the receiver to keep the output at the video detector almost constant despite changes in the input signal to the tuner.

ADVANTAGES OF AGC

The advantages of AGC are:

(a) Intensity and contrast of the picture, once set with manual controls, remain almost constant despite changes in the input signal strength, since the AGC circuit reduces gain of the receiver with increase in input signal strength.

(b) Contrast in the reproduced picture does not change much when the receiver is switched from one station to another.

(c) Amplitude and cross modulation distortion on strong signals is avoided due to reduction in gain.

(d) AGC also permits increase in gain for weak signals. This is achieved by delaying the application of AGC to the RF amplifier until the signal strength exceeds $150 \mu\text{V}$ or so. Therefore the signal to noise ratio remains large even for distant stations. This reduces snow effect in the reproduced picture.

(e) Flutter in the picture due to passing aero planes and other fading effects is reduced.

(f) Sound signal, being a part of the composite video signal, is also controlled by AGC and thus stays constant at the set level.

(g) Separation of sync pulses becomes easy since a constant amplitude video signal becomes available for the sync separator. AGC does not change the gain in a strictly linear fashion with change in signal strength, but overall control is quite good. For example, with an antenna signal of $200 \mu\text{V}$ the combined RF and IF section gain will be 10,000 to deliver 2 V of video signal at the detector output, whereas with an input of $2000 \mu\text{V}$, the gain instead of falling to 1000 to deliver the same output, might attain a value of 1500 to deliver 3 V at the video detector.

Basic AGC Circuit

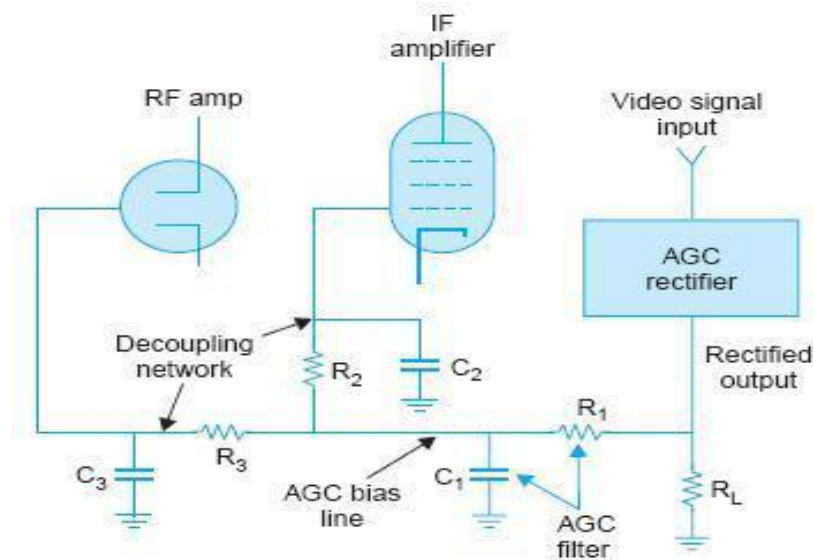


Figure. Basic AGC circuit.

- The circuit of Fig. illustrates how AGC bias is developed and fed to RF and IF amplifiers. The video signal on rectification develops a unidirectional voltage across RL . This voltage must be filtered since a steady dc voltage is needed for bias. $R1$ and $C1$, with a time constant of about 0.2 seconds, constitute the AGC filter.
- A smaller time constant, will fail to remove low frequency variations in the rectified signal, whereas, too large a time constant will not allow the AGC bias to change fast enough when the receiver is tuned to stations having different signal strengths.
- In addition, a large time constant will fail to suppress flutter in the picture which occurs on account of unequal signal picked up by the antenna after reflection from the wings of an aero plane flying nearby.
- With tubes, a typical AGC filter has $0.1 \mu F$ for $C1$ and $2 M$ for $R1$. For transistors, typical values are $20 k$ for $R1$ and $10 \mu F$ for $C1$. The filtered output voltage across $C1$ is the source of AGC bias to be distributed by the AGC line.
- Each stage controlled by AGC has a return path to the AGC line for bias, and thus the voltage on the AGC line varies the bias of the controlled stages.

2.12. DC REINSERTION

- As explained earlier, relative relationship of ac signal to the blanking and sync pulses remains same with or without the dc component. Furthermore, brighter the line, greater is the separation between the picture information variations and the associated pulses.
- As the scene becomes darker, the two components move closer to each other. It is from these relationships that a variable bias can be developed to return the pulses to the same level which existed before the signal was applied to the RC network.
- DC Restoration with a Diode. A simple transistor-diode clamp circuit for lining up sync pulses is shown in Fig. The V_{CC} supply is set for a quiescent voltage of 15 V. In the absence of any input signal the coupling capacitor 'C' charges to 15 V and so the voltage across the parallel combination of resistor R and diode D will be zero. Assume that on application of a video signal, the collector voltage swings by 8 V peak to peak.
- The corresponding variations in collector to emitter voltage are illustrated in Fig. The positive increase in collector voltage is coupled through C to the anode of diode D, turning it on. Since a forward biased diode may be considered to be a short, it effectively ties (clamps) the output circuit to ground (zero level). In effect, each positive sync pulse tip will be clamped to zero level, thereby lining them up and restoring the dc level of the video signal.
- In the case under consideration the diode will cause the coupling capacitor to charge to a peak value of 19 V. However, during negative excursion of the collector voltage the capacitor fails to discharge appreciably, because the diode is now reverse biased and the value of R has been chosen to be quite large.
- The average reverse bias across the diode is $-4 V$, being the difference between the quiescent collector voltage and peak value across the capacitor. Note that as the input video

signal varies in amplitude a corresponding video signal voltage appears across the resistor R and it varies in amplitude from 0 to -8 V (peak to peak). This, as shown in Fig., is the composite video signal clamped to zero.

- Similarly as and when the average brightness of the scene varies the capacitor C charges to another peak value thereby keeping the sync tips clamped to zero level. Reversing the diode in the restorer circuit will result in negative peak of the input signal being clamped to zero.
- This would mean that the dc output voltage of the circuit will be positive. The video signal can also be clamped to any other off-set voltage by placing a dc voltage of suitable polarity in series with the clamping diode.

Limitations of Diode Clamping

- It was assumed while explaining the mechanism of dc restoration that charge across the coupling Capacitor C does not change during negative swings of the collector voltage. However, it is not so because of the finite value of RC .
- The voltage across C does change somewhat when the condenser tends to discharge through the resistor R . Another aspect that merits attention is the fact that whenever average brightness of the picture changes suddenly the dc restorer is not capable of instant response because of inherent delay in the charge and discharge of the capacitor.
- Some receivers employ special dc restoration techniques but cost prohibits their use in average priced sets.

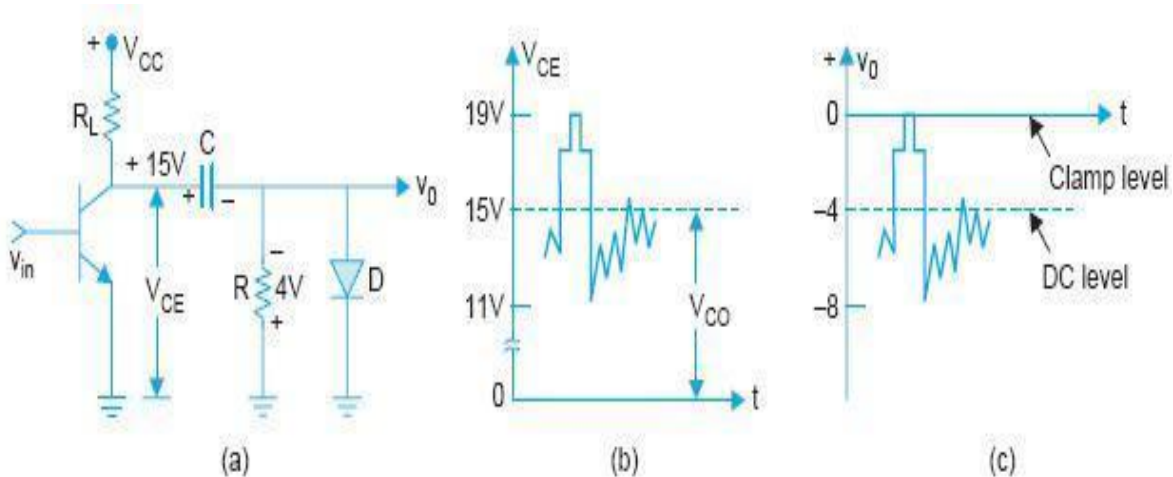


Figure. Diode dc restorer (a) circuit (b) collector voltage (c) output voltage applied to the grid of the tube.

- This, being positive, reduces the net negative voltage between the grid and cathode and the scene then moves to a brighter area on the picture tube characteristics.
- Any decrease in average brightness of the scene being televised will have the opposite effect and net grid bias will become more negative to reduce background illumination of the picture on the raster.
- Thus the diode with the associated components serves to restore the dc content of the picture signal and the difference in potential between 'X' and 'Y' serves as a variable dc bias to change the average brightness of the scene.

2.13. VIDEO AMPLIFIER CIRCUIT

- A transistorized video amplifier circuit with emitter follower drive and partial dc coupling is shown in Fig. The salient features of this circuit are :
 - (i) Signal from the video detector is dc coupled to the base of Q 1 . This transistor combines the functions of an emitter follower and CE amplifier. The high input impedance of emitter follower minimizes loading of the video detector. The sync circuit is fed from the collector of this transistor, where as signal for the sound section and AGC circuit is taken from the output of the emitter follower.
 - (ii) The output from the emitter follower is dc coupled to the base of Q 2 . This is a 5 W power transistor, with a heat-sink mounted on the case. The collector supply is 140 V, to provide enough voltage swing for the 80 V P-P video signal output.
 - (iii) In the output circuit of Q 2 , contrast control forms part of the collector load. The video output signal is coupled by the 0.22 μ F (C 2) capacitor to the cathode of picture tube. The partial dc coupling is provided by the 1 M (R 2) resistor connected at the collector of Q 2 .
 - (iv) The parallel combination of L 1 and C 1 is tuned to resonate at 5.5 MHz to provide maximum negative feedback to the sound signal. This prevents appearance of sound signal at the output of video amplifier.
 - (v) The neon bulb in the grid circuit provides protection of a spark-gap since the neon bulb ionizes and shorts to ground with excessive voltage. The 'spark gaps' are employed to protect external receiver circuitry from 'flash overs' within the tube. The accumulation of charge at the various electrodes of the picture tube results in the appearance of high voltages at the electrodes, which if not discharged to ground, will do so through sections of the receiver circuitry and cause damage.
 - (vi) Note that dc voltages at the base and emitter of the two transistors have been suitably set to give desired forward bias.
 - (vii) Vertical retrace blanking pulses are fed at the grid of the picture tube through C 3, and the grid-return to ground is provided by R 3 .
 - (viii) Brightness control. The adjustment of average brightness of the reproduced scene is carried out by varying the bias potential between cathode and control grid of the picture tube. In the circuit being considered a 100 K potentiometer is provided to adjust dc voltage at the cathode.

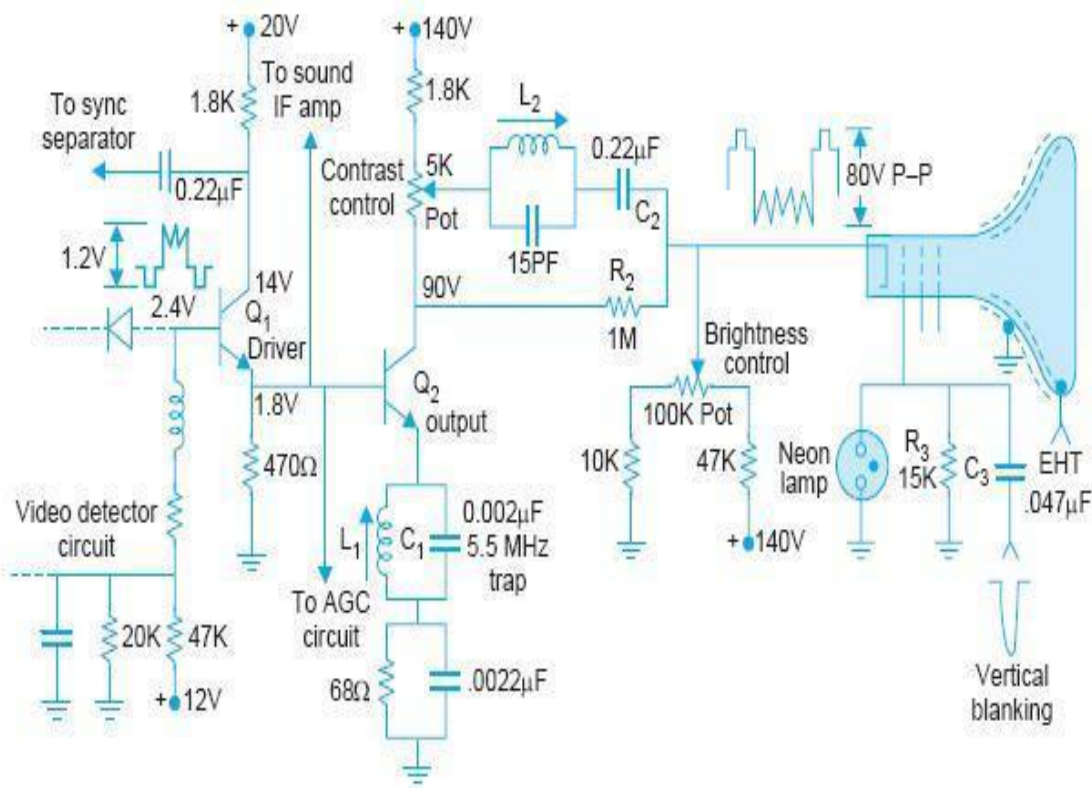


Figure. Video amplifier employing partial dc coupling.

This bias sets correct operating point for the tube and in conjunction with the video blanking pulses cuts-off the electron beam at appropriate moments. The setting of grid bias depends upon the strength of signal being received. A signal of small amplitude, say from a distant station, requires more fixed negative bias on the grid than a strong signal. The dependency of picture tube grid bias on the strength of the arriving signal is illustrated in Fig. For a weak signal, the bias must be advanced to the point where combination of the relatively negative blanking voltage plus the tube bias drives the tube into cut-off. However, with a strong signal the negative grid bias must be reduced, otherwise some of the picture details are lost. Since the bias of the picture tube may require an adjustment for different stations, or under certain conditions from the same station, the brightness control is provided at the front panel of the receiver. The effects of brightness and contrast controls described earlier overlap to some extent. If setting of the contrast control is increased so that the video signal becomes stronger, then the brightness control must be adjusted to meet the new condition, so that no retrace lines are visible and the picture does not look milky or washed out. Too small a value of the negative grid bias allows average illumination of the scene to increase thus making part of the retrace visible. In addition, the picture assumes a washed out appearance. Too low a setting of the brightness control, which results in a high negative bias on the picture tube grid, will cause some of the darker portions of the image to be eliminated. Besides this overall illumination of the scenes will also decrease. To correct this latter condition, either the brightness control can be adjusted or the contrast control setting can be advanced until correct

illumination is obtained. If the brightness control is varied over a wide range the focus of the picture tube may be affected. However, in the normal range of brightness setting made by the viewer, changes in focus do not present any problem. It is now apparent that despite the fact that video signal, as received from any television station, contains all the information about the background shadings of the scene being televised, an optimum setting of both contrast control and brightness control by the viewer is a must to achieve desired results. Many viewers do not get the best out of their receivers because of incorrect settings of these controls. However, to ensure that retrace lines are not seen on the screen due to incorrect setting of either contrast or brightness control, all television receivers provide blanking pulses on the grid electrode of the picture tube

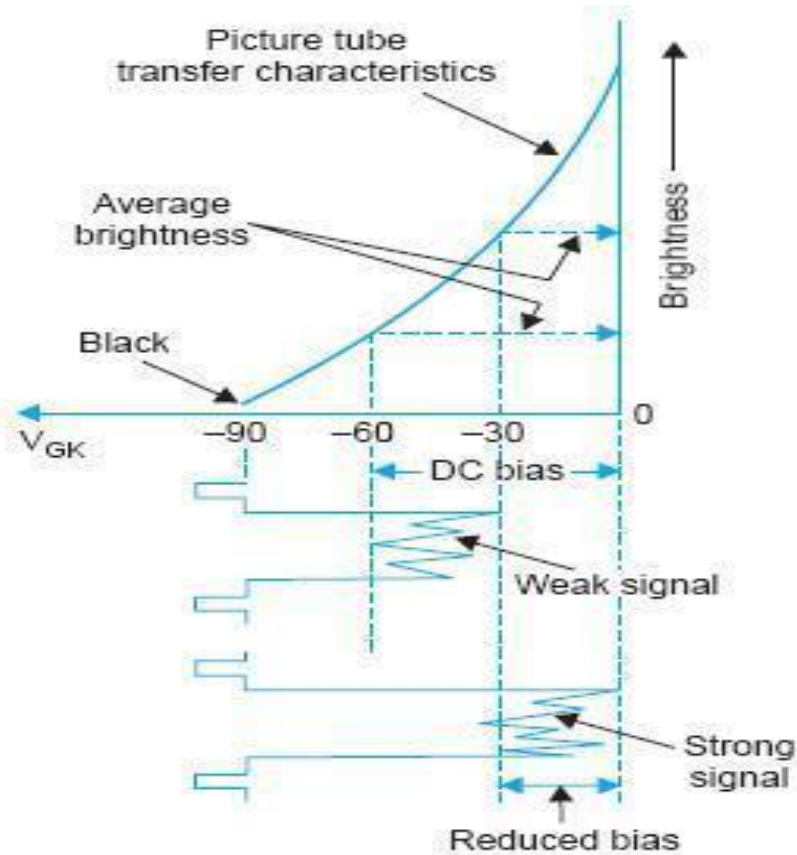


Figure. Optimum setting of contrast control for different amplitudes of the video signal.

2.16. DEFLECTION CURRENT WAVEFORMS

Figure. illustrates the required nature of current in deflection coils. As shown there it has a linear rise in amplitude which will deflect the beam at uniform speed without squeezing or spreading the picture information. At the end of ramp the current amplitude drops sharply for a fast retrace or flyback. Zero amplitude on the sawtooth waveform corresponds to the beam at center of the screen. The peak-to-peak amplitude of the sawtooth wave determines the amount of deflection from the centre. The electron beam is at extreme left (or right) of the raster when the horizontal deflecting sawtooth wave has its positive (or negative) peak. Similarly the beam is at top and bottom for peak amplitudes of the vertical deflection sawtooth wave. The sawtooth waveforms can be positive or negative going, depending on the direction of windings on the yoke for deflecting the beam from left to right and top to bottom. In both cases the trace includes linear rise from start at point 1 to the end at point 2, which is the start of retrace finishing at point 3 for a complete sawtooth cycle.

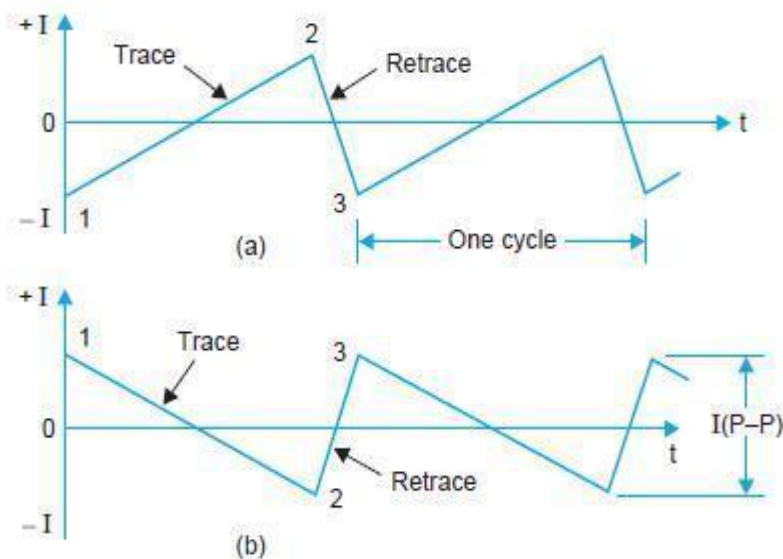


Figure. Deflection current waveforms (a) for positive going trace (b) for negative going trace.

Driving Voltage Waveform

- The current which flows into the horizontal and vertical deflecting coils must have a sawtooth waveform to obtain linear deflection of the beam during trace periods. However, because of inductive nature of the deflecting coils, a modified sawtooth voltage must be applied across the coils to achieve a sawtooth current through them.
- To understand this fully, consider the equivalent circuit of a deflecting coil consisting of a resistance R in series with a pure inductance L , where R includes the effect of driving source (internal) resistance.
- The voltage drops across R and L for a sawtooth current, when added together would give the voltage waveform that must be applied across the coil. The voltage drop across R has the same sawtooth waveform as that of the current that flows through it.

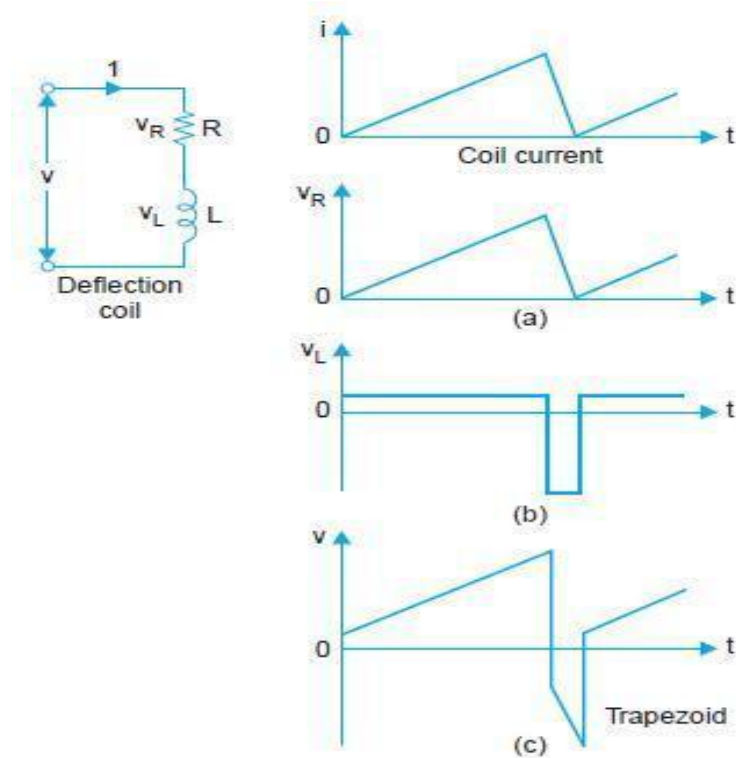


Figure. Current and voltage wave shapes in a deflection coil
(a) voltage drop across the resistive component of coil impedance
(b) voltage drop across the inductive component of coil impedance
(c) resultant voltage 'v' ($v_R + v_L$) across input terminals of the coil for a sawtooth current in the winding.

- A faster change in i_L , produces more self induced voltage v_L . Furthermore, for a constant rate of change in i_L , the value of v_L is constant. As a result, v_L in Fig. is at a relatively low level during trace time, but because of fast drop in i_L during the retrace period, a sharp voltage peak or spike appears across the coil.
- The polarity of the flyback pulse is opposite to the trace voltage, because i_L is then decreasing instead of increasing. Therefore, a sawtooth current in L produces a rectangular voltage.
- This means, that to produce a sawtooth current in an inductor, a rectangular voltage should be applied across it. When the voltage drops across R and L are added together, the result is a trapezoidal waveform.
- Thus to produce a sawtooth current in a circuit having R and L in series, which in the case.

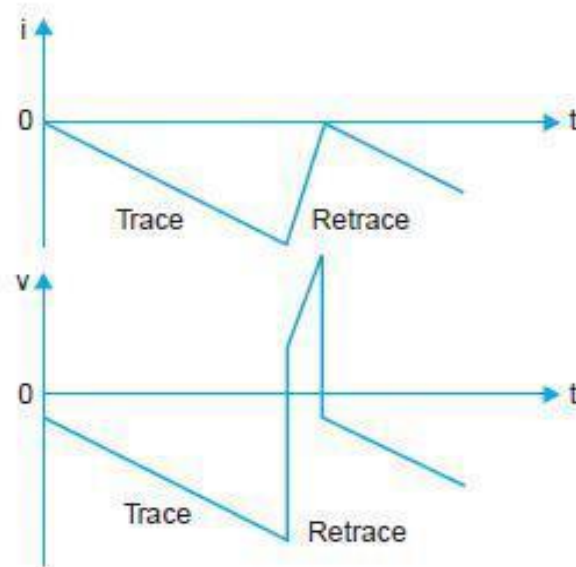


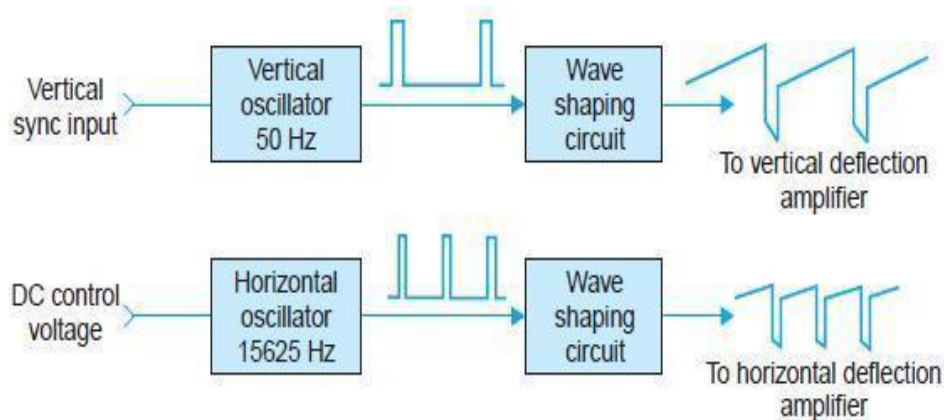
Figure. Inverted polarity of i and v .

2.16. DEFLECTION OSCILLATORS

- Under consideration represents a deflection coil, a trapezoidal voltage must be applied across it. Note that for a negative going sawtooth current, the resulting trapezoid will naturally have an inverted polarity as illustrated in Fig.
- As explained above, for linear deflection, a trapezoidal voltage wave is necessary across the vertical deflecting coils. However, the resulting voltage waveform for the horizontal yoke will look closer to a rectangular wave shape, because voltage across the inductor overrides significantly the voltage across the resistance on account of higher rate of rise and fall of coil current. Effect of Driving Source Impedance on Wave shapes.
- In deflection circuits employing vacuum tubes, the magnitude of R is quite large because of high plate resistance of the tube. Therefore, voltage wave shape across the vertical deflection coils and that needed to drive the vertical output stage is essentially trapezoidal. However, in a horizontal output circuit employing a tube, the wave shape will be close to rectangular because of very high scanning frequency.
- When transistors are employed in vertical and horizontal deflection circuits, the driving impedance is very low and equivalent yoke circuits appear to be mainly inductive. This needs an almost rectangular voltage wave shape across the yoke.
- To produce such a voltage wave shape, the driving voltage necessary for horizontal and vertical scanning circuits would then be nearly rectangular. Thus the driving voltage waveforms to be generated by the deflection oscillator circuits would vary depending on deflection frequency, device employed and deflection coil impedance.

Deflection Oscillators

- In order to produce a picture on the screen of a TV receiver that is in synchronism with the one scanned at the transmitting end, it is necessary to first produce a synchronized raster. The video signal that is fed to the picture tube then automatically generates a copy of the transmitted picture on the raster.
- While actual movement of the electron beam in a picture tube is controlled by magnetic fields produced by the vertical and horizontal deflection coils, proper vertical and horizontal driving voltages must first be produced by synchronized oscillators and associated wave shaping circuits. As illustrated in Fig.
- For vertical deflection the frequency is 50 Hz, while for horizontal deflection it is 15625 Hz. The driving waveforms thus generated are applied to power amplifiers which provide sufficient current to the deflecting coils to produce a full raster on the screen of picture tube.
- Free running relaxation type of oscillators are preferred as deflection voltage sources because these are most suited for generating the desired output waveform and can be easily locked into synchronism with the incoming sync pulses.



The oscillators commonly used in both vertical and horizontal deflection sections of the receiver are:

- (i) Blocking oscillator,
- (ii) Multivibrator,
- (iii) Complementary pair relaxation oscillator,
- (iv) Overdriven sine-wave oscillator.

- It may be noted that complementary pair circuits are possible only with transistors while all other types may employ tubes or transistors.
- As explained earlier, both vertical and horizontal deflection oscillators must lock with corresponding incoming sync pulses directly or indirectly to produce a stable television picture.

2.20. TELEVISION RECEIVER ANTENNAS

- For both VHF and UHF television channels, one-half-wave length is a practical size and therefore an ungrounded resonant dipole is the basic antenna often employed for reception of television signals.
- The dipole intercepts radiated electromagnetic waves to provide induced signal current in the antenna conductors.
- A matched transmission line connects the antenna to the input terminals of the receiver. It may be noted that the signal picked up by the antenna contains both picture and sound signal components.
- This is possible, despite the 5.5 MHz separation between the two carriers, because of the large bandwidth of the antenna. In fact a single antenna can be designed to receive signals from several channels that be close to each other.

Antennas for VHF Channels

- Although most receivers can produce a picture with sufficient contrast even with a weak signal, but for a picture with no snow and ghosts, the required antenna signal strength lies between 100 and 2000 μV .
- Thus, while a half-wave dipole will deliver satisfactory signal for receivers located close to the transmitter, elaborate arrays become necessary for locations far away from the transmitter.

Yagi-Uda Antenna

- The antenna widely used with television receivers for locations within 40 to 60 km from the transmitter is the folded dipole with one reflector and one director. This is commonly known as Yagi-Uda or simply Yagi antenna.
- The elements of its array as shown in Fig. are arranged collinearly and close together. This antenna provides a gain close to 7 db and is relatively unidirectional as seen from its radiation pattern drawn in Fig.
- These characteristics are most suited for reception from television transmitters of moderate capacity. To avoid pick-up from any other side, the back lobe of the radiation pattern can be reduced by bringing the radiators closer to each other.
- The resultant improvement in the front to back ratio of the signal pick-up makes the antenna highly directional and thus can be oriented for efficient pick-up from a particular station.
- However, bringing the radiators closer has the adverse effect of lowering the input impedance of the array.

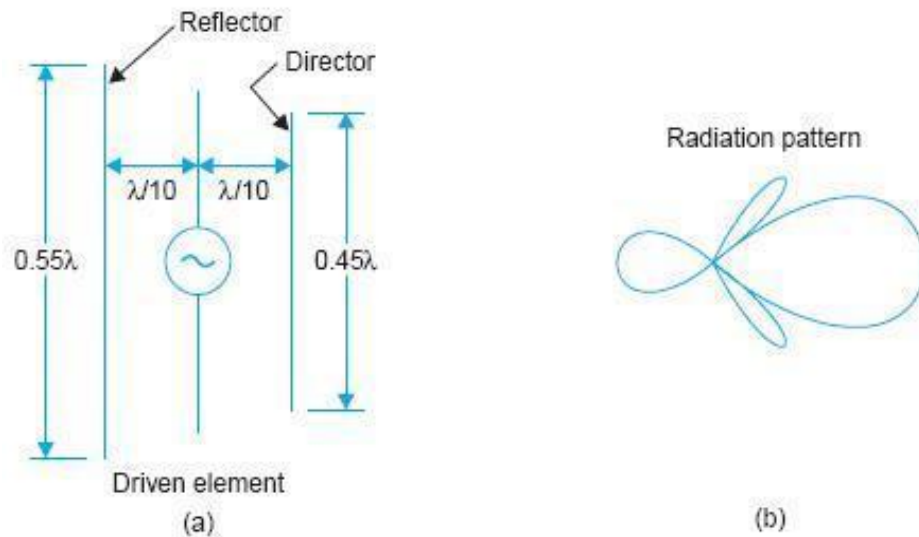


Figure. Yagi-Uda antenna (a) antenna (b) radiation pattern.

- As mentioned earlier, it is not necessary to erect a separate antenna for each channel because the resonant circuit formed by the antenna is of low 'Q' (quality factor) and as such has a broad band response.
- For the lower VHF channels (Band I—channels 2 to 4) the length of the antenna may be computed for a middle value. While this antenna will not give optimum results at other frequencies, the reception will still be quite satisfactory in most cases if the stations are not located far away. Though the antenna length used should be as computed by the usual expression:

$$\text{Wavelength (} \lambda \text{)} = 3 \times 10^8 \text{ meters,}$$

- But in practice it is kept about 6 percent less than the f (Hz) calculated value. This is necessary because the self-capacitance of the antenna alters the current distribution at its ends. The small distance between the two quarter wave rods of the driver, where the lead-in line is connected can be taken as too small and hence neglected. Note that this gap does not affect the current distribution significantly.

Antenna Mounting

- The receiving antenna is mounted horizontally for maximum pick-up from the transmitting antenna. As stated earlier, horizontal polarization results in more signal strength, less reflection and reduced ghost images.
- The antenna elements are normally made out of $1/4$ (0.625 cm) to $1/2$ (1.25 cm) dia aluminum pipes of suitable strength.

- The thickness of the pipe should be so chosen that the antenna structure does not get bent or twisted during strong winds or occasional sitting and flying off of birds. A hollow conductor is preferred because on account of skin effect, most of the current flows over the outer surface of the conductor.
- The antenna is mounted on a suitable structure at a height around 10 metres above the ground level. This not only insulates it from the ground but results in induction of large signal strength which is free from any interference. The centre of the closed section of the half-wave folded dipole is a point of minimum voltage, allowing direct mounting at this point to the grounded metal mast without shorting the signal voltage.
- A necessary precaution while mounting the antenna is that it should be at least two metres away from other antennas and large metal objects. In crowded city areas close to the transmitter, the resultant signal strength from the antenna can sometimes be very low on account of out of phase reflections from surrounding buildings.
- In such situations, changing the antenna placement only about a metre horizontally or vertically can make a big difference in the strength of the received signal, because of standing waves set up in such areas that have large conductors nearby. Similarly rotating the antenna can help minimize reception of reflected signals, thereby eliminating the appearance of ghost images.
- In areas where several stations are located nearby, antenna rotators are used to turn its direction. These are operated by a motor drive to set the broad side of the antenna for optimum reception from the desired station.
- However, in installations where a rotating mechanism is not provided, it is a good practice to connect the antenna to the receiver before it is fixed in place permanently and proceed as detailed below:
 - (i) Try changing the height of the antenna to obtain maximum signal strength.
 - (ii) Rotate the antenna to check against ghost images and reception of signals from far-off stations.
 - (iii) When more than one station is to be received, the final placement must be a compromise for optimum reception from all the stations in the area. In extreme cases, it may be desirable to erect more than one antenna.
- Indoor Antennas In strong signal areas it is sometimes feasible to use indoor antennas provided the receiver is sufficiently sensitive. These antennas come in a variety of shapes.
- Most types have selector switches which are used for modifying the response pattern by changing the resonant frequency of the antenna so as to minimize interference and ghost signals.
- Generally the switch is rotated with the receiver on, until the most satisfactory picture is obtained on the screen. Almost all types of indoor antennas have telescopic dipole rods both for adjusting the length and also for folding down when not in use.

Fringe Area Antenna

- In fringe areas where the signal level is very low, high-gain antenna arrays are needed. The gain of the antenna increases with the number of elements employed. A Yagi antenna with a large number of directors is commonly used with success in fringe areas for stations in the VHF band.

- As already mentioned, a parasitic element resonant at a lower frequency than the driven element will act as a mild reflector, and a shorter parasitic element will act as a mild 'concentrator' of radiation.
- As a parasitic element is brought closer to the driven element, then regardless of its precise length, it will load the driven element more and therefore reduce its input impedance.
- This is perhaps the main reason for invariable use of a folded dipole as the driven element of such an array. A gain of more than 10 db with a forward to back ratio of about 15 is easily obtained with such an antenna. Such high gain combinations are sharply directional and so must be carefully aimed while mounting, otherwise the captured signal will be much lower than it should be.
- A typical Yagi antenna for use in fringe areas is shown in Fig.

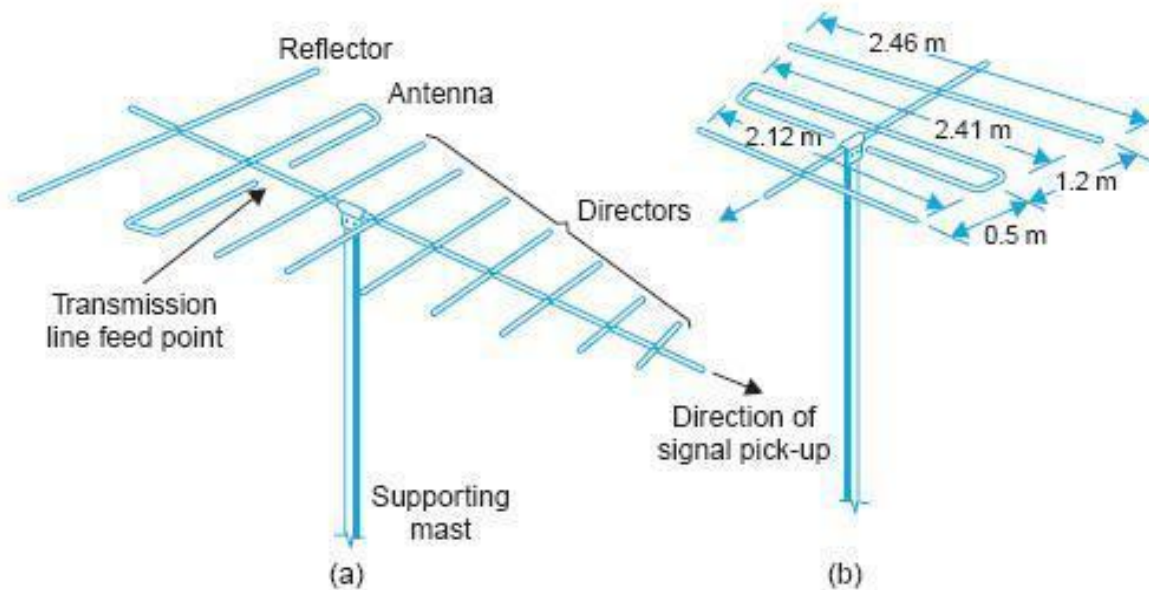


Fig. A typical Yagi antenna, (b) Channel four antenna.

- In such antennas the reflectors are usually 5 per cent longer than the dipole and may be spaced from it at 0.15 to 0.25 wavelengths depending on design requirements.
- Similarly the directors may be 4 per cent shorter than the antenna element, but where broadband characteristics are needed successive directors are usually made shorter (see Fig.) to be resonant for the higher frequency signals of the spectrum.
- In some fringe area installations, transistorized booster amplifiers are also used along with the Yagi antenna to improve reception.
- These are either connected just close to the antenna or after the transmission line, before the signal is delivered to the receiver.

Yagi Antenna Design

- The following expressions can be used as a starting point while designing any Yagi antenna array.
 Length of dipole (in metres) $\approx 143/f$ (f is the centre frequency of the channel) f (MHz)
 Length of reflector (in metres) $\approx 152/f$ (MHz)
 Length of first director (in metres) $\approx 137/f$ (MHz)
- Length of subsequent directors reduces progressively by 2.5 per cent.
- Spacing between reflector and dipole $\approx 0.25 \times 75/f$ (MHz)
- Spacing between director and dipole $\approx 0.13 \times 40/f$ (MHz)
- Spacing between director and director $\approx 0.13 \times 39/f$ (MHz)
- The above lengths and spacings are based on elements of 1 to 1.2 cm in diameter. It may be noted that length of the folded dipole is measured from centre of the fold at one end to the centre of the fold at the other end.
- It must be remembered that the performance of Yagi arrays can only be assessed if all the characteristics like impedance, gain, directivity and bandwidth are taken into account together. Since there are so many related variables, the dimensions of commercial antennas may differ from those computed with the expressions given above.
- However, for single channel antennas the variation is not likely to be much. Figure shows a dimensioned sketch of channel four (61 to 68 MHz) antenna designed for locations not too far from the transmitter. It has an impedance $= 40 + j20 \Omega$, a front to back pick up ratio = 30 db, and an overall length = 0.37 wavelength.

Multiband Antennas

- It is not possible to receive all the channels of lower and higher VHF band with one antenna. The main problem in using one dipole for both the VHF bands is the difficulty of maintaining a broadside response.
- This is because the directional pattern of a low-band dipole splits into side lobes at the third and fourth harmonic frequencies in the 174 to 223 MHz band. On the other hand a high-band dipole cut for a half wavelength in the 174 to 233 MHz band is not suitable for the 47 to 68 MHz band because of insufficient signal pick-up at the lower frequencies.
- As a result, antennas for both the VHF bands generally use either separate dipoles for each band or a dipole for the lower VHF band modified to provide broadside unidirectional response in the upper VHF band also.

Diplexing of VNF Antennas

- When it is required to combine the outputs from the lower and upper VHF band antennas to a common lead-in wire (feeder) it is desirable to employ a filter network that not only matches the signal sources to the common feeder but also isolates the signals in the antennas from each other.
- Such a filter arrangement is called a 'diplexer'. Its circuit with approximate component values for bands I (47 to 68 MHz) and III (174 to 263 MHz) is given in Fig.

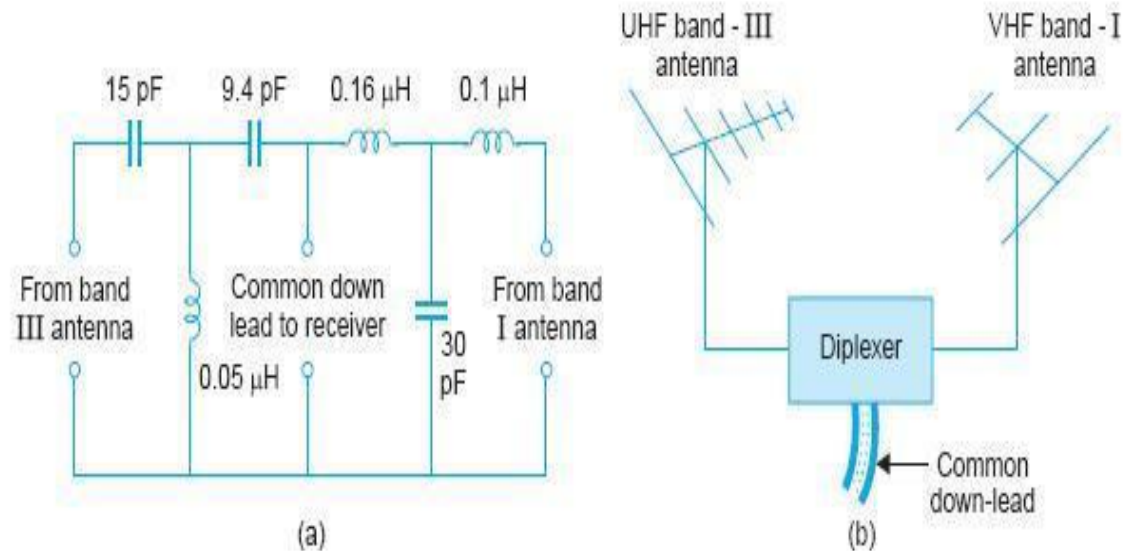


Figure. Diplexing antenna outputs (a) diplexer network, H.P.-L.P.-filter combination (b) diplexer connections.

- The manner in which it is connected to the two antennas is shown in Fig. Similarly a triplexer filter can be employed when three different antennas are to feed their outputs to a common socket in the receiver.
- The combining arrangement can be further modified to connect the output from a UHF antenna to the same feeder line.

UNIT III

ESSENTIALS OF COLOR TELEVISION

3.1. COMPATIBILITY

- Regular color TV broadcast could not be started till 1954 because of the stringent requirement of making color TV compatible with the existing monochrome system. Compatibility implies that

- (i) The color television signal must produce a normal black and white picture on a monochrome receiver without any modification of the receiver circuitry
- (ii) A color receiver must be able to produce a black and white picture from a normal monochrome signal. This is referred to as reverse compatibility.

To achieve this, that is to make the system fully compatible the composite color signal must meet the following requirements:

- (i) It should occupy the same bandwidth as the corresponding monochrome signal.
- (ii) The location and spacing of picture and sound carrier frequencies should remain the same.
- (iii) The color signal should have the same luminance (brightness) information as would a monochrome signal, transmitting the same scene.
- (iv) The composite color signal should contain color information together with the ancillary signals needed to allow this to be decoded.
- (v) The color information should be carried in such a way that it does not affect the picture reproduced on the screen of a monochrome receiver.
- (vi) The system must employ the same deflection frequencies and sync signals as used for monochrome transmission and reception.

- In order to meet the above requirements it becomes necessary to encode the color information of the scene in such a way that it can be transmitted within the same channel bandwidth of 7 MHz and without disturbing the brightness signal. Similarly at the receiving end a decoder must be used to recover the color signal back in its original form for feeding it to the tri-color picture tube. Before going into details of encoding and decoding the picture signal, it is essential to gain a good understanding of the fundamental properties of light. It is also necessary to understand mixing of colors to produce different hues on the picture screen together with limitations of the human eye to perceive them. Furthermore a knowledge of the techniques employed to determine different colors in a scene and to generate corresponding signal voltages by the color television camera is equally essential.

3.2. COLOR PERCEPTION

- All objects that we observe are focused sharply by the lens system of the eye on its retina. The retina which is located at the back side of the eye has light sensitive organs which measure the visual sensations.
- The retina is connected with the optic nerve which conducts the light stimuli sensed by the organs to the optical centre of the brain. According to the theory formulated by Helmholtz the light sensitive organs are of two types rods and cones.

- The rods provide brightness sensation and thus perceive objects only in various shades of grey from black to white. The cones that are sensitive to color are broadly in three different groups. One set of cones detects the presence of blue color in the object focused on the retina, the second set perceives red color and the third is sensitive to the green range. Each set of cones, may be thought of as being 'tuned' to only a small band of frequencies and so absorb energy from a definite range of electromagnetic radiation to convey the sensation of corresponding color or range of color.
- The combined relative luminosity curve showing relative sensation of brightness produced by individual spectral colors radiated at a constant energy level is shown in Fig. It will be seen from the plot that the sensitivity of the human eye is greatest for green light, decreasing towards both the red and blue ends of the spectrum.
- In fact the maximum is located at about 550 nm, a yellow green, where the spectral energy maximum of sunlight is also located.

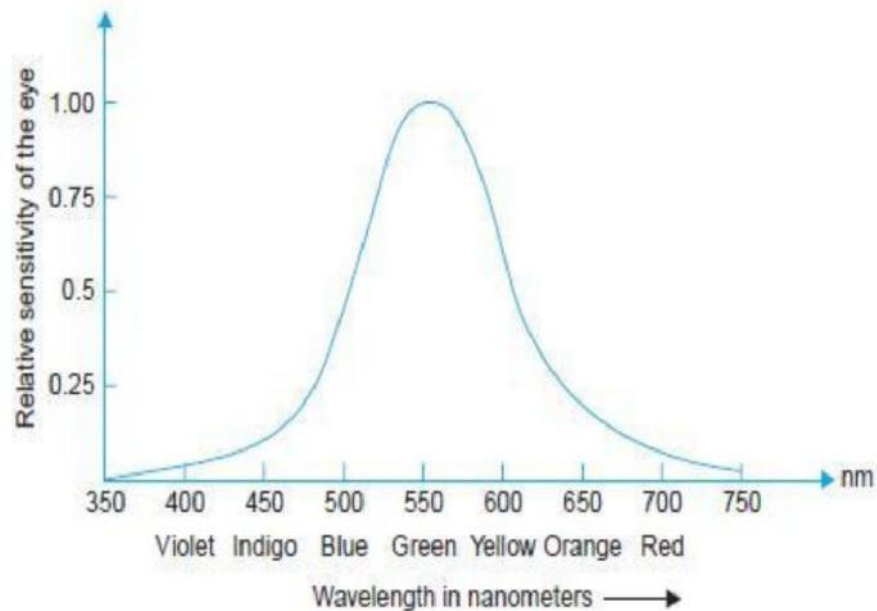


Figure. Approximate relative response of the eye to different colors

3.3. THREE COLOR THEORY

- All light sensations to the eye are divided (provided there is an adequate brightness stimulus on the operative cones) into three main groups. The optic nerve system then integrates the different color impressions in accordance with the curve shown in Fig. to perceive the actual color of the object being seen.
- This is known as additive mixing and forms the basis of any color television system. A yellow color, for example, can be distinctly seen by the eye when the red and green groups of the cones are excited at the same time with corresponding intensity ratio.

Similarly and color other than red, green and blue will excite different sets of cones to generate the cumulative sensation of that color.

- A white color is then perceived by the additive mixing of the sensations from all the three sets of cones. Mixing of Colors Mixing of colors can take place in two ways subtractive mixing and additive mixing.
- In subtractive mixing, reflecting properties of pigments are used, which absorb all wavelengths but for their characteristic color wavelengths.
- When pigments of two or more colors are mixed, they reflect wavelengths which are common to both. Since the pigments are not quite saturated (pure in color) they reflect a fairly wide band of wavelengths.
- This type of mixing takes place in painting and color printing. In additive mixing which forms the basis of color television, light from two or more colors obtained either from independent sources or through filters can create a combined sensation of a different color.
- Thus different colors are created by mixing pure colors and not by subtracting parts from white. The additive mixing of three primary colors red, green and blue in adjustable intensities can create most of the colors encountered in everyday life.
- The impression of white light can also be created by choosing suitable intensities of these colors. Red, green and blue are called primary colors. These are used as basic colors in television. By pairwise additive mixing of the primary colors the following complementary colors are produced:
 - Red + Green = Yellow
 - Red + Blue = Magenta (purplish red shade)
 - Blue + Green = Cyan (greenish blue shade)
- Color plate 1 depicts the location of primary and complementary colors on the color circle. If a complementary is added in appropriate proportion to the primary which it itself does not contain, white is produced.
- This is illustrated in Fig. where each circle corresponds to one primary color. Color plate 2 shows the effect of color mixing. Similarly Fig, illustrates the process of subtractive mixing. Note that as additive mixing of the three primary colors produces white, their subtractive mixing results in black.

(Research has shown that the actual neural process of color perception is substantially different from the tricolor process. However, all color reproduction processes in television or printing use variations of this process and is found satisfactory).

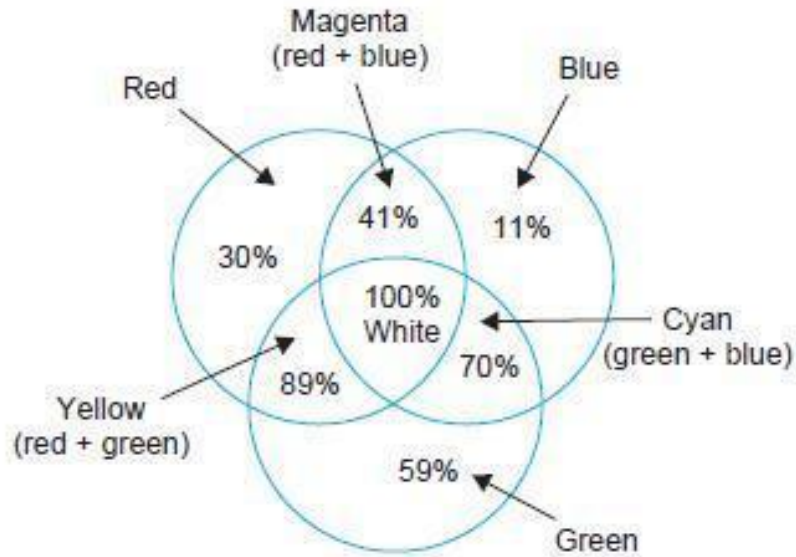


Figure. Additive color mixing. The diagram shows the effect of projecting green, red and blue beams on a white screen in such a way that they overlap

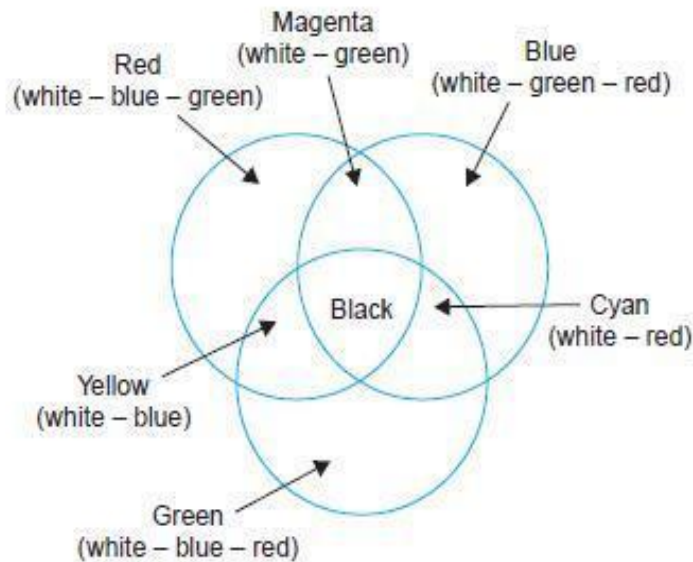


Figure. Subtractive color mixing. The diagram shows the effect of mixing color pigments under white light.

3.4. LUMINANCE, HUE AND SATURATION

Any color has three characteristics to specify its visual information. These are (i) luminance, (ii) hue or tint, and (iii) saturation. These are defined as follows:

(i) Luminance or Brightness

- This is the amount of light intensity as perceived by the eye regardless of the color. In black and white pictures, better lighted parts have more luminance than the dark areas. Different colors also have shades of luminance in the sense that though equally illuminated appear more or less bright as indicated by the relative brightness response curve of Fig. Thus on a monochrome TV screen, dark red color will appear as black, yellow as white and a light blue color as grey.

(ii) Hue

- This is the predominant spectral color of the received light. Thus the color of any object is distinguished by its hue or tint. The green leaves have green hue and red tomatoes have red hue. Different hues result from different wavelengths of spectral radiation and are perceived as such by the sets of cones in the retina.

(iii) Saturation

- This is the spectral purity of the color light. Since single hue colors occur rarely alone, this indicates the amounts of other colors present. Thus saturation may be taken as an indication of how little the color is diluted by white. A fully saturated color has no white. As an example. Vivid green is fully saturated and when diluted by white it becomes light green. The hue and saturation of a color put together is known as chrominance. Note that it does not contain the brightness information. Chrominance is also called chroma.

Chromaticity Diagram.

- Chromaticity diagram is a convenient space coordinate representation of all the spectral colors and their mixtures based on the tristimulus values of the primary colors contained by them. Fig. is a two dimensional representation of hue and saturation in the X-Y plane (see color plate 3).
- If a three dimensional representation is drawn, the 'Z' axis will show relative brightness of the color. As seen in the figure the chromaticity diagram is formed by all the rainbow colors arranged along a horseshoe-shaped triangular curve.
- The various saturated pure spectral colors are represented along the perimeter of the curve, the corners representing the three primary colors red, green and blue. As the central area of the triangular curve is approached, the colors become de-saturated representing mixing of colors or a white light.
- The white lies on the central point 'C' with coordinates $x = 0.31$ and $y = 0.32$. Actually there is no specific white light sunlight, skylight, daylight are all forms of white light.

- The illuminant 'C' marked in Fig. (a) Represents a particular white light formed by combining hues having wavelength: 700 nm (red) 546.1 nm (green) and 438.8 nm (blue) with proper intensities.
- This shade of white which has been chosen to represent white in TV transmission and reception also corresponds to the subjective impression formed in the human eye by seeing a mixture of 30 percent of red color, 59 percent of green color and 11 percent of the blue color at wavelengths specified above.
- A practical advantage of the chromaticity diagram is that, it is possible to determine the result of additive mixing of any two or more color lights by simple geometric construction.
- The color diagram contains all colors of equal brightness. Since brightness is represented by the 'Z' axis, as brightness increase, the color diagram becomes larger as shown in Fig.

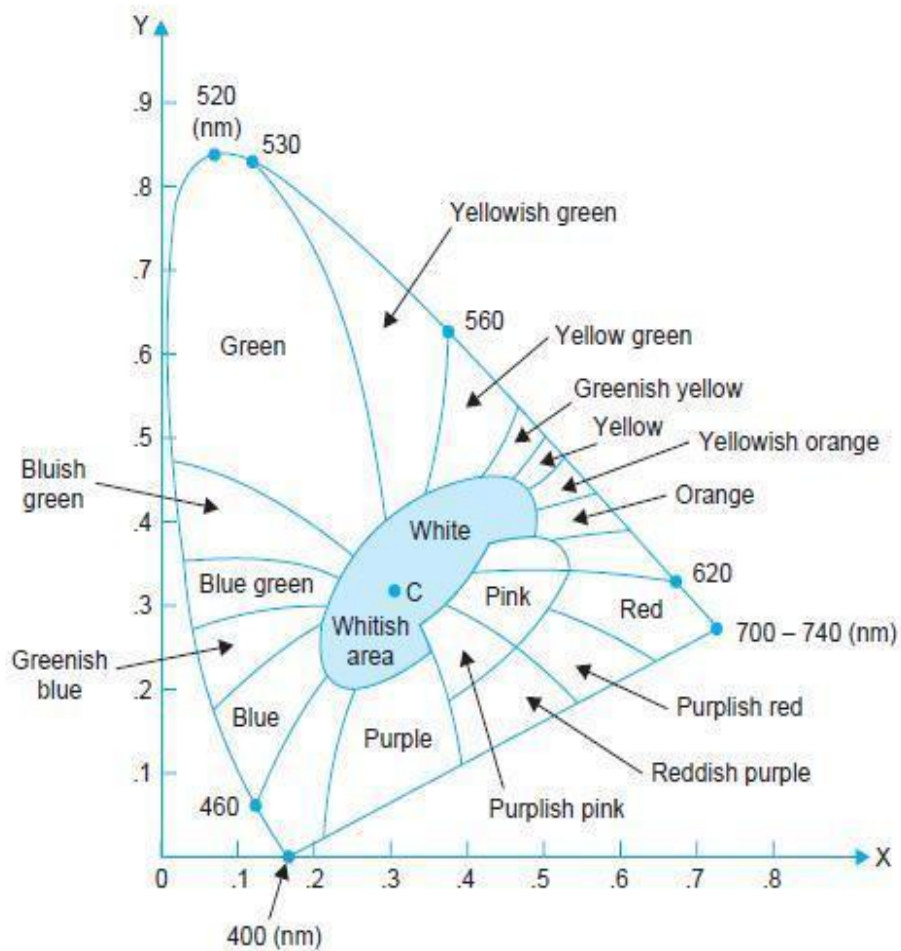


Figure. Chromaticity diagram. Note that red, green and blue have been standardized at wavelengths of 700, 646.1 and 438.8 nanometers respectively. X and Y denote color coordinates. For example white lies at $X = 0.31$ and $Y = 0.32$.

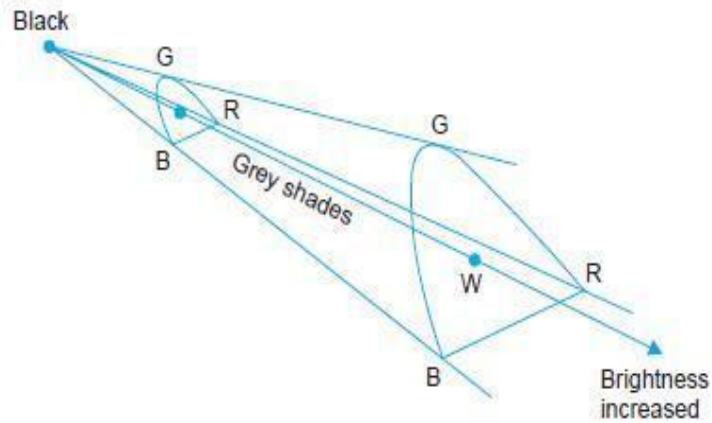


Figure. Representation of luminance (brightness).

3.5. COLOR TELEVISION CAMERA

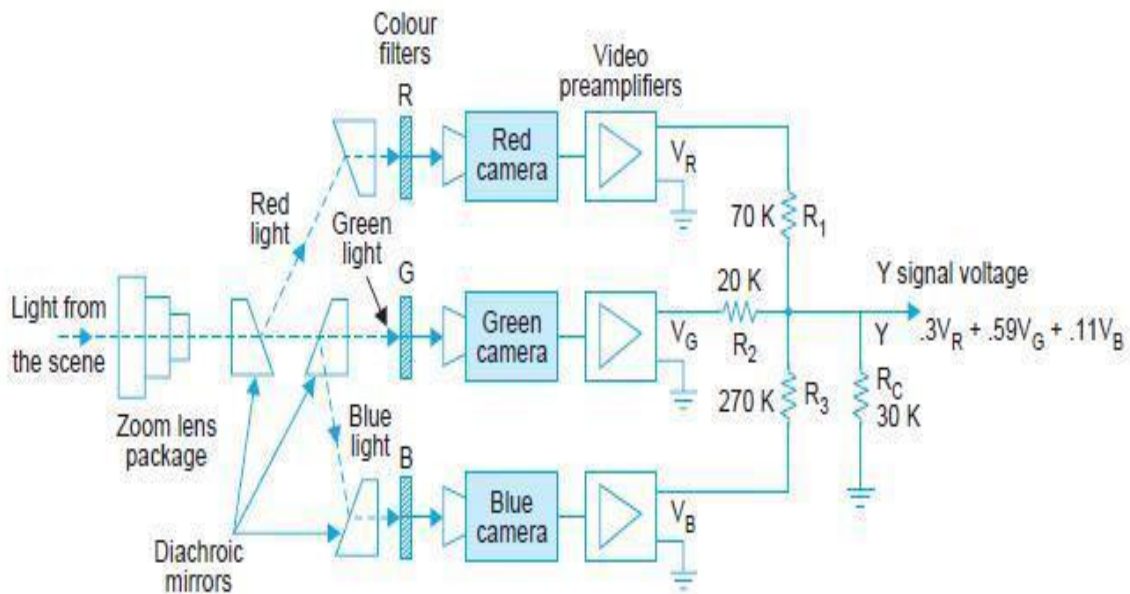


Figure. Plan of a color television camera showing generation of color signals and Y matrix for obtaining the luminance (brightness) signal

- Figure shows a simple block schematic of a color TV camera. It essentially consists of three camera tubes in which each tube receives selectively filtered primary colors.
- Each camera tube develops a signal voltage proportional to the respective color intensity received by it. Light from the scene is processed by the objective lens system. The image formed by the lens is split into three images by means of glass prisms.
- These prisms are designed as dichroic mirrors. A dichroic mirror passes one wavelength and rejects other wavelengths (colors of light). Thus red, green, and blue color images are formed. The rays from each of the light splitters also pass through color filters called trimming filters.
- These filters provide highly precise primary color images which are converted into video signals by image-orthicon or vidicon camera tubes. Thus the three color signals are generated. These are called Red (R), Green (G) and Blue (B) signals. Simultaneous scanning of the three camera tubes is accomplished by a master deflection oscillator and sync generator which drives all the three tubes.
- The three video signals produced by the camera represent three primaries of the color diagram. By selective use of these signals, all colors in the visible spectrum can be reproduced on the screen of a special (color) picture tube.

Color Signal Generation

- At any instant during the scanning process the transmitted signal must indicate the proportions, of red, green and blue lights which are present in the element being scanned. Besides this, to fulfil the requirements of compatibility, the luminance signal which represents the brightness of the elements being scanned must also be generated and transmitted along with the color signals.
- Figure illustrates the method of generating these signals. The camera output voltages are labelled as V R, V G and V B but generally the prefix V is omitted and only the symbols R, G, and B are used to represent these voltages. With the specified source of white light the three cameras are adjusted to give equal output voltage.

Gamma Correction

- To compensate for the non-linearity of the system including TV camera and picture tubes, a correction is applied to the voltages produced by the three camera tubes.
- The output voltages are then referred as R, G and B. However, in our discussion we will ignore such a distinction and use the same symbols i.e., R, G and B to represent gamma corrected output voltages.
- Furthermore, for convenience of explanation the camera outputs corresponding to maximum intensity (100%) of standard white light to be handled are assumed adjusted at an arbitrary value of one volt. Then on grey shades, i.e., on white of lesser brightness, R, G and B voltages will remain equal but at amplitude less than one volt.

3.6. VALUES OF LUMINANCE (Y) AND COLOR DIFFERENCE SIGNALS

- When televising color scenes even when voltages R, G and B are not equal, the 'Y' signal still represents monochrome equivalent of the color because the proportions 0.3, 0.59 and 0.11 taken of R, G and B respectively still represent the contribution which red, green and blue lights make to the luminance. This aspect can be illustrated by considering some specific colors.

De-saturated Purple

- Consider a de-saturated purple color, which is a shade of magenta. Since the hue is magenta (purple) it implies that it is a mixture of red and blue. Two word de-saturated indicates that some white light is also there. The white light content will develop all the three i.e., R, G and B voltages, the magnitudes of which will depend on the intensity of desaturation of the color.
 - Thus R and B voltages will dominate and both must be of greater amplitude than G. As an illustration let $R = 0.7$, $G = 0.2$ and $B = 0.6$ volts. The white content is represented by equal quantities of the three primaries and the actual amount must be indicated by the smallest voltage of the three, that is, by the magnitude of G.
 - Thus white is due to 0.2 R, 0.2 G and 0.2 B. The remaining, 0.5 R and 0.4 B together represent the magenta hue.
- (i) The luminance signal $Y = 0.3 R + 0.59 G + 0.11 B$.
Substituting the values of R, G, and B we get,
 $Y = 0.3 (0.7) + 0.59 (0.2) + 0.11(0.6) = 0.394$ (volts).
- (ii) The color difference signals are:
 $(R - Y) = 0.7 - 0.394 = + 0.306$ (volts)
 $(B - Y) = 0.6 - 0.394 = + 0.206$ (volts)
- (iii) Reception at the color receiver—At the receiver after demodulation, the signals, Y, (B - Y) and (R - Y), become available. Then by a process of matrixing the voltages B and R are obtained as:
 $R = (R - Y) + Y = 0.306 + 0.394 = 0.7$ V
 $B = (B - Y) + Y = 0.206 + 0.394 = 0.6$ V
- (iv) (G - Y) matrix—The missing signal (G - Y) that is not transmitted can be recovered by using a suitable matrix based on the explanation given below:
 $Y = 0.3 R + 0.59G + 0.11B$
also $(0.3 + 0.59 + 0.11)Y = 0.3R + 0.59G + 0.11B$
Rearranging the above expression we get:
 $0.59(G - Y) = - 0.3 (R - Y) - 0.11 (B - Y)$
 $\therefore (G - Y) = - 0.3059.(R - Y) - 0.11059.(B - Y)$
 $(B - Y) = - 0.51(R - Y) - 0.186 (B - Y)$
Substituting the values of (R - Y) and (B - Y)
 $(G - Y) = - (0.51 \times 0.306) - 0.186(0.206) = - 0.15606 - 0.038216 = - 0.194$
 $\therefore G = (G - Y) + Y = - 0.194 + 0.394 = 0.2$,
and this checks with the given value.

(v) Reception on a monochrome receiver Since the value of luminance signal $Y = 0.394V$, and the peak white corresponds to 1 volt (100%) the magenta will show up as a fairly dull grey in a black and white picture. This is as would be expected for this color.

De-saturated Orange

- A de-saturated orange having the same degree of desaturation as in the previous example is considered now. Taking $R = 0.7$, $G = 0.6$, and $B = 0.2$, it is obvious that the output voltages due to white are $R = 0.2$, $G = 0.2$ and $B = 0.2$.
- Then red and green colors which dominate and represent the actual color content with, $R = 0.5$ and $G = 0.4$ give the orange hue. Proceeding as in the previous example we get:
 - (i) Luminance signal $Y = 0.3 R + 0.59G + 0.11 B$. Substituting the values of R , G and B we get $Y = 0.586$ volt.
 - (ii) Similarly, the color difference signal magnitudes are:

$$(R - Y) = (0.7 - 0.586) = + 0.114$$

$$(B - Y) = (0.2 - 0.586) = - 0.386 \quad \text{and}$$

$$(G - Y) = - 0.51(R - Y) - 0.186(B - Y) = 0.014$$
 - (iii) At the receiver by matrixing we get

$$R = (R - Y) + Y = 0.7$$

$$G = (G - Y) + Y = 0.6$$

$$B = (B - Y) + Y = 0.2$$

This checks with the voltages developed by the three camera tubes at the transmitting end.

(iv) Reception on a monochrome receiver Only the luminance signal is received and, as expected, with $Y = 0.586$, the orange hue will appear as bright grey.

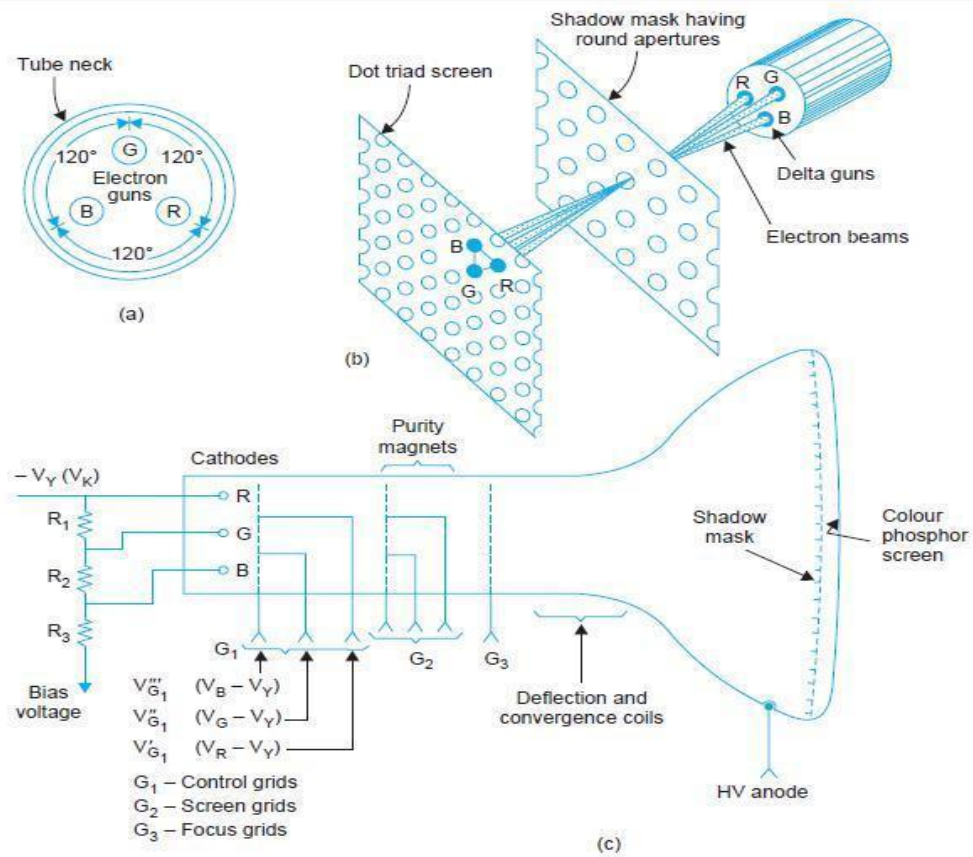
3.7. COLOR TELEVISION DISPLAY TUBES

- The color television picture tube screen is coated with three different phosphors, one for each of the chosen red, green and blue primaries.
- The three phosphors are physically separate from one another and each is energized by an electron beam of intensity that is proportional to the respective color voltage reproduced in the television receiver.
- The object is to produce three coincident raster's with produce the red, green and blue contents of the transmitted picture.
- While seeing from a normal viewing distance the eye integrates the three color information to convey the sensation of the hue at each part of the picture. Based on the gun configuration and the manner in which phosphors are arranged on the screen, three different types of color picture tubes have been developed.

These are:

1. Delta-gun color picture tube
2. Guns-in-line or Precision-in-line (P-I-L) color picture tube.
3. Single sun or Trinitron Color picture tube.

3.8. DELTA-GUN COLOR PICTURE TUBE



- This tube was first developed by the Radio Corporation of America (R.C.A.). It employs three separate guns (see Fig. (a)), one for each phosphor. The guns are equally spaced at 120° interval with respect to each other and tilted inwards in relation to the axis of the tube.
- They form an equilateral triangular configuration. As shown in Fig. (b) The tube employs a screen where three color phosphor dots are arranged in groups known as triads. Each phosphor dot corresponds to one of the three primary colors.
- The triads are repeated and depending on the size of the picture tube, approximately 1,000,000 such dots forming nearly 333,000 triads are deposited on the glass face plate.
- About one cm behind the tube screen (see Figs. (b) And (c)) is located a thin perforated metal sheet known as the shadow mask. The mask has one hole for every phosphor dot triad on the screen. The various holes are so oriented that electrons of the three beams on passing through any one hole will hit only the corresponding color phosphor dots on the screen.
- The ratio of electrons passing through the holes to those reaching the shadow mask is only about 20 percent. The remaining 80 percent of the total beam current energy is dissipated as a heat loss in the shadow mask.

- While the electron transparency in other types of color picture tubes is more, still, relatively large beam currents have to be maintained in all color tubes compared to monochrome tubes. This explains why higher anode voltages are needed in color picture tubes than are necessary in monochrome tubes.
- Generation of Color Rasters The overall color seen is determined both by the intensity of each beam and the phosphors which are being bombarded. If only one beam is 'on' and the remaining two are cut-off, dots of only one color phosphor get excited. Thus the raster will be seen to have only one of the primary colors. Similarly, if one beam is cut-off and the remaining two are kept on, the rasters produced by excitation of the phosphors of two colors will combine to create the impression of a complementary color.
- The exact hue will be determined by the relative strengths of the two beams. When all the three guns are active simultaneously, lighter shades are produced on the screen. This is so because red, green and blue combine in some measure to form white, and this combines with whatever colors are present to de-saturate them.
- Naturally, intensity of the color produced depends on the intensity of beam currents. Black in a picture is just the absence of excitation when all the three beams are cut-off. If the amplitude of color difference signals drops to zero, the only signal left to control the three guns would be the Y signal and thus a black and white (monochrome) picture will be produced on the screen. Primary Color Signals.
- The demodulators in the receiver recover $(B - Y)$ and $(R - Y)$ video signals. The $(G - Y)$ color video signal is obtained from these two through a suitable matrix. All the three color difference signals are then fed to the three grids of color picture tube (see Fig (c)).
- The inverted luminance signal $(- Y)$ is applied at the junction of the three cathodes. The signal voltages subtract from each other to develop control voltages for the three guns,

i.e.,

$$V_{G1} - V_k = (V_R - V_Y) - (- V_Y) = V_R$$

$$V_{G1} - V_k = (V_G - V_Y) - (- V_Y) = V_G \quad \text{and}$$

$$V_{G1} - V_k = (V_B - V_Y) - (- V_Y) = V_B$$
- In some receiver designs the Y signal is subtracted in the matrix and resulting color voltages are directly applied to the corresponding control grids. The cathode is then returned to a fixed negative voltage.

3.9. PRECISION-IN-LINE (P.I.L.) COLOR PICTURE TUBE

- This tube as the name suggests has three guns which are aligned precisely in a horizontal line. The gun and mask structure of the P.I.L. tube together with yoke mounting details are illustrated in Fig. The in-line gun configuration helps in simplifying convergence adjustments.
- As shown in the figure color phosphors are deposited on the screen in the form of vertical strips in triads. (R, G, B) which are repeated along the breadth of the tube. To obtain the same color fineness as in a delta-gun tube the horizontal spacing between the strips of the same color in adjacent triads is made equal to that between the dots of the same color in the delta-gun tube.
- As shown in Fig.(b), the aperture mask has vertical slots corresponding to color phosphor stripes. One vertical line of slots is for one group of fine strips of red green and blue phosphors. Since all the three electron beams are on the same plane, the beam in the

center (green) moves along the axis of the tube. However, because of inward tilt of the right and left guns the blue and red beams travel at an angle and meet the central beam at the aperture grille mask.

- The slots in the mask are so designed that each beam strikes its own phosphor and is prevented from landing on other color phosphors. The P.I.L. tube is more efficient, i.e., has higher electron transparency and needs fewer convergence adjustments on account of the in-line gun structure.
- It is manufactured with minor variations under different trade names in several countries and is the most used tube in present day color receivers.

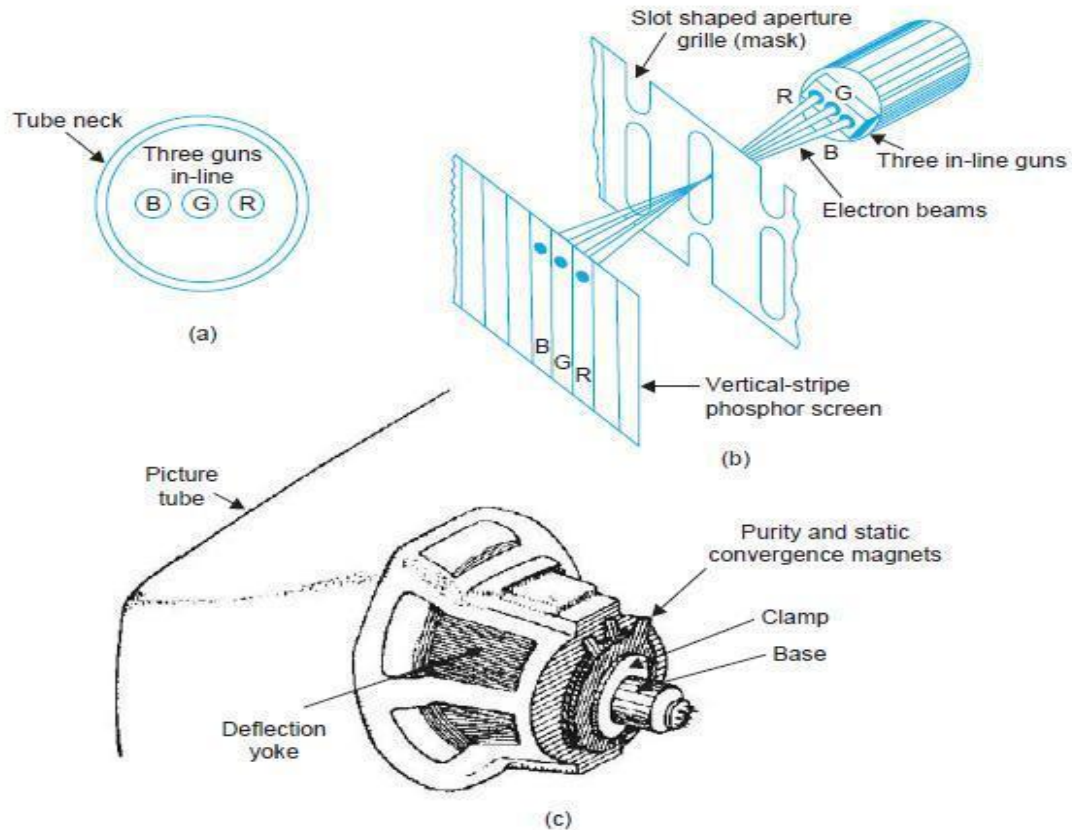


Figure. Precision in-line (P-I-L) or cathodes-in-line color picture tube

(a) in-line guns (b) electron beams, aperture grille and striped three color phosphor screen (c) mountings on neck and bowl of the tube

3.10. TRINTRON COLOR PICTURE TUBE

- The Trinitron or three in-line cathodes color picture tube was developed by 'SONY' Corporation of Japan around 1970.
- It employs a single gun having three in-line cathodes. This simplifies constructional problems since only one electron gun assembly is to be accommodated. The three phosphor triads are arranged in vertical strips as in the P.I.L. tube. Each strip is only a few thousandth of a centimeter wide.

- A metal aperture grille like mask is provided very close to the screen. It has one vertical slot for each phosphor triad. The grille is easy to manufacture and has greater electron transparency as compared to both delta-gun and P.I.L. tubes. The beam and mask structure, together with constructional and focusing details of the Trinitron are shown in Fig. The three beams are bent by an electrostatic lens system and appear to emerge from the same point in the lens assembly.
- Since the beams have a common focus plane a sharper image is obtained with good focus over the entire picture area. All this simplifies convergence problems and fewer adjustments are necessary. The latest version of Trinitron was perfected in 1978. It incorporates a low magnification electron gun assembly, long focusing electrodes and a large aperture lens system.
- The new high precision deflection yoke with minimum convergence adjustments provides a high quality picture with very good resolution over large screen display tubes.

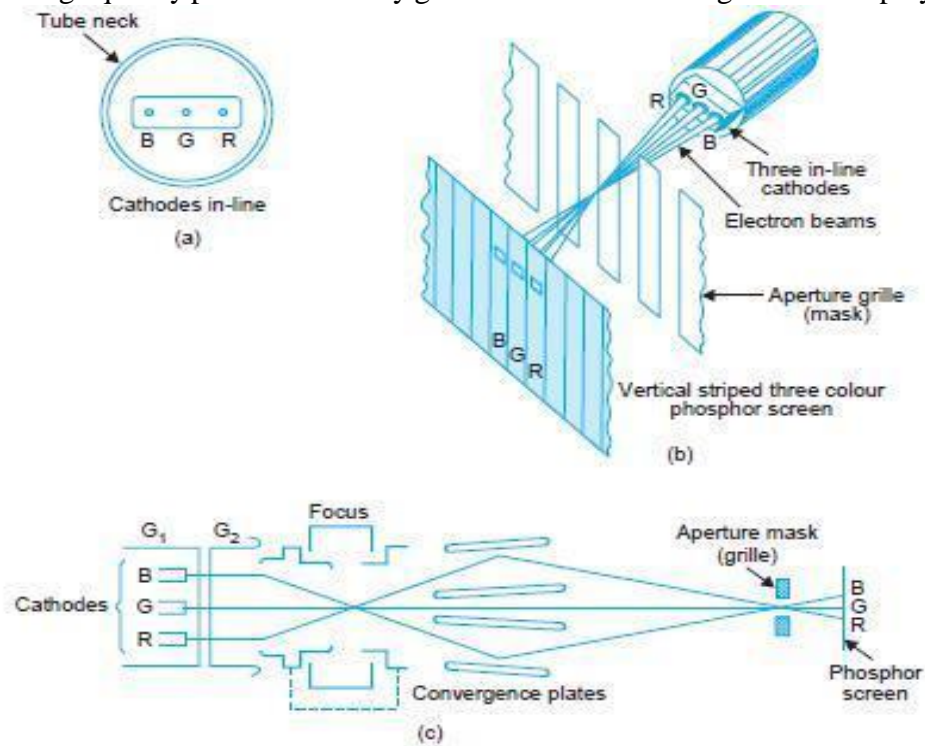


Figure. Trinitron (cathodes in-line) color picture tube (a) gun structure (b) electron beams, vertical-striped three color phosphor screen (c) constructional, focus and convergence details.

3.11. PURITY AND CONVERGENCE

- While deflecting the three beams by vertical and horizontal deflecting coils it is necessary to ensure that each beam produces a pure color and all the three color rasters fully overlap each other.

- For obtaining color purity each beam should land at the center of the corresponding phosphor dot irrespective of the location of the beams on the raster. This needs precise alignment of the color beam and is carried out by a circular magnet assembly known as the purity magnet.
- It is mounted externally on the neck of the tube and close to the deflection yoke. The purity magnet assembly consists of several flat washer like magnets held together by spring clamps in such a way that these can be rotated freely.
- The tabs on the magnets can be moved apart to reduce resultant field strength. This is illustrated for a two pole magnet in Fig.
- As shown in the same figure, the tabs when moved together change the direction of magnetic field. Two, four and six pole magnet units are employed to achieve individual and collective beam deflections. Thus to affect purity and static convergence the beams can be deflected up or down, right or left and diagonally by suitably orienting the purity magnets.

Yoke Position

- The position of the yoke on the tube neck determines the location of the deflection centre of the electron beams. A wrong setting will result in poor purity due to improper entry angles of the beams into the mask openings.
- Since deflection due to yoke fields affects the landing of the beams on the screen more towards the edges of the tube, the yoke is moved along the neck of the tube to improve purity in those regions.

Convergence

- The technique of bringing the beams together so that they hit the same part of the screen at the same time to produce three coincident rasters is referred to as convergence. Convergence errors are caused by (i) non-coincident convergence planes, (ii) non uniformity of the deflection field and (iii) flat surface of the picture tube screen. Figure illustrates correct and incorrect convergence of beams.
- Proper convergence is achieved by positional adjustment of the individual beams. It falls into two parts referred to as (i) static and (ii) dynamic convergence.
- Static convergence involves movement of the beams by permanent magnetic fields which, once correctly set, bring the beams into convergence in the central area of the screen. Convergence over the rest of the screen is achieved by continuously varying (dynamic) magnetic fields, the instantaneous strengths of which depend upon the positions of the spots on the screen.
- These fields are set up by electromagnets which carry currents at horizontal(line) and vertical (field) frequencies. In practice convergence coils are often connected in series with respective yoke windings.

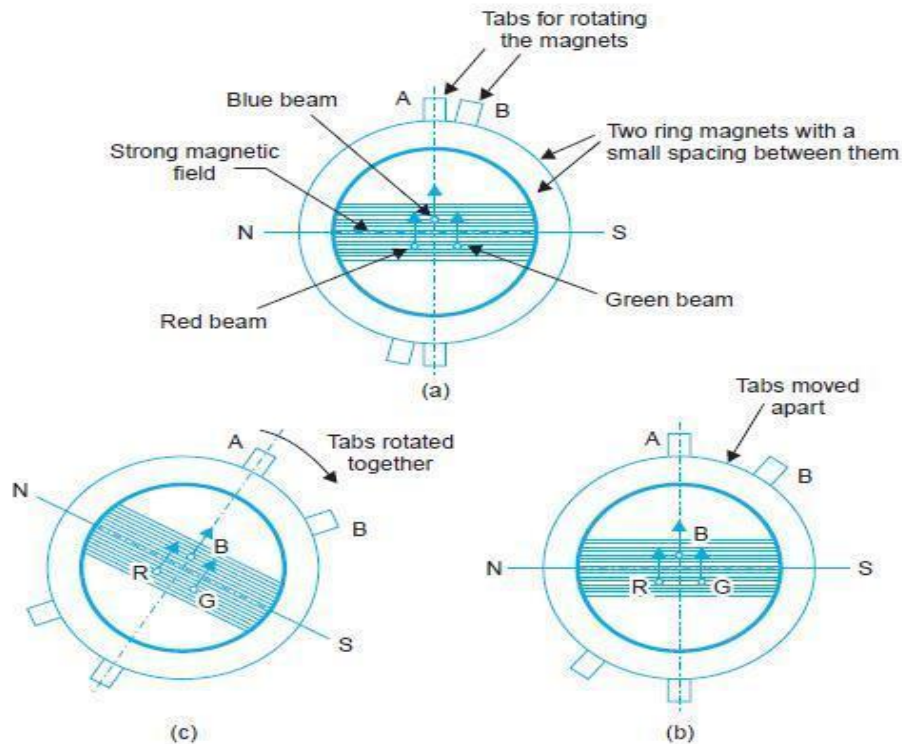


Figure. Two pole purity magnet assembly (a) strong magnetic field when tabs (A and B) are nearly together (b) spreading the tabs reduces magnetic field (c) rotating the magnets together rotates the magnetic field to cause change in the direction of beam deflection

Purity and Static Convergence

- Modern P.I.L. tubes are manufactured with such precision that hardly any purity and static convergence adjustments are necessary. However, to correct for small errors due to mounting tolerances and stray magnetic fields multi pole permanent magnet units are provided.
- Such a unit is mounted on the neck of the tube next to the deflection yoke. The various magnets are suitably oriented to achieve color purity, static convergence and straightness of horizontal raster lines.

Convergence Errors

- The need for the three rasters to be accurately superposed on each other with no east to west (lateral) or north to south (vertical) displacement (i.e., in proper color register) puts stringent constraints on distribution of the deflection field.
- Non-optimum distribution of the field along with the fact that the screen is a nearly flat surface (and not spherical) can produce two kinds of lack of color registration, commonly known as convergence errors.

- These are (a) astigmatism and (b) coma effects. (a) Astigmatism. As shown in Fig. (a), with a uniform field the rays from a vertical row of points (P, G, Q) converge short of the screen producing a vertical focal line on the screen. However, rays (R, G, B) from a row of horizontal points converge beyond the screen producing a horizontal line on the screen.
- Such an effect is known as astigmatism and causes convergence errors. In the case of a P.I.L. tube, beams R, G and B emerge only from a horizontal line and so any vertical astigmatism will have no effect. However, if horizontal astigmatism is to be avoided, the horizontal focus must be a point on the screen and not a line for any deflection.
- A given change in the shape of the deflection field produces opposite changes in vertical and horizontal astigmatic effects. Since vertical astigmatism is of no consequence in a P-I-L tube, suitable field adjustments can be made to ensure that the beams coming from in-line guns in a horizontal line converge at the same point on the screen irrespective of the deflection angle. Such a correction will however, be at the cost of a much larger vertical astigmatism but as stated above it does not interfere with the correct registration of various colors. (b) Coma Effect.
- Due to non-uniformity of the deflection field all the beams are not deflected by the same amount. As shown in Fig (b) the central beam (green) deflects by a smaller amount as compared to the other two beams.
- For a different non-uniformity of the deflection field, the effect could be just opposite producing too large a displacement of the central beam. Such a distortion is known as coma and results in mis-convergence of the beams.

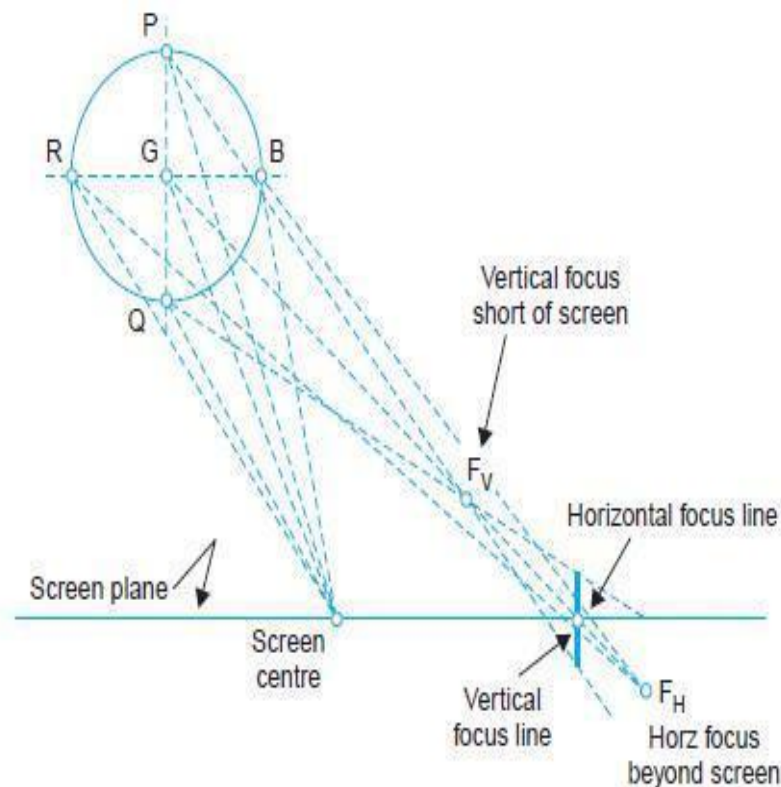


Figure. Astigmatism in a uniform deflection field

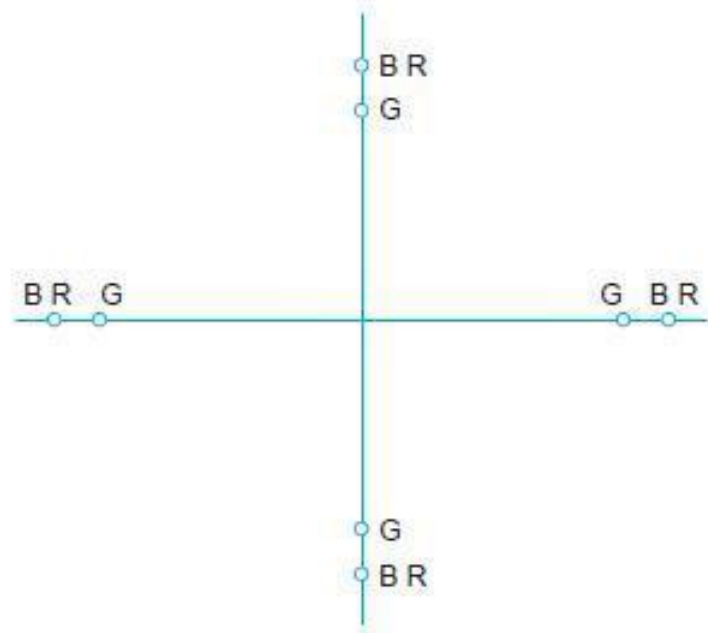


Figure. The coma effect—central beam deflection less (or more) than the side beams

Field Distribution for Optimum Convergence

- In order to correct astigmatic and coma effects different field configurations are necessary. To help understand this, it is useful to visualize the deflection field in roughly two parts, the half of it closer to the screen and the other half closer to the guns.
- Astigmatism is caused by only that part of the field which is closer to the screen whereas coma effects occur due to non uniformities of the field all over the deflection area. To correct for mis convergence due to astigmatism in a P.I.L. tube the horizontal deflection field must be pincushion shaped and the vertical deflection field barrel shaped (Fig.) in the half near the screen.
- But such a field configuration produces undue amounts of coma error. To circumvent this, the gun end of the field can be modified in such a way that the coma produced by the screen end field is just neutralized, thus giving a scan that is free from all convergence errors.
- This needs that the field distribution at the gun end be barrel shaped horizontally and pincushion vertically. The above two requirements are illustrated in Fig. (b) which shows necessary details of horizontal and vertical field distributions relative to each other along the axis of the tube.
- Though complicated, the above constraints of field distribution are met by proper deflection coil design and thus both astigmatic and coma effects are eliminated.

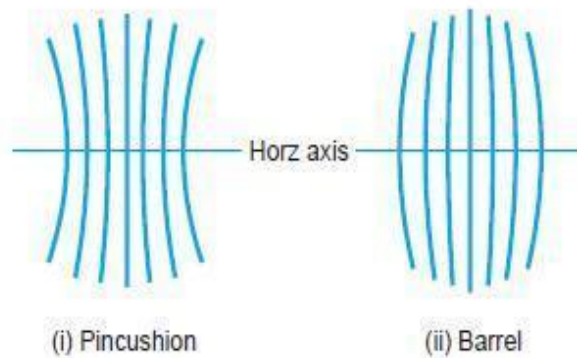


Figure. Field configurations (i) pincushion horizontal deflection field (ii) barrel shaped vertical deflection field

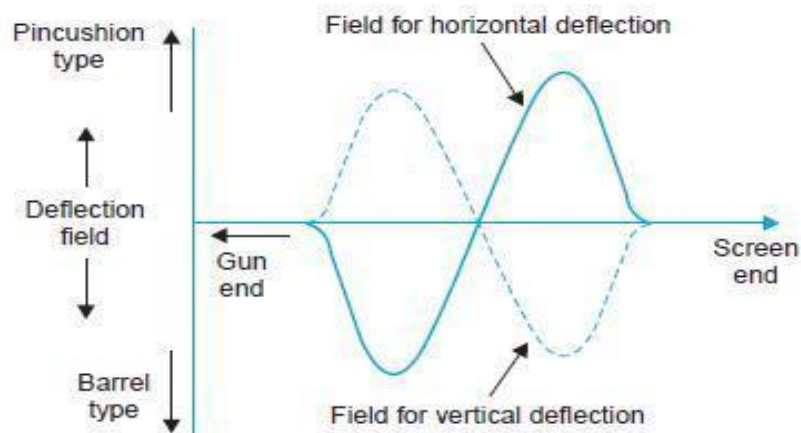


Figure. Quantitative visualization of deflection field distribution for astigmatism and coma corrections in a P-I-L picture tube.

DYNAMIC CONVERGENCE ADJUSTMENTS

- The display unit consisting of picture tube and deflection unit is inherently self-converging. However, small adjustments become necessary and are provided. For this purpose two types of four-pole dynamic magnetic fields are used.
- One is generated by additional windings on the yoke ring of the deflection unit. It is energized by adjustable sawtooth currents synchronized with scanning. The other type of dynamic field is generated by sawtooth and parabolic currents which are synchronized with scanning and flow through the deflection coils. (i) Line symmetry. Figure (a) shows a situation in which the plane where the beams are converged automatically is slightly tilted with respect to the screen plane due to some small left-right asymmetry in the distribution of the horizontal deflection field.
- As a result, horizontal convergence errors of opposite signs occur at the sides of the screen. The same type of error can be caused by a horizontal deviation of the un deflected

beams from the screen center. As shown in Fig. (b) such an error can be corrected by a 4-pole field aligned diagonally with respect to the deflection fields. This field is generated by driving a sawtooth current at line frequency through an additional four-pole winding provided around the core of the deflection yoke.

- The sawtooth current is obtained directly from the line deflection circuit. (ii) Field symmetry. As illustrated in Fig. vertical displacement of the plane of the beams with respect to the center of the vertical deflection causes horizontal convergence errors during vertical deflection.
- These errors can be corrected by feeding a rectified sawtooth current at field frequency through the additional 4-pole winding on the deflection unit. (iii) Line balance. Vertical displacement of the plane of beams with respect to center of the horizontal deflection field causes cross-over of the horizontal red and blue lines.
- This illustrated in Fig. The same type of error can also be caused by top-bottom asymmetry of the horizontal deflection field. It can be corrected by a four-pole field which is aligned orthogonally with respect to the deflection fields.
- Such a field is generated by unbalancing (see corresponding figures) the line deflection current through the two halves of the horizontal deflection coils acted with respect to its normal orientation, a parabolic vertical convergence error occurs during both horizontal and vertical deflection (Fig.).
- This error can be corrected by feeding a parabolic current at line frequency through the line deflection coils.(v) Field balance at top and bottom. Left-right asymmetry of the vertical deflection field or horizontal deviation of the un-deflected beams from the screen center causes vertical convergence errors during vertical deflection.
- This is illustrated (Fig) separately for top and bottom of the screen. The correction at the top is made by unbalancing the field deflection coils during the first-half of the field scan. Similarly correction at the bottom is made by unbalancing the field deflection coils during the second-half of the field scan.

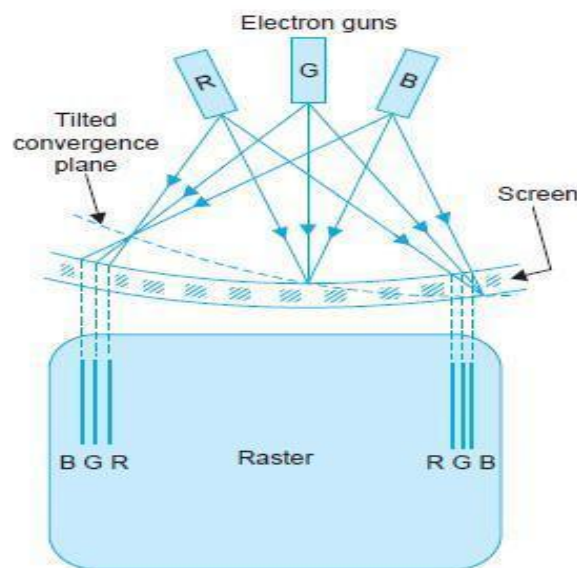


Figure. Horizontal convergence errors.

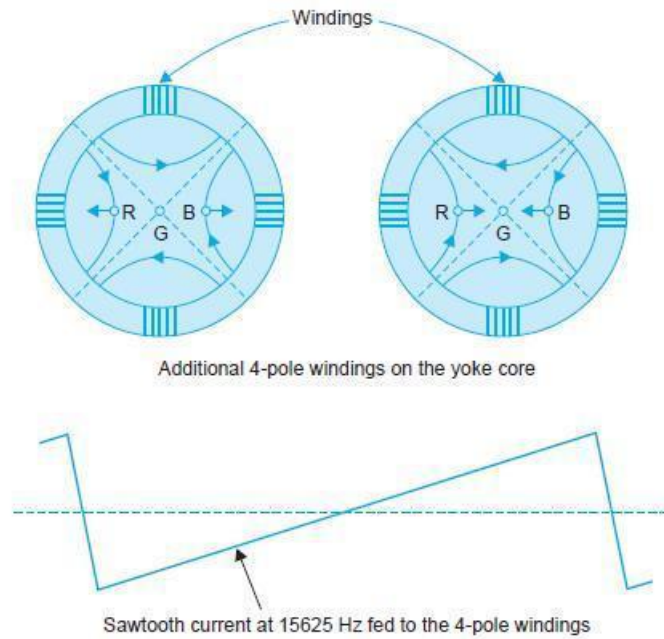


Figure. Line symmetry correction (horizontal red-to-blue distance) at the ends of horizontal axis.

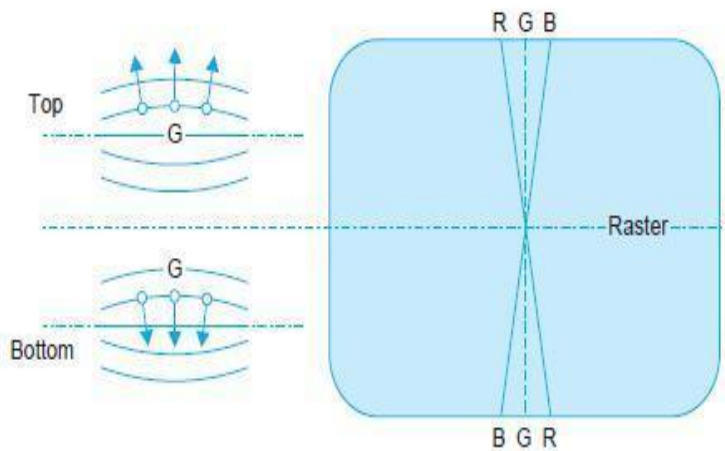


Figure. Field symmetry. Red-blue cross-over of the vertical lines cause horizontal convergence errors at the ends of vertical axis.

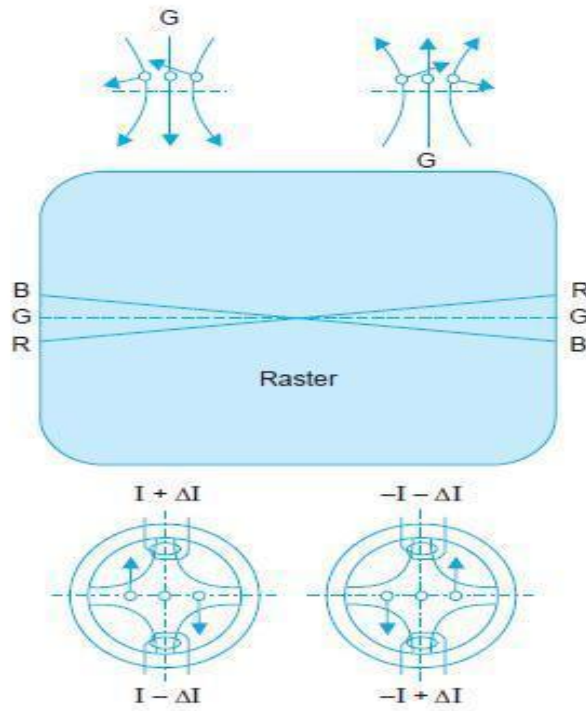


Figure. of causes

Red-blue cross-over horizontal lines vertical convergence

errors at the end of horizontal axis.

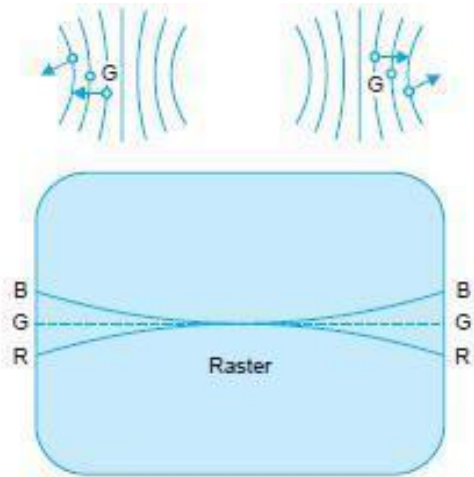


Figure. Rotation of electron beams causes vertical convergence errors of a parabolic nature

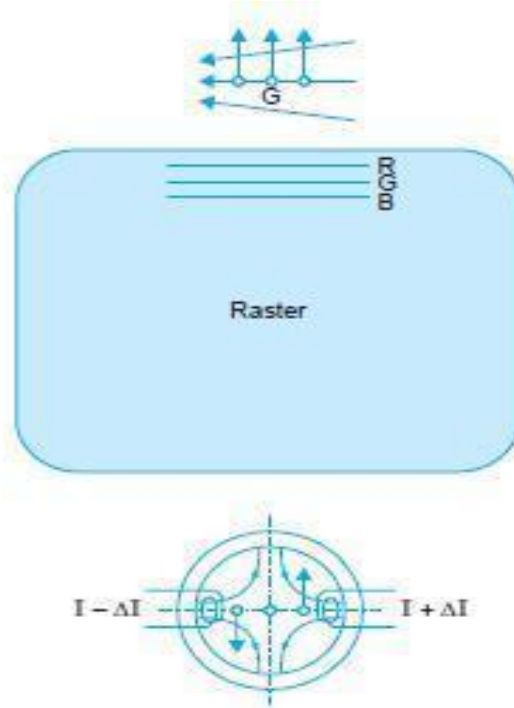
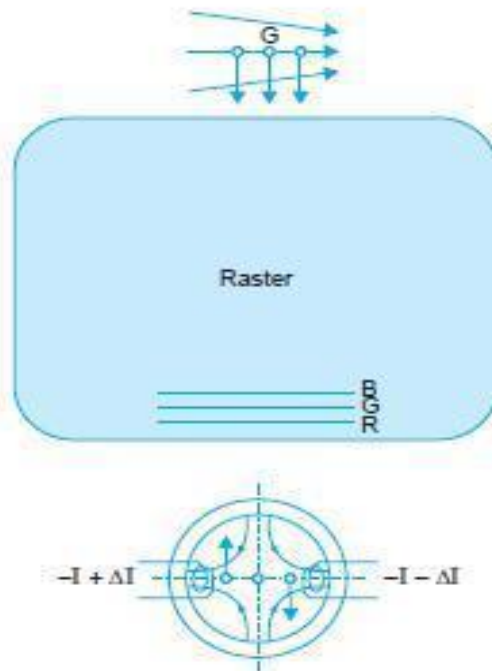


Figure. Vertical mis-convergence at the top



Vertical mis-convergence at the bottom.

3.12. PINCUSHION CORRECTION TECHNIQUES

- As mentioned earlier, dynamic pincushion corrections are necessary in color picture tubes. Figure is the sketch of a raster with a much exaggerated pincushion distortion. The necessary correction is achieved by introducing some cross modulation between the two deflection fields.
- E-W Correction To correct E-W (horizontal) pin cushioning, the horizontal deflection sawtooth current must be amplitude modulated at a vertical rate so that when the electron beam is at the top or bottom of the raster, the horizontal amplitude is minimum and when it is at the center of the vertical deflection interval the horizontal sawtooth amplitude is maximum.
- To achieve this a parabolic voltage obtained by integrating the vertical sawtooth voltage (network R 1,C 1 in Fig. is inserted in series with the dc supply to the horizontal deflection circuit. As a result, amplitude of individual cycles of the 15625 Hz horizontal output varies in step with the series connected 50 Hz parabolic voltage.
- As shown in Fig. (b) The modified horizontal sawtooth wave shape over a period of the vertical cycle (20 ms) has the effect of pulling out the raster at the center to correct E-W pin cushioning.

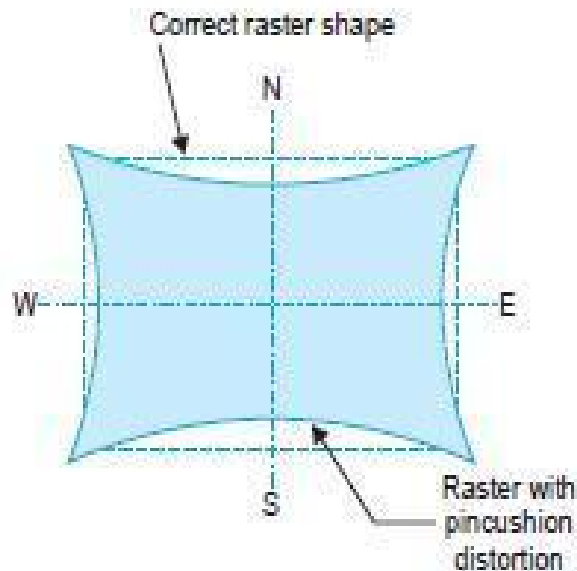
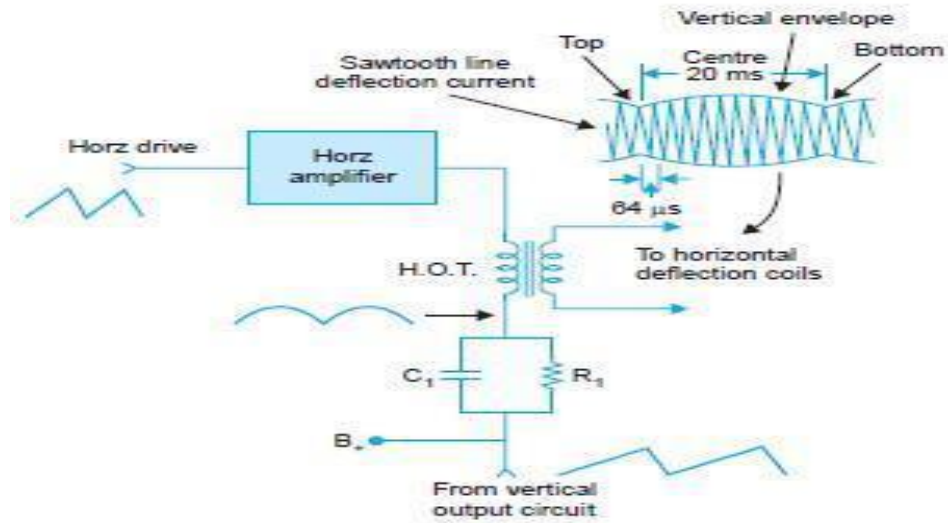


Figure. Pincushion distortion.



N-S Correction

- The top and bottom or N-S pincushion correction is provided by forcing the vertical sawtooth current to pulsate in amplitude at the horizontal scanning rate. During top and bottom scanning of the raster a parabolic waveform at the horizontal rate is superimposed on the vertical deflection sawtooth.
- In fact this increases vertical size during the time the beam is moving through the midpoint of its horizontal scan. The parabolic waveform at the top of the raster is of opposite polarity to that at the bottom since the raster stretch required at the top is opposite to the needed at the bottom.
- The amplitude of the parabolic waveform required for top and bottom pincushion correction decreases to zero as vertical deflection passes through the centre of the raster.

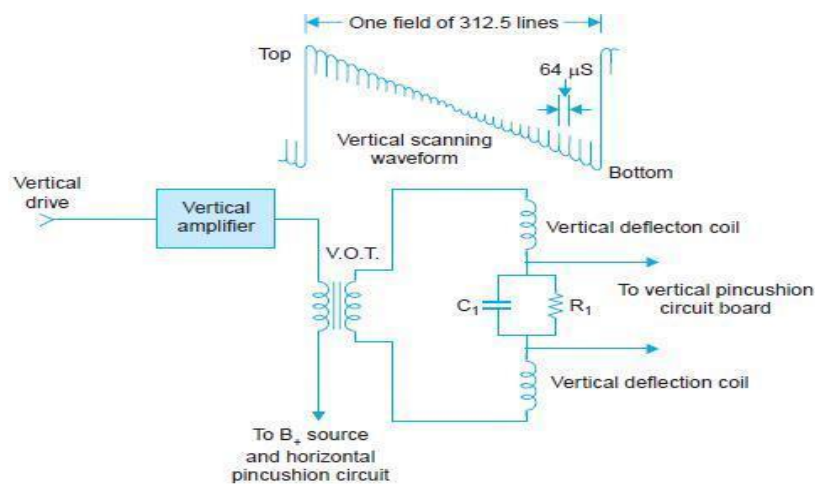


Figure. Vertical (N – S) pincushion correction circuit and waveforms.

3.13. AUTOMATIC DEGAUSSING (ADG) CIRCUIT

- There are many degaussing circuits in use. Figure shows details of a popular automatic degaussing circuit. It uses a thermistor and a varistor for controlling the flow of alternating current through the degaussing coil.
- When the receiver is turned on the ac voltage drop across the thermistor is quite high (about 60 volts) and this causes a large current to flow through the degaussing coil. Because of this heavy current, the thermistor heats up, its resistance falls and voltage drop across it decreases.
- As a result, voltage across the varistor decreases thereby increasing its resistance. This in turn reduces ac current through the coil to a very low value. The circuit components are so chosen that initial surge of current through the degaussing coil is close to 4 amperes and drops to about 25 mA in less than a second.
- This is illustrated in Fig. Once the thermistor heats up degaussing ends and normal ac voltage is restored to the B + rectifier circuit.

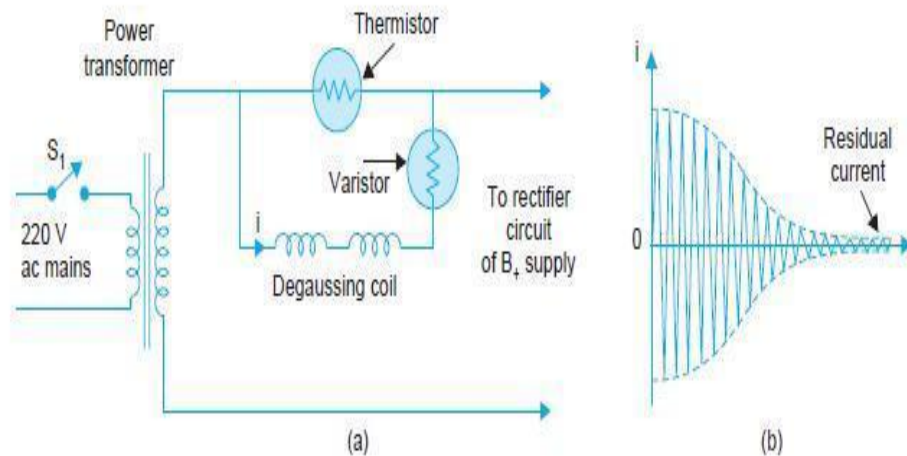


Figure. Automatic degaussing (ADG) (a) typical circuit (b) variation of current in the degaussing coil when receiver is just switched on.

3.14. GREY SCALE TRACKING

- It may be recalled that red, green and blue lights must combine in definite proportions to produce white light. The three phosphors have different efficiencies. Also the three guns may not have identical I_p/V_{gk} characteristics and cut-off points.
- Therefore, it becomes necessary to incorporate suitable adjustments such that monochrome information is reproduced correctly (with no color tint) for all settings of the contrast control. In practice, this amounts to two distinct steps:

(a) Adjustment of Low Lights

- Non-coincident I_p / V_{gk} characteristics and consequent difference in cut-off points of the three guns, results in appearance of colored tint instead of pure dark grey shades in areas of low brightness. To correct this it is necessary to bring the cut-off points in coincidence. This is achieved by making the screen grid (i.e., 1st anode) voltage different from each other. Potentiometers are normally provided for this purpose in the dc voltage supply to the three screen grids.

(b) Adjustment of High Lights

- It is equally necessary to ensure that all other levels of white are also correctly reproduced. This amounts to compensating for the slightly different slopes and also for the substantially different phosphor efficiencies.
- This is achieved by varying the video (luminance) signal drive to the three guns. Since the red phosphor has the lowest efficiency, maximum video signal is fed to the red cathode and then by the use of potentiometers video signal amplitudes to the green and blue guns are varied (see Fig.) to obtain optimum reproduction of high lights

3.15. COLOR SIGNAL TRANSMISSION

- The color video signal contains two independent information, that of hue and saturation. It is a difficult matter to modulate them to one and the same carrier in such a way that these can be easily recovered at the receiver without affecting each other.
- The problem is accentuated by the need to fit this color signal into a standard TV channel which is almost fully occupied by the 'Y' signal. However, to satisfy compatibility requirements the problem has been ingeniously solved by combining the color information into a single variable and by employing what is known as frequency interleaving.

(In the CCIR PAL I standards the picture and sound carrier are 6 MHz apart and the channel bandwidth is 8 MHz. The only difference between PAL-B and PAL-G is in the channel bandwidth)

- PAL-B with channel bandwidth of 7 MHz does not provide any inter-channel gap, whereas PAL-G with channel bandwidth of 8 MHz provides a band gap of 1 MHz in-between successive channels.

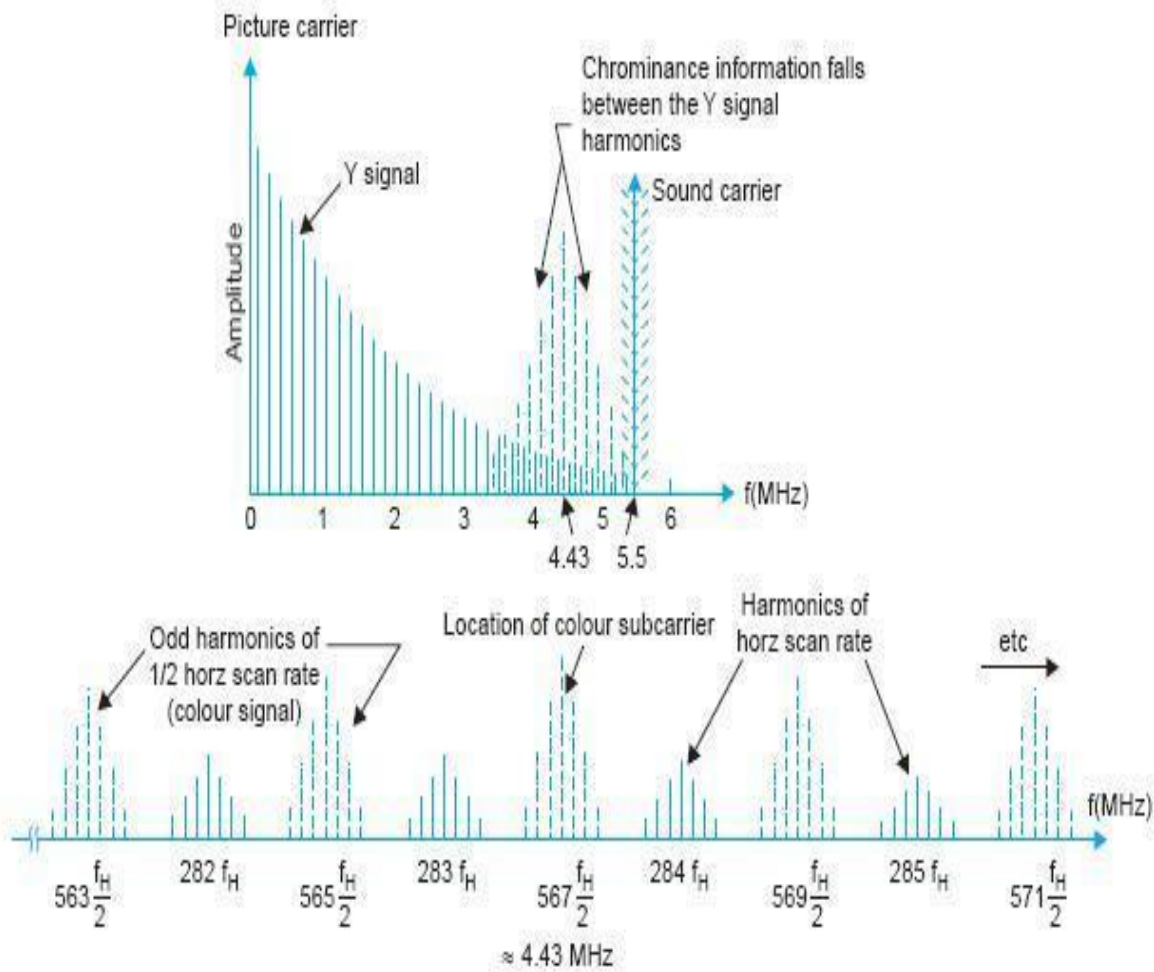


Figure. Interleaving of the color signal.

3.15. COLOR SIGNAL TRANSMISSION AND RECEPTION

- Frequency interleaving in television transmission is possible because of the relationship of the video signal to the scanning frequencies which are used to develop it. It has been determined that the energy content of the video signal is contained in individual energy ‘bundles’ which occur at harmonics of the line frequency (15.625, 31.250 ... KHz) the components of each bundle being separated by a multiplier of the field frequency (50, 100, ... Hz).
- The shape of each energy bundle shows a peak at the exact harmonics of the horizontal scanning frequency. This is illustrated in Fig. As shown there, the lower amplitude excursions that occur on either side of the peaks are spaced at 50 Hz intervals and represent harmonics of the vertical scanning rate.

- The vertical sidebands contain less energy than the horizontal because of the lower rate of vertical scanning. Note that the energy content progressively decreases with increase in the order of harmonics and is very small beyond 3.5 MHz from the picture carrier.
- It can also be shown that when the actual video signal is introduced between the line sync pedestals, the overall spectra still remains 'bundled' around the harmonics of the line frequency and the spectrum of individual bundles become a mixture of continuous portion due to the video signal are discrete frequencies due to the field sync as explained earlier.
- Therefore, a part of the bandwidth in the monochrome television signal goes unused because of spacing between the bundles. This suggests that the available space could be occupied by another signal. It is here where the color information is located by modulating the color difference signals with a carrier frequency called 'color subcarrier'. The carrier frequency is so chosen that its sideband frequencies fall exactly mid-way between the harmonics of the line frequency.
- This requires that the frequency of the subcarrier must be an odd multiple of half the line frequency. The resultant energy clusters that contain color information are shown in Fig. by dotted chain lines along with the Y signal energy bands. In order to avoid crosstalk with the picture signal, the frequency of the subcarrier is chosen rather on the high side of the channel bandwidth.
- It is 567 times one-half the line frequency in the PAL system. This comes to: $(2 \times 283 + 1) 15625/2 = 4.43$ MHz. Note that in the American 525 line system, owing to smaller bandwidth of the channel, the subcarrier employed is 455 times one-half the line frequency i.e., $(2 \times 227 + 1) 15750/2$ and is approximately equal to 3.58 MHz.

3.16. BANDWIDTH FOR COLOR SIGNAL TRANSMISSION

- The Y signal is transmitted with full frequency bandwidth of 5 MHz for maximum horizontal details in monochrome. However, such a large frequency spectrum is not necessary for color video signals.
- The reason being, that for very small details, the eye can perceive only the brightness but not the color. Detailed studies have shown that perception of colors by the human eye, which are produced by combinations of the three primary colors is limited to objects which have relatively large colored areas ($1/25$ th of the screen width or more). On scanning they generate video frequencies which do not exceed 0.5 MHz. Further, for medium size objects or areas which produce a video frequency spectrum between 0.5 and 1.5 MHz, only two primary colors are needed.
- This is so, because for finer details the eye fails to distinguish purple (magenta) and green-yellow hues from greys. As the colored areas become very small in size (width), the red and cyan hues also become indistinguishable from greys.
- Thus for very fine color details produced by frequencies from 1.5 MHz to 5 MHz, all persons with normal vision are color blind and see only changes in brightness even for colored areas.
- Therefore, maximum bandwidth necessary for color signal transmission is around 3 MHz (± 1.5 MHz).

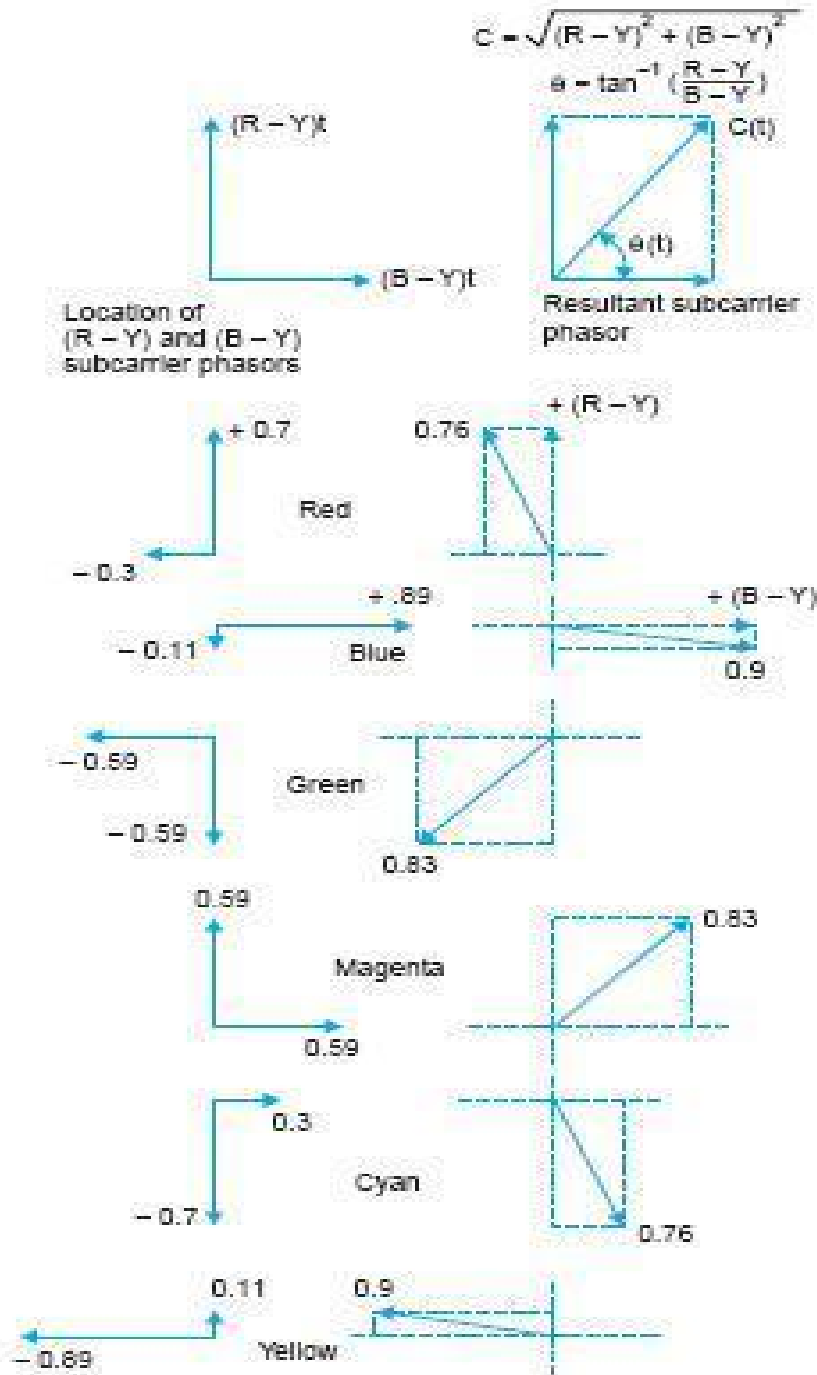


Figure. Quadrature amplitude modulated color difference signals and the position of resultant subcarrier phasor for the primary and complementary colors. Note that the magnitudes shown correspond to unweighted values of color difference signals.

MODULATION OF COLOR DIFFERENCE SIGNALS

- The problem of transmitting (B-Y) and (R-Y) video signals simultaneously with one carrier frequency is solved by creating two carrier frequencies from the same color subcarrier without any change in its numerical value.
- Two separate modulators are used, one for the (B-Y) and the other for the (R-Y) signal. However, the carrier frequency fed to one modulator is given a relative phase shift of 90° with respect to the other before applying it to the modulator.
- Thus, the two equal subcarrier frequencies which are obtained from a common generator are said to be in quadrature and the method of modulation is known as quadrature modulation.
- After modulation the two outputs are combined to yield C, the resultant subcarrier phasor. Since the amplitude of C, the chrominance signal, corresponds to the magnitudes of color difference signals, its instantaneous value represents color saturation at that instant.
- Maximum amplitude corresponds to greatest saturation and zero amplitude to no saturation i.e., white. Similarly, the instantaneous value of the C phasor angle () which may vary from 0° to 360° represents hue of the color at that moment.
- Thus the chrominance signal contains full information about saturation and hue of various colors. This being a crucial point in color signal transmission, is illustrated by a few examples. However, it would be necessary to first express (R-Y) and (B-Y) in terms of the three camera output voltages.
- This is done by substituting $Y = 0.59G + 0.3R + 0.11B$ in these expressions.
- Thus (R-Y) becomes $R - 0.59G - 0.3R - 0.11B = 0.7R - 0.59G - 0.11B$.
- Similarly, (B-Y) becomes $B - 0.59G - 0.3R - 0.11B = 0.89B - 0.59G - 0.3R$.
- Now suppose that only pure red color is being scanned by the color camera. This would result in an output from the red camera only, while the green and blue outputs will be zero. Therefore, (R-Y) signal will become simply $+ 0.7R$ and (B-Y) signal will be reduced to $- 0.3R$.
- The resultant location of the subcarrier phasor after modulation is illustrated in Fig. Note that the resultant phasor is counter clockwise to the position of $+ (R-Y)$ phasor. Next consider that the color camera scans a pure blue color scene.
- This yields $(R-Y) = - 0.11B$ and $(B-Y) = 0.89 B$. The resultant phasor for this color lags $+ (B-Y)$ vector by a small angle. Similarly the location and magnitude for any color can be found out. This is illustrated in Fig. for the primary and complementary colors.
- Another point that needs attention is the effect of desaturation on the color phasors. Since desaturation results in reduction of the amplitudes of both (B-Y) and (R-Y) phasors, the resultant chrominance phasor accordingly changes its magnitude depending on the degree of de-saturation.
- Thus any change in the purity of a color is indicated by a change in the magnitude of the resultant subcarrier phasor. Color Burst Signal Suppressed carrier double sideband working is the normal practice for modulating color- difference signals with the color subcarrier frequency.

- This is achieved by employing balanced modulators. The carrier is suppressed to minimize interference produced by the chrominance signals both on monochrome receivers when they are receiving color transmissions and in the luminance channel of color receivers themselves. As explained in an earlier chapter the ratio of the sideband power to carrier power increases with the depth of modulation.
- However, even at 100% modulation two-thirds of the total power is in the carrier and only one-third is the useful sideband power. Thus suppressing the carrier clearly eliminates the main potential source of interference.
- In addition of this, the color-difference signals which constitute the modulating information are zero when the picture detail is non-colored (i.e., grey, black or white shades) and so at such times the sidebands also disappear leaving no chrominance component in the video signal.
- As explained above the transmitted does not contain the subcarrier frequency but it is necessary to generate it in the receiver with correct frequency and phase relationship for proper detection of the color sidebands.
- To ensure this, a short sample of the subcarrier oscillator, 8 to 11 cycles) called the 'color burst' is sent to the receiver along with sync signals. This is located in the back porch of the horizontal blanking pedestal.
- The color burst does not interfere with the horizontal sync because it is lower in amplitude and follows the sync pulses. Its exact location is shown in Fig.
- The color burst is gated out at the receiver and is used in conjunction with a phase comparator circuit to lock the local subcarrier oscillator frequency and phase with that at the transmitter.
- As the burst signal must maintain a constant phase relationship with the scanning signals to ensure proper frequency interleaving, the horizontal and vertical sync pulses are also derived from the subcarrier through frequency divider circuits.

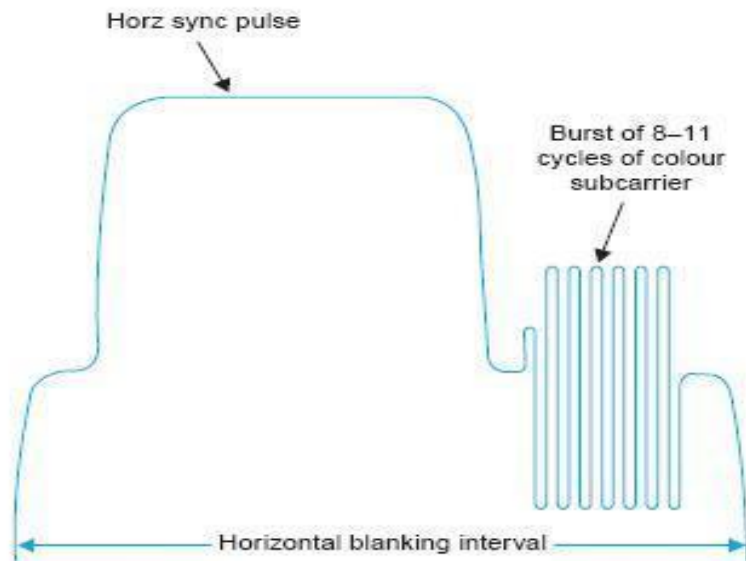


Figure. Location of color burst on the back porch of each horizontal sync pulse.

3.17. WEIGHTING FACTORS

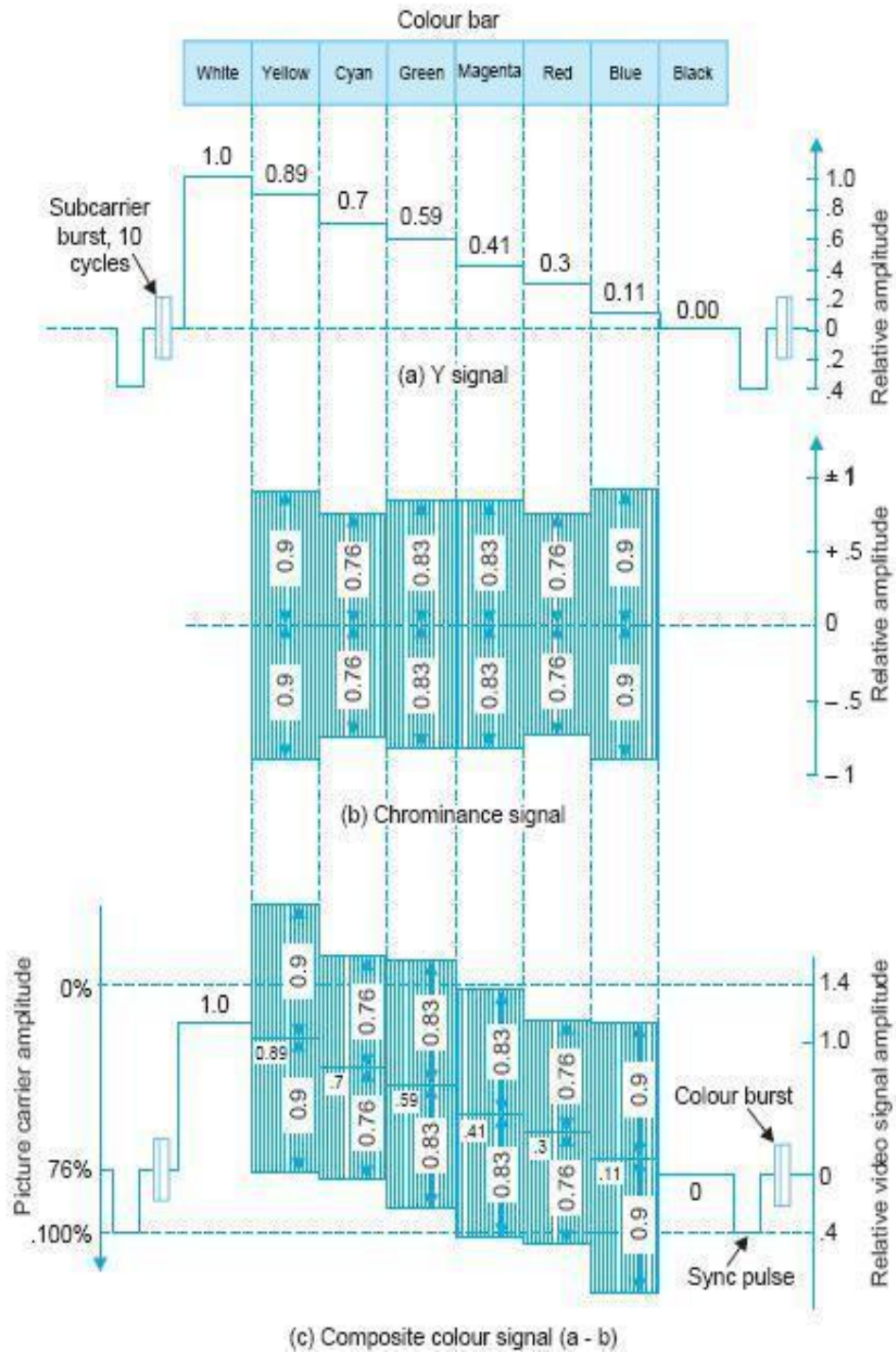
- The resultant chrominance signal phasor (C) is added to the luminance signal (Y) before modulating it with the channel carrier for transmission. The amplitude, i.e., level line of Y signal becomes the zero line for this purpose.
- Such an addition is illustrated in Fig. for a theoretical 100 percent saturated, 100 percent amplitude color bar signal. The peak-to-peak amplitude of green signal (± 0.83) gets added to the corresponding luminance amplitude of 0.59.
- For the red signal the chrominance amplitude of ± 0.76 adds to its brightness of 0.3. Similarly other colors add to their corresponding luminance values to form the chroma signal.
- However, observe that it is not practicable to transmit this chroma waveform because the signal peaks would exceed the limits of 100 percent modulation. This means that on modulation with the picture carrier some of the color signal amplitudes would exceed the limits of maximum sync tips on one side and white level on the other.
- For example, in the case of magenta signal, the chrominance value of ± 0.83 when added to its luminance amplitude of 0.41 exceeds the limits of 100 percent modulation of both white and black levels.
- Similarly blue signal amplitude greatly exceeds the black level and will cause a high degree of over modulation. If over modulation is permitted the reproduced colors will get objectionably distorted.
- Therefore, to avoid over modulation on 100 percent saturation color values, it is necessary to reduce the amplitude of color difference video signal before modulating them with the color subcarrier. Accordingly, both (R-Y) and (B-Y) components of the color video signal are scaled down by multiplying them with what are known as 'weighting factors'.
- Those used are 0.877 for the (R-Y) component and 0.493 for the (B-Y) component. The compensated values are obtained by using potentiometers at the outputs of (R-Y) and (B-Y) adders (see Fig.).
- Note that no reduction is made in the amplitude of Y signal. It may also be noted that since the transmitter radiates weighted chrominance signal values, these must be increased to the uncompensated values at the color TV receiver for proper reproduction of different hues.
- This is carried out by adjusting gains of the color difference signal amplifiers. The unweighted and weighted values of color difference signals are given below in Table.

Colour	Luminance signal (λ)	$B-Y$	$R-Y$	$G-Y$	C_{SC}	$B-Y$	$R-Y$	C_{SC}
		Unweighted			Weighted			
White	1	0	0	0	0	0	0	0
Yellow	0.89	-0.89	+0.11	+0.11	0.9	-0.4385	+0.096	0.44
Cyan	0.7	+0.3	-0.7	+0.3	0.76	+0.148	-0.614	0.63
Green	0.59	-0.59	-0.59	+0.41	0.83	-0.29	-0.517	0.59
Magenta	0.41	+0.59	+0.59	-0.41	0.83	+0.29	+0.517	0.59
Red	0.3	-0.3	+0.7	-0.3	0.76	-0.148	+0.614	0.63
Blue	0.11	+0.89	-0.11	-0.11	0.9	+0.4388	-0.096	0.44
Black	0	0	0	0	0	0	0	0

$$C_{SC} = \sqrt{(B-Y)^2 + (R-Y)^2}$$

$$(B-Y) \text{ weighted} = 0.493 (B-Y) \text{ unweighted}$$

$$(R-Y) \text{ weighted} = 0.877 (R-Y) \text{ unweighted}$$



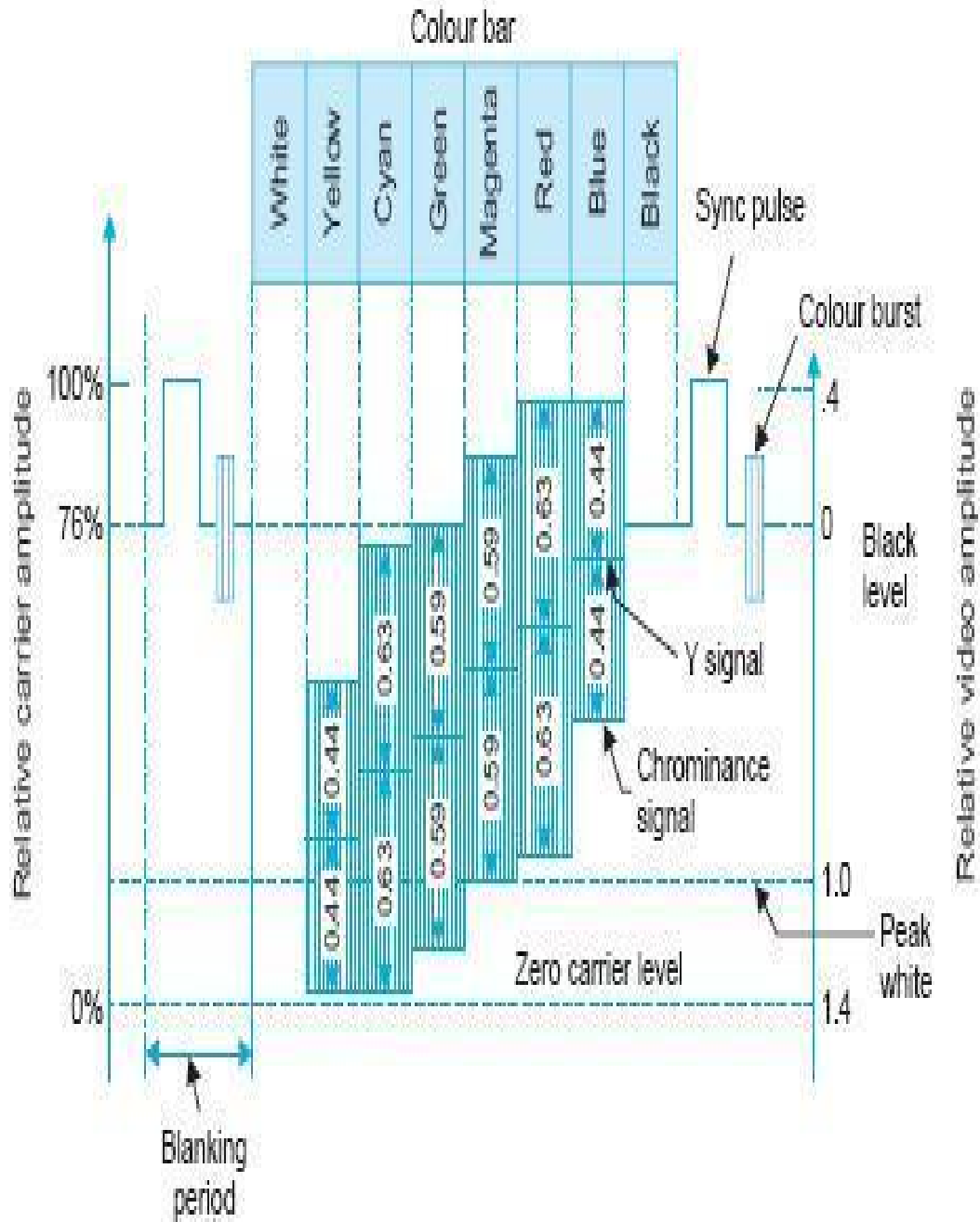
- Generation of composite color signal for a theoretical 100% saturated, 100% amplitude color bar signal. As seen from the relative amplitude scales, the composite video signal would cause gross over-modulation. Therefore in practice the color difference signals are reduced in amplitude to avoid any excessive over-modulation

3.18. FORMATION OF THE CHROMINANCE SIGNAL

- Using the information of Table, Fig. illustrates the formation of the chroma signal for a color bar pattern after the color difference signals have been scaled down in accordance with corresponding weighting factors.
- Note that new amplitudes of the chrominance subcarrier signals are 0.63 for red and cyan, 0.59 for green and magenta and 0.44 for blue and yellow.
- These amplitudes will still cause over modulation to about 33%. This is permitted, because in practice, the saturation of hues in natural and staged scenes seldom exceeds 75 percent.
- Since the amplitude of chroma signal is proportional to the saturation of hue, maximum chroma signal amplitudes are seldom encountered in practice.
- Therefore, the weighted chroma values result in a complete color signal that will rarely, if ever, over modulate the picture carrier of a CTV transmitter. Hence it is not necessary to further decrease the signal amplitudes by employing higher weighting factors.

Chroma Signal Phasor Diagram

- The compensation (readjustment) of chroma signal values results in a change of chroma phase angles. In the NTSC system it is a common practice to measure phase angles relative to the $-(B-Y)$ phasor.
- This location has been designated 0° or the reference phase position on the phasor diagram (see Fig.) because this is also the phase of the color burst that is transmitted on the back porch of each horizontal sync pulse.
- Referring to Fig. the compensated color magenta is represented by a phasor at an angle of 119° . In the same manner the diagram indicates phase angles and amplitudes of other color signals. Note that primary colors are 120° apart and complementary colors differ in phase by 180° from their corresponding primary colors.



- 100% saturated, 100% amplitude color-bar signal in which the color difference signals are reduced by weighting factors to restrict the chrominance signal excursions to 33% beyond black and peak white levels.

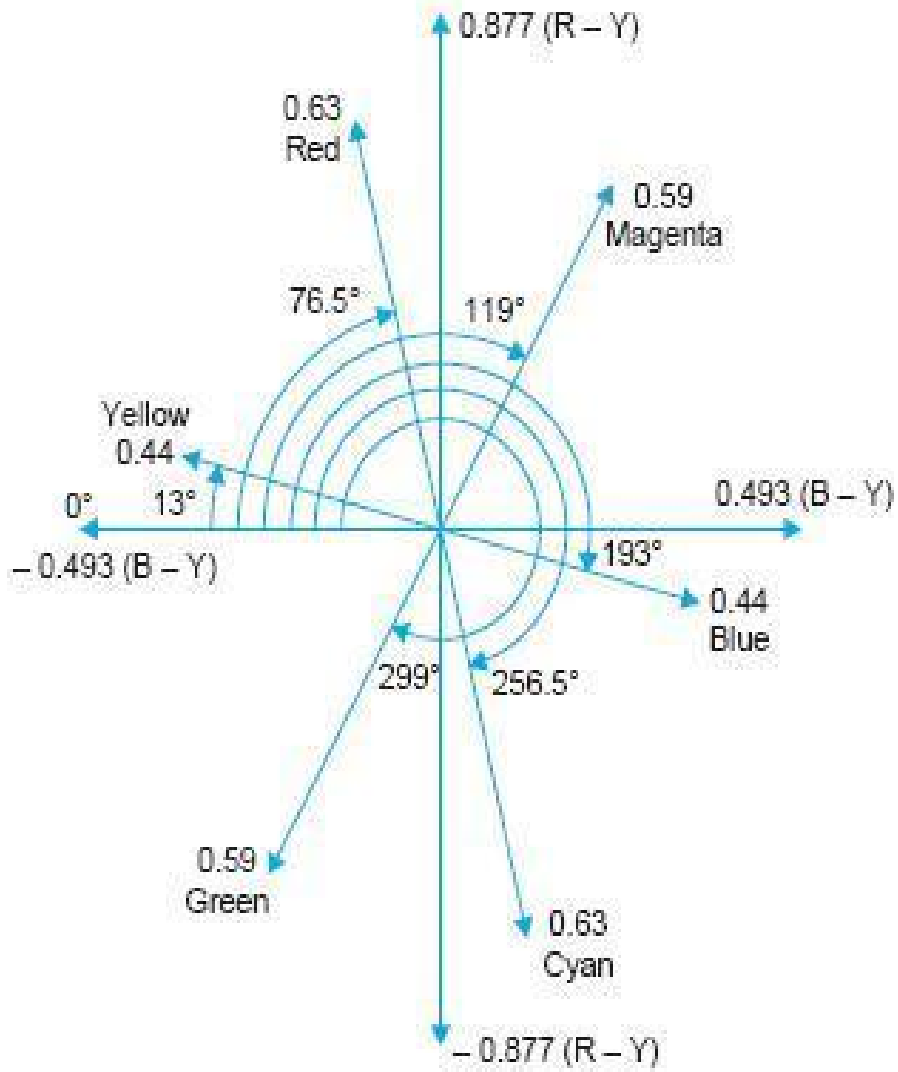


Figure. Magnitude and phase relationships of compensated chrominance signals for the primary and complementary colors.

UNIT IV

COLOUR TELEVISION SYSTEMS

4.1. NTSC COLOUR TV SYSTEM

- The NTSC colour system is compatible with the American 525 line monochrome system. In order to save bandwidth, advantage is taken of the fact that eye's resolution of colours along the reddish blue-yellowish green axis on the colour circle is much less than those colours which lie around the yellowish red-greenish blue axis.
- Therefore two new colour video signals, which correspond to these colour regions, are generated.
- These are designated as I and Q signals. The I signal lies in a region 33° counter clockwise to $+(R - Y)$ where the eye has maximum colour resolution. It* is derived from the $(R - Y)$ and $(B - Y)$ signals and is equal to $0.60R - 0.28G - 0.32B$.
- As shown in Fig. it is located at an angle of 57° with respect to the colour burst in the balanced modulator circuits. Similarly the Q** signal is derived from colour difference signals by suitable matrix and equals $0.21R - 0.52G + 0.31B$. It is located 33° counter clockwise to the $+(B - Y)$ signal and is thus in quadrature with the I signal.
- As illustrated in Fig. the Q signal covers the regions around magenta (reddish-blue) and yellow-green shades.
- Similarly orange hues correspond to phase angles centred around $+I$ and the

$$I = 0.74(R - Y) - 0.27(B - Y).$$

$$Q = 0.48(R - Y) + 0.41(B - Y).$$

complementary blue-green (cyan) hues are located around the diametrically opposite $-I$ signal. Since the eye is capable of resolving fine details in these regions, I signal is allowed to possess frequencies up to 1.5 MHz.

- However, the eye is least sensitive to colours that lie around the $\pm Q$ signals, and therefore it is allowed a bandwidth of only ± 0.5 MHz with respect to the colour subcarrier.

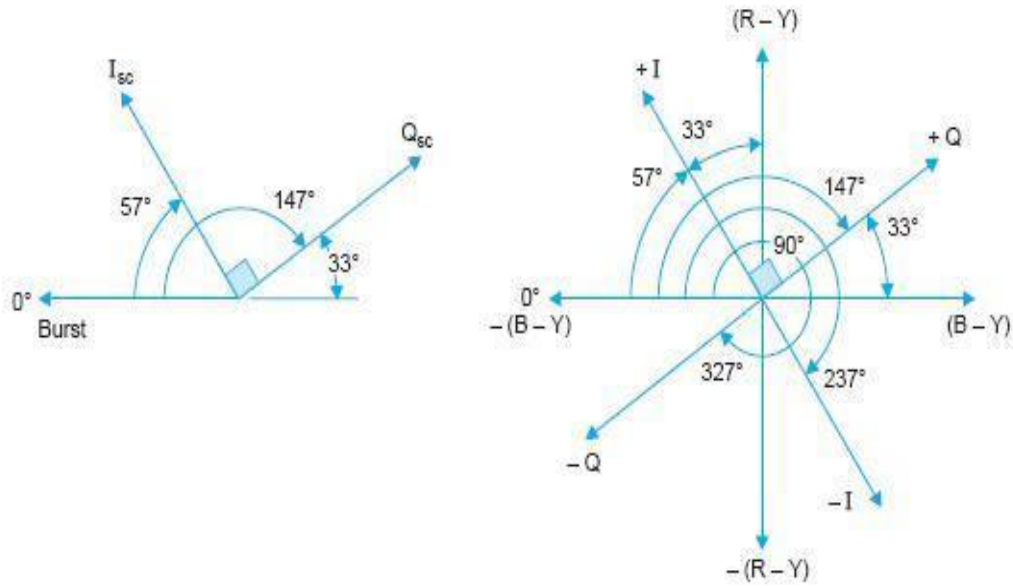


Figure. Phasor diagrams of the I and Q signals in the NTSC system.

- It may be noted that both I and Q signals are active up to 0.5 MHz and being at right angles to each other, combine to produce all the colours contained in the chrominance signal.
- However, the Q signal drops out after 0.5 MHz and only I signal remains between 0.5 and 1.5 MHz to produce colours, the finer details of which the eyes can easily perceive.
- To help understand this fact it may be recalled that only one colour difference signal is needed for producing colours which are a mixture of only two colours. Thus the Q signal is not necessary for producing colours lying in the region of orange (red + green) and cyan (green +blue) hues.
- Hence at any instant when $Q = 0$ and only I signal is active the colours produced on the screen will run the gamut from reddish orange to bluish green. Bandwidth Reduction
Double sideband transmission is allowed for the Q signal and it occupies a channel bandwidth of 1 MHz (± 0.5 MHz). However, for the I signal the upper sideband is restricted to a maximum of 0.5 MHz while the lower sideband is allowed to extent up to 1.5 MHz. As such it is a form of vestigial sideband transmission.
- Thus in all, a bandwidth of 2 MHz is necessary for colour signal transmission. This is a saving of 1 MHz as compared to a bandpass requirement of 3 MHz if $(B - Y)$ and $(R - Y)$ are directly transmitted. It is now obvious that in the NTSC system, advantage is taken of the limitations of the human eye to restrict the colour signal bandwidth, which in turn results in reduced interference with the sound and picture signal sidebands.

- The reduction in colour signal sidebands is also dictated by the relatively narrow channel bandwidth of 6 MHz in the American TV system.
- **Exact Colour Subcarrier Frequency** The colour subcarrier frequency in the NTSC system has been chosen to have an exact value equal to 3.579545 MHz. The reason for fixing it with such a precision is to maintain compatibility between monochrome and colour systems.
- Any interference between the chrominance signal and higher video frequencies is minimized by employing suppressed carrier (colour subcarrier) transmission and by using a notch filter in the path of the luminance signal. However, when a colour transmission is received on a monochrome receiver a dot pattern structure appears along each raster line on the receiver screen.
- This is caused by the colour signal frequencies that lie within the pass-band of the video section of the receiver. As illustrated below such an interference can be eliminated if the subcarrier frequency is maintained at the exact value mentioned above. Assume that the interfering colour signal has a sinusoidal variation which rides on the average brightness level of the monochrome signal.
- This produces white and black dots on the screen. If the colour subcarrier happens to be a multiple of the line frequency ($n \times f_h$) the phase position of the disturbing colour frequency will be same on successive even or odd fields. Thus black and white dots will be produced at the same spots on the screen and will be seen as a persistent dot pattern interference.
- However, if a half-line offset is provided by fixing the sub-carrier frequency to be an odd multiple of the half-line frequency, the disturbing colour signal frequency will have opposite polarity on successive odd and even fields. Thus as the same spot on the display screen a bright dot image will follow a dark one alternately.
- The cumulative effect of this on the eye would get averaged out and the dot pattern will be suppressed. As an illustration of this phenomenon assume that a simple five line scanning system is being used. Figure shows the effect of sinewave luminance signal that is an odd harmonic of one-half of the scanning frequency.
- Each negative excursion of the signal at the cathode of the picture tube will produce a unit area of brightness on the screen while the positive going excursions of the signal will cause unit dark areas on the picture.
- In the illustration under consideration where the sinewave completes 3.5 cycles during one active horizontal line, four dark areas and three areas of brightness will be produced during the first line scan. Because of the extra half-cycle the next horizontal scan begins

with an area of brightness and the entire line contains only three dark areas. the same off-set occurs on each succeeding line, producing a checkerboard pattern on the screen.

- Since the scanning rate in the example utilizes an odd number of horizontal scans for each complete presentation, the luminance signal will be 180° out of phase with the previous signal as line number one is again scanned. Thus the pattern obtained on the screen will be the reverse of that which was generated originally.
- The total effect of the above process on the human eye is one of cancellation. Since in actual practice scanning takes place at a very fast rate, the presistency of the eye blends the patterns together with the effect that visibility of the dot structure is considerably reduced and goes unnoticed on a monochrome receiver.
- The compatibility considerations thus dictate that the colour sub-carrier frequency (f_{sc}) should be maintained at 3.583125, i.e., $(2 \times 227 + 1) \times 15750/2$ MHz.
- However, the problem does not end here, because the sound carrier and the colour sub-carrier beat with each other in the detector and an objectionable beat note of 0.92 MHz is produced ($4.5 - 3.58 = 0.92$).
- This interferes with the reproduced picture. In order to cancel its cumulative effect it is necessary that the sound carrier frequency must be an exact multiple of an even harmonic of the line frequency.
- The location of the sound carrier at 4.5 MHz away from the picture carrier cannot be disturbed for compatibility reasons and so 4.5 MHz is made to be the 286th harmonic of the horizontal deflection frequency. Therefore, $f_h = 4.5 \text{ MHz} / 286 = 15734.26 \text{ Hz}$ is chosen.
- Note that this is closest to the value of 15750 Hz used for horizontal scanning for monochrome transmission.
- A change in the line frequency necessitates a change in the field frequency since 262.5 lines must be scanned per field. Therefore the field frequency (f_v) is changed to be $15734.26/262.5 = 59.94 \text{ Hz}$ in place of 60 Hz.
- The slight difference of 15.74 Hz in the line frequency ($15750 - 15734.26 = 15.74 \text{ Hz}$) and of 0.06 Hz in the field frequency ($60 - 59.94 = 0.06 \text{ Hz}$) has practically no effect on the deflection oscillators because an oscillator that can be triggered by 60 Hz pulses can also be synchronized to produce 59.94 Hz output.
- Similarly the AFC circuit can easily adjust the line frequency to a slightly different value while receiving colour transmission.

- As explained earlier the colour sub-carrier frequency must be an odd multiple of half the line frequency to suppress dot pattern interference. Therefore f_{sc} is fixed at $(2n + 1) f_h / 2$, i.e., $455 \times 15734.26/2 = 3.579545$ MHz.
- To obtain this exact colour sub-carrier frequency, a crystal controlled oscillator is provided. Encoding of Colour Picture Information Figure illustrates the encoding process of colour signals at the NTSC transmitter.
- A suitable matrix is used to get both I and Q signals directly from the three camera outputs. Since $I = 0.60R - 0.28G - 0.32B$, the green and blue camera outputs are inverted before feeding them to the appropriate matrix. Similarly for $Q = 0.21R - 0.52G + 0.31B$, an inverter is placed at the output of green camera before mixing it with the other two camera outputs. Balanced modulators.
- The subcarrier to the I modulator is phase shifted 57° clockwise with respect to the colour burst. The carrier is shifted by another 90° before applying it to the Q modulator. Thus relative phase shift of 90° between the two subcarriers is maintained for quadrature amplitude modulation.
- It is the characteristic of a balanced modulator that while it suppresses the carrier and provides frequency translation, both the amplitude and phase of its output are directly related to the instantaneous amplitude and phase of the modulating signal.
- Thus, with the subcarrier phase angles shifted to the locations of I and Q, the outputs from both the modulators retain full identity of the modulating colour difference signals. The sideband restricted output from the I modulator combines with the output of Q modulator to form the chrominance signal. It is then combined with the composite Y signal and colour burst in an adder to form composite chrominance signal. The output from the adder feeds into the main transmitter and modulates the channel picture carrier frequency. Note that colour subcarrier has the same frequency (3.579545 MHz) for all the stations whereas the assigned picture carrier frequency is different for each channel. A simplified block diagram of the NTSC colour receiver is shown in Fig.. The signal from the selected channel is processed in the usual way by the tuner, IF and video detector stages. The sound signal is separately detected, demodulated and amplified before feeding it to the loudspeaker. Similarly AGC, sync separator and deflection circuits have the same form as in monochrome receivers except for the inclusion of purity, convergence and pincushion correction circuits. At the output of video detector the composite video and chrominance signals reappear in their original premodulated form. The Y signal is processed as in a monochrome receiver except that the video amplifier needs a delay line. The delay line introduces a delay of about 500 ns which is necessary to ensure time coincidence of the luminance and chroma signals because of the restricted bandwidth of the latter.

Decoding of the Chroma (C) Signal

- The block diagram of Fig. shows more details of the colour section of the receiver. The chroma signal is available along with other components of the composite signal at the output of the video preamplifier.
- It should be noted that the chrominance signal has colour information during active trace time of the picture and the burst occurs during blanking time when there is no picture. Thus, although the 'C' signal and burst are both at 3.58 MHz, they are not present at the same time.

Chrominance Bandpass Amplifier

- The purpose of the bandpass amplifier is to separate the chrominance signal from the composite video signal, amplify it and then pass it on to the synchronous demodulators. The amplifier has fixed tuning with a bandpass wide enough (2 MHz) to pass the chroma signal. The colour burst is prevented from appearing at its output by horizontal blanking pulses which disable the bandpass amplifier during the horizontal blanking intervals. The blanking pulses are generally applied to the colour killer circuit which is turn biases-off the chrominance amplifier during these periods.

Colour Demodulators

- Synchronous demodulators are used to detect the modulating signal. Such a demodulator may be thought of as a combination of phase and amplitude detectors because the output is dependent on both phase and amplitude of the chroma signal. As shown in the block diagram (Fig) each demodulator has two input signals, the chroma which is to be demodulated and a constant amplitude output from the local subcarrier oscillator. The oscillator output is coupled to the demodulators by phase-shifting networks. The I demodulator oscillator voltage has a phase of 57° with respect to the burst phase ($f_{sc} \angle 0^\circ$) and so has the correct delay to detect the I colour difference signal. Similarly the oscillator voltage to the Q demodulator is delayed by 147° ($57^\circ + 90^\circ$) for detecting the Q colour-difference signal. Thus the I and Q synchronous demodulators convert the chroma signal (a vector quantity) into its right-angle components (polar to rectangular conversion).

The Colour Matrix

- This matrix is designed to produce (R – Y), (G – Y) and (B – Y) signals from the I and Q video signals. Colour difference signal amplifiers are required to perform two functions. While amplifying the signals they also compensate for the chroma signal compression (weighting factors) that was introduced at the transmitter as a means of preventing overmodulation.
- The (R – Y) amplifier provides a relative boost of $1.14 = 1/87.7\%$ while the (B – Y) amplifier does so by a factor of $2.03 = 1/49\%$. Similarly the (G – Y) amplifier reduces its output level to become $0.7(70\%)$ in a relative sense.

- The grids and cathode of the picture tube constitute another matrix. The grids are fed positive colour difference signals and the cathode receives $-Y$ signal.
- The resultant voltages between the three grids and cathode become:

$$(R - Y) - (-Y) = R, \quad (G - Y) - (-Y) = G \quad \text{and} \quad (B - Y) - (-Y) = B$$

and so correspond to the original red, green and blue signals generated by the colour camera at the transmitting end.

Burst Separator

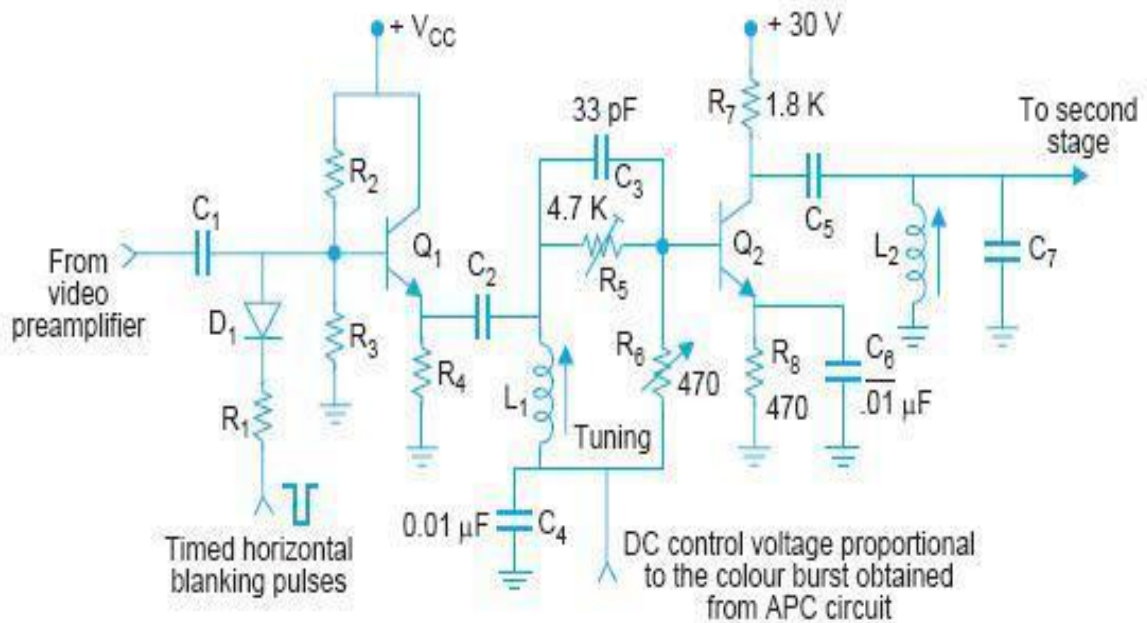
- The burst separator circuit has the function of extracting 8 to 11 cycles of reference colour burst which are transmitted on the back porch of every horizontal sync pulse.
- The circuit is tuned to the subcarrier frequency and is keyed 'on' during the flyback time by pulses derived from the horizontal output stage.
- The burst output is fed to the colour phase discriminator circuit also known as automatic frequency and phase control (AFPC) circuit.

Colour Subcarrier Oscillator

- Its function is to generate a carrier wave output at 3.579545 MHz and feed it to the demodulators. The subcarrier frequency is maintained at its correct value and phase by the AFPC circuit.
- Thus, in a way the AFPC circuit holds the hue of reproduced colours at their correct values.

Colour Killer Circuit

- As the name suggests this circuit becomes 'on' and disables the chroma bandpass amplifier during monochrome reception.
- Thus it prevents any spurious signals which happen to fall within the bandpass of the chroma amplifier from getting through the demodulators and causing coloured interference on the screen.
- This colour noise is called 'confetti' and looks like snow but with large spots in colour. The receiver thus automatically recognizes a colour or monochrome signal by the presence or absence of the colour sync burst.
- This voltage is processed in the AFPC circuit to provide a dc bias that cuts off the colour killer circuit. Thus when the colour killer circuit is off the chroma bandpass amplifier is 'on' for colour information.
- In some receiver designs the colour demodulators are disabled instead of the chroma bandpass amplifier during monochrome reception.



Colour burst blanking circuit and 1st stage of the chroma bandpass amplifier.

Manual Colour Controls

- The two additional operating controls necessary in the NTSC colour receivers are colour (saturation) level control and tint (hue) control.
- These are provided on the front panel of the colour receiver. The colour control changes the gain of the chrominance bandpass amplifier and thus controls the intensity or amount of colour in the picture.
- The tint control varies phase of the 3.58 MHz oscillator with respect to the colour sync burst. This circuit can be either in the oscillator control or AFPC circuit.

LIMITATIONS OF THE NTSC SYSTEM

- The NTSC system is sensitive to transmission path differences which introduce phase errors that results in colour changes in the picture.
- At the transmitter, phase changes in the chroma signal take place when changeover between programmes of local and television network systems takes place and when video tape recorders are switched on.
- The chroma phase angle is also effected by the level of the signal while passing through various circuits. In addition crosstalk between demodulator outputs at the receiver causes colour distortion.
- All this requires the use of an automatic tint control (ATC) circuit with provision of a manually operated tint control.

4.2. SECAM SYSTEM

- The SECAM system was developed in France. The fundamental difference between the SECAM system on the one hand and the NTSC and PAL systems on the other is that the latter transmit and receive two chrominance signals simultaneously while the SECAM system is “sequential a memoire”, i.e., only one of the two colour difference signals is transmitted at a time.
- The subcarrier is frequency modulated by the colour difference signals before transmission. The magnitude of frequency deviation represents saturation of the colour and rate of deviation its fineness.
- If the red difference signal is transmitted on one line then the blue difference signal is transmitted on the following line. This sequence is repeated for the remaining lines of the raster. Because of the odd number of lines per picture, if nth line carries (R – Y) signal during one picture, it will carry (B – Y) signal during scanning of the following picture.
- At the receiver an ultrasonic delay line of 64 μ s is used as a one line memory device to produce decoded output of both the colour difference signals simultaneously.
- The modulated signals are routed to their correct demodulators by an electronic switch operating at the rate of line frequency. The switch is driven by a bistable multivibrator triggered from the receiver’s horizontal deflection circuitry.
- The determination of proper sequence of colour lines in each field is accomplished identification (Ident) pulses which are generated and transmitted during vertical blanking intervals.

SECAM III

- During the course of development the SECAM system has passed through several stages and the commonly used system is known as SECAM III. It is a 625 line 50 field system with a channel bandwidth of 8 MHz.
- The sound carrier is + 5.5 MHz relative to the picture carrier. The nominal colour subcarrier frequency is 4.4375 MHz. As explained later, actually two subcarrier frequencies are used.
- The Y signal is obtained from the camera outputs in the same way as in the NTSC and PAL systems.
- However, different weighting factors are used and the weighted colour difference signals are termed D R and D B where $|D R| = 1.9 (R - Y)$ and $|D B| = 1.5 (B - Y)$.

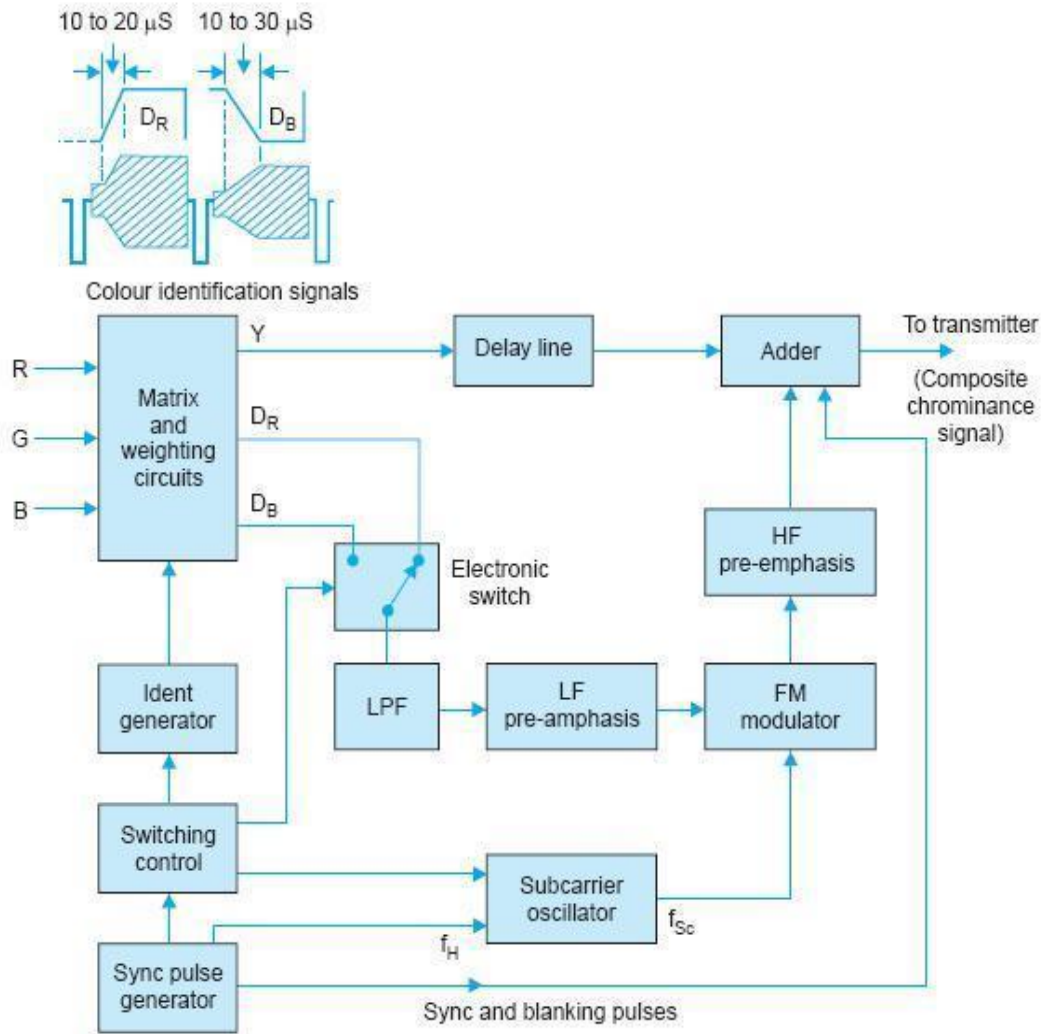


Figure. Functional diagram of a SECAM III Coder.

Modulation of the Subcarrier

- The use of FM for the subcarrier means that phase distortion in the transmission path will not change the hue of picture areas.
- Limiters are used in the receiver to remove amplitude variations in the subcarrier. The location of subcarrier, 4.4375 MHz away from the picture carrier reduces interference and improves resolution.

- In order to keep the most common large deviations away from the upper end of the video band, a positive frequency deviation of the subcarrier is allowed for a negative value of $(R - Y)$.
- Similarly for the blue difference signals a positive deviation of the subcarrier frequency indicates a positive $(B - Y)$ value. Therefore, the weighted colour signals are: $D R = -1.9(R - Y)$ and $D B = 1.5(B - Y)$.
- The minus sign for $D R$ indicates that negative values of $(R - Y)$ are required to give rise to positive frequency deviations when the subcarrier is modulated.
- In order to suppress the visibility of a dot pattern on monochrome reception, two different subcarriers are used. For the red difference signal it is $282 f H = 4.40625 \text{ MHz}$ and for the blue difference signal it is $272 f H = 4.250 \text{ MHz}$.

Pre-emphasis

- The colour difference signals are bandwidth limited to 1.5 MHz. As is usual with frequency modulated signals the SECAM chrominance signals are pre-emphasised before they are transmitted.
- On modulation the subcarrier is allowed a linear deviation = $280 D R \text{ KHz}$ for the red difference signals and $230 D B \text{ KHz}$ for the blue difference signals. The maximum deviation allowed is 500 KHz in one direction and 350 KHz in the other direction for each signal although the limits are in opposite directions for the two chrominance signals. After modulating the carrier with the pre-emphasised and weighted colour difference signals ($D R$ and $D B$), another form of pre-emphasis is carried out on the signals.
- This takes the form of increasing the amplitude of the subcarrier as its deviation increases. Such a pre-emphasis is called high-frequency pre-emphasis. It further improves signal to noise ratio and interference is very much reduced.
- Line Identification Signal The switching of $D R$ and $D B$ signals line-by-line takes place during the line sync pulse period.
- The sequence of switching continues without interruption from one field to the next and is maintained through the field blanking interval. However, it is necessary for the receiver to be able to deduce as to which line is being transmitted.
- Such an identification of the proper of colour lines in each field is accomplished by identification pulses that are generated during vertical blanking periods. The signal consists of a sawtooth modulated subcarrier (see Fig.) which is positive going for a red colour-difference signal and negative going for the blue colour-difference signal.
- At the receiver the Ident pulses generate positive and negative control signals for regulating the instant and sequence of switching.

SECAM Coder

- Figure is a simplified functional diagram of a SECAM III coder. The colour camera signals are fed into a matrix where they are combined to form the luminance ($Y = 0.3R + 0.59G + 0.11B$) and colour-difference signals.

- The SECAM weighting and sign factors are applied to the colour-difference signals so that the same subcarrier modulator can be used for both the chrominance (D R and D B) signals. The Ident signal is also added in the same matrix.
- An electronic switch which changes its mode during every line blanking interval directs D R and D B signals to the frequency modulator in a sequential manner, i.e., when D R is being transmitted on the line, then D B is not used and vice versa. Sync Pulse Generation and Control The line frequency pulses from the sync pulse generator are passed through selective filters which pick out the 272nd and 282nd harmonics of f_H .
- These harmonics are amplified and used as the two subcarrier references. The sync pulse generator also synchronizes the switching control unit which in turn supplies operating pulses to the electronic switch for choosing between D R and D B signals.
- The switching control also operates the circuit which produces modulated waveforms of the Ident signal. These are added to the chrominance signals during field blanking period and before they are processed for modulation.
- The output from the electronic switch passes through a low-pass filter which limits the bandwidth to 1.5 MHz. The bandwidth limited signals are pre-emphasized and then used to frequency modulate the subcarrier.
- The modulator output passes through a high frequency pre-emphasis filter having a bell-shaped response before being added to the Y signal.
- The sync and blanking pulses are also fed to the same adder. The adder output yields composite chrominance signal which is passed on to the main transmitter.

SECAM Decoder

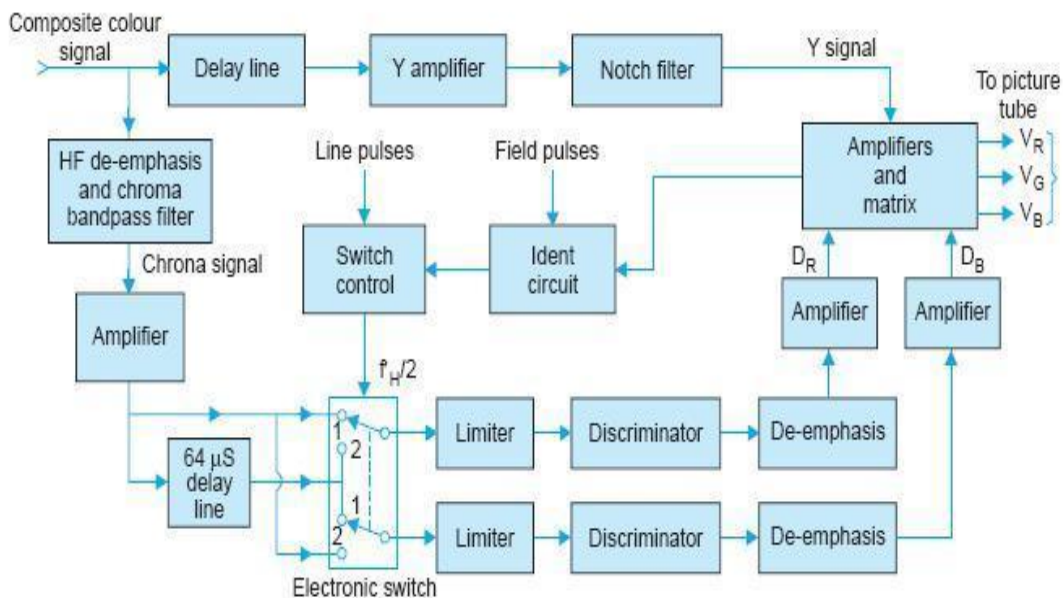


Figure. Functional diagram of a SECAM III decoder.

- SECAM receivers are similar in most respects to the NTSC and PAL colour receivers and employ the same type of colour picture tubes. The functional diagram of a SECAM III decoder is shown in Fig.
- The chroma signal is first filtered from the composite colour signal. The bandpass filter, besides rejecting unwanted low frequency luminance components, has inverse characteristics to that of the bell-shaped high frequency pre-emphasis filter used in the coder.
- The output from the bandpass filter is amplified and fed to the electronic line-by-line switch via two parallel paths. The 64 μ s delay lines ensures that each transmitted signal is used twice, one on the line on which it is transmitted and a second time on the succeeding line of that field.
- The electronic switch ensures that D R signals, whether coming by the direct path or the delayed path, always go to the D R demodulator. Similarly D B signals are routed only to the D B demodulator. i.e., it is directing D R and D B signals to the wrong demodulators, the output of each demodulator during the Ident signal period becomes positive instead of negative going. A sensing circuit in the Ident module then changes the switching phase.
- The electronic switch directs the frequency modulated signals to limiters and frequency discriminators. The discriminators have a wider bandwidth than that employed for detecting commercial FM sound broadcasts.
- After demodulation the colour difference signals are de-emphasized with the same time constant as employed while pre-emphasizing. As in other receivers the matrix networks combine the colour difference signals with the Y signal to give primary colour signals R, G and B which control the three electronic beams of the picture tube.
- It may be noted that a SECAM receiver requires only two controls—brightness and contrast, both for monochrome and colour reception. The saturation and hue controls are not needed because the system is immune to these distortions.
- This is so because the colour signals are constant amplitude, frequency modulated signals and the frequency deviations which carry colour information are not affected during transmission.

MERITS AND DEMERITS OF SECAM SYSTEMS

- Several advantages accrue because of frequency modulation of the subcarrier and transmission of one line signal at a time. Because of FM, SECAM receivers are immune to phase distortion.
- Since both the chrominance signals are not present at the same time, there is no possibility of cross-talk between the colour difference signals. There is no need for the use of Q.A.M. at the transmitter and synchronous detectors at the receiver.
- The subcarrier enjoys all the advantages of FM. The receiver does not need ATC and ACC circuits. A separate manual saturation control and a hue control are not necessary. The contrast control also serves as the saturation control.

- All this makes the SECAM receiver simple and cheaper as compared to NTSC and PAL receivers. It may be argued that the vertical resolution of the SECAM system is inferior since one line signal combines with that of the previous to produce colours.
- However, subjective tests do not bring out this deficiency since our visual perception for colours is rather poor. In addition, while SECAM is a relatively easy signal to record there is one serious drawback in this system.
- Here luminance is represented by the amplitude of a voltage but hue and saturation are represented by the deviation of the sub-carrier. When a composite signal involving luminance and chrominance is faded out in studio operation it is the luminance signal that is readily attenuated and not the chrominance.
- This makes the colour more saturated during fade to black. Thus a pink colour will change to red during fade-out. This is not the case in NTSC or PAL systems. Mixing and lap dissolve presents similar problems.
- In conclusion it may be said that all television systems are compromises since changing one parameter may improve one aspect of performance but degrade another, for example increasing bandwidth improves resolution of the picture but also increases noise.
- In fact when all factors are taken into account it is difficult to justify the absolute superiority of one system over the other. In many cases political and economic factors have been the apparent considerations in adopting a particular monochrome and the compatible colour system.
- It can therefore be safely concluded that the three colour systems will co-exist. Possibly some consensus on international exchange will be reached in due course of time.

4.3. PAL COLOUR TELEVISION SYSTEM

- The PAL system which is a variant of the NTSC system, was developed at the Telefunken Laboratories in the Federal Republic of Germany. In this system, the phase error susceptibility of the NTSC system has been largely eliminated.
- The main features of the PAL system are: (i) The weighted (B – Y) and (R – Y) signals are modulated without being given a phase shift of 33° as is done in the NTSC system. (ii) On modulation both the colour difference quadrature signals are allowed the same bandwidth of about 1.3 MHz.
- This results in better colour reproduction. However, the chroma signal is of vestigial sideband type. The upper sideband attenuation slope starts at 0.57 MHz, i.e., ($5 - 4.43 = 0.57$ MHz) but the lower sideband extends to 1.3 MHz before attenuation begins. (iii)
- The colour subcarrier frequency is chosen to be 4.43361875 MHz. It is an odd multiple of one-quarter of the line frequency instead of the half-line offset as used in the NTSC system. This results in somewhat better cancellation of the dot pattern interference. (iv)
- The weighted (B – Y) and (R – Y) signals are modulated with the subcarrier in the same way as in the NTSC system (QAM) but with the difference, that phase of the subcarrier to one of the modulators (V modulator) is reversed from $+ 90^\circ$ to $- 90^\circ$ at the line frequency. In fact the system derives its name, phase alteration by line (i.e., PAL), from this mode of modulation.

- This technique of modulation cancels hue errors which result from unequal phase shifts in the transmitted signal.
- As explained earlier the $(B - Y)$ and $(R - Y)$ subcarrier components in the chrominance signal are scaled down by multiplying them with the 'weighting' factors. For brevity the weighted signals are then referred to as U and V components of the chrominance signal where $U = 0.493 (B - Y)$ and $V = 0.877 (R - Y)$.
- Thus as illustrated in Fig. C PAL = $U \sin \omega t \pm V \cos \omega t = \sqrt{U^2 + V^2} \sin(\omega t \pm \theta)$ where $\tan \theta = V/U$. The switching action naturally occurs during the line blanking interval to avoid any visible disturbance.

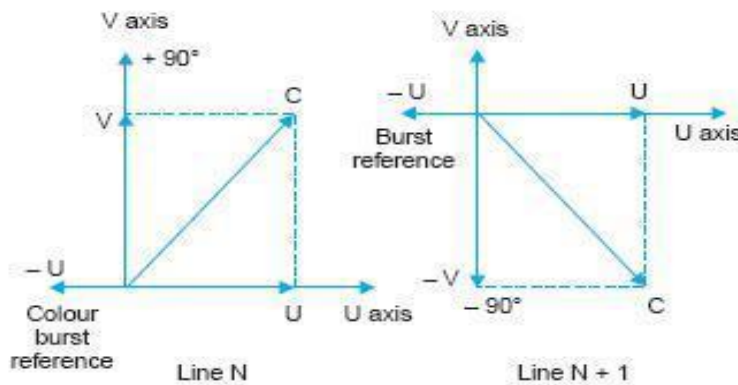


Figure. Sequence of modulation i.e., phase change of 'V' signal on alternate lines in the PAL colour system.

The PAL Burst

- If the PAL signal were applied to an NTSC type decoder, the $(B - Y)$ output would be U as required but the $(R - Y)$ output would alternate as $+V$ and $-V$ from line to line. Therefore, the V demodulator must be switched at half the horizontal (line) frequency rate to give '+V' only on all successive lines.
- Clearly the PAL receiver must be told how to achieve the correct switching mode. A colour burst (10 cycles at 4.43 MHz) is sent out at the start of each line. Its function is to synchronize the receiver colour oscillator for reinsertion of the correct carrier into the U and V demodulators.
- While in NTSC the burst has the phase of $-(B - Y)$ and a peak-to-peak amplitude equal to that of the sync, in PAL the burst is made up to two components $-(B - Y)$ component as in NTSC but with only $1/2$ of the NTSC amplitude and an $(R - Y)$ component which like all the $(R - Y)$ information is reversed in phase from line to line.

- This $\pm (R - Y)$ burst signal has an amplitude equal to that of the $-(B - Y)$ burst signal, so that the resultant burst amplitude is the same as in NTSC.
- Note that the burst phase actually swings $\pm 45^\circ$ see about the $-(B - Y)$ axis from line to line. However the sign of $(R - Y)$ burst component indicates the same sign as that of the $(R - Y)$ picture signal.
- Thus the necessary switching mode information is always available. Since the colour burst shifts on alternate lines by $\pm 45^\circ$ about the zero reference phase it is often called the swinging burst.

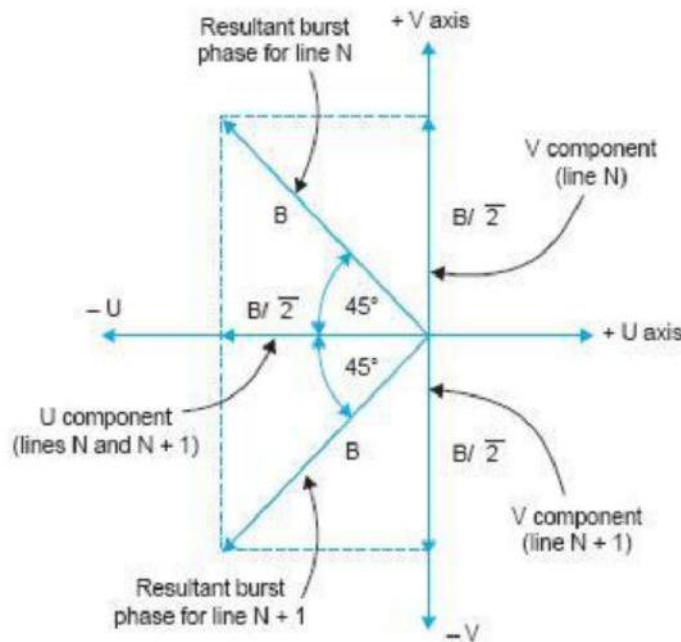


Illustration of PAL colour burst swing.

4.4. CANCELLATION OF PHASE ERRORS

- As already pointed out the chroma signal is susceptible to phase shift errors both at the transmitter and in the transmission path.
- This effect is sometimes called 'differential phase error' and its presence results in changes of hue in the reproduced picture. This actually results from a phase shift of the colour sideband frequencies with respect to colour burst phase.
- The PAL system has a built-in protection against such errors provided the picture content remains almost the same from line to line.

- This is illustrated by phasor diagrams. Figure (a) shows phasors representing particular U and V chroma amplitudes for two consecutive lines of a field. Since there is no phase error the resultant phasor (R) has the same amplitude on both the lines.
- Detection along the U axis in one synchronous detector and along the V axis in another, accompanied by sign switching in the latter case yields the required U and V colour signals. Thus correct hues are produced in the picture.
- Now suppose that during transmission the phasor R suffers a phase shift by an angle θ . As shown in Fig (b) (i), the corresponding changes in the magnitude of U and V would mean a permanent hue error in the NTSC system.
- However, in the PAL system ((b) (ii)) the resultant phasor at the demodulator will swing between R 1 and R 2 as illustrated in Fig. (b) (iii). It is now obvious that the phase error would cancel out if the two lines are displayed at the same time. In actual practice however, the lines are scanned in sequence and not simultaneously.
- The colours produced by two successive lines, therefore, will be slightly on either side of the actual hue.
- Since the lines are scanned at a very fast rate the eye due to persistence of vision will perceive a colour that lies between the two produced by R 1 and R 2 respectively.
- Thus the colour seen would more or less be the actual colour. It is here, where the PAL system claims superiority over the NTSC system.

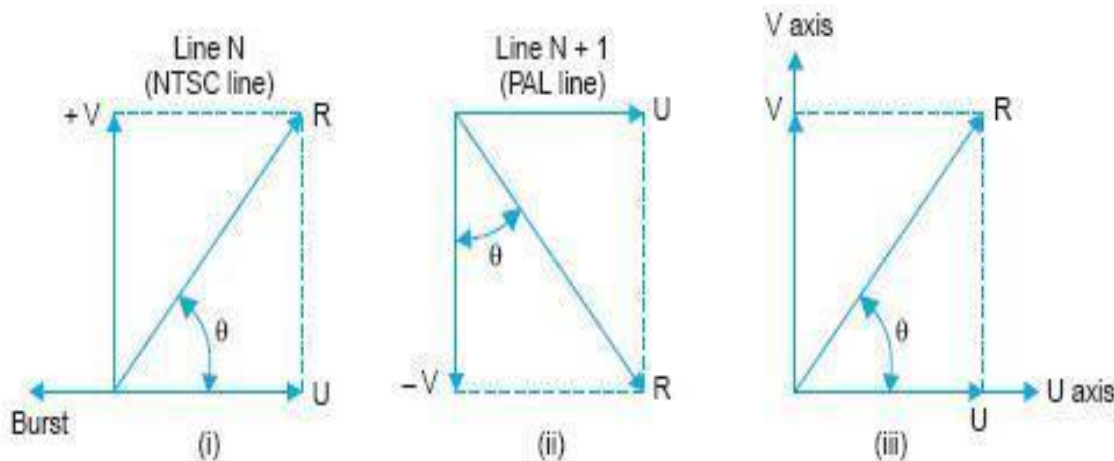


Figure. No phase error—(i) and (ii) show subcarrier phasors on two consecutive lines while (iii) depicts location of resultant phasor at the demodulator. Note that the phasor ($U \pm jV$) chosen for this illustration represents a near magenta shade.

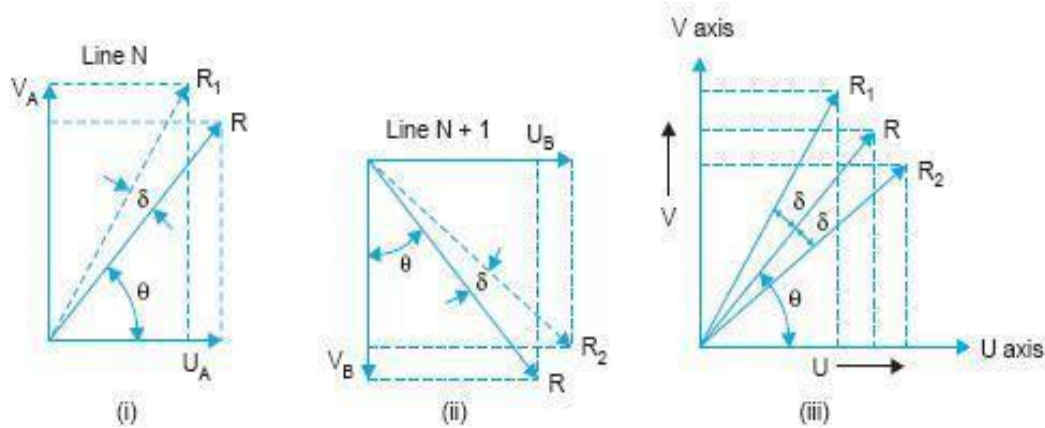


Figure. Cancellation of phase error. (i) and (ii) show subcarrier phasors on two consecutive lines when a phase shift occurs. (iii) location of resultant phasor at the demodulator.

4.5. PAL-D COLOUR SYSTEM

- The use of eye as the averaging mechanism for the correct hue is the basis of 'simple PAL' colour system. However, beyond a certain limit the eye does see the effect of colour changes on alternate lines, and so the system needs modification.
- Remarkable improvement occurs in the system if a delay line is employed to do the averaging first and then present the colour to the eye. This is known as PAL-D or Delay Line PAL method and is most commonly used in PAL colour receivers.
- As an illustration of the PAL-D averaging technique, Fig shows the basic circuit used for separating individual U and V products from the chrominance signal. For convenience, both U and V have been assumed to be positive, that is, they correspond to some shade of magenta (purple).
- Thus for the first line when the V modulator product is at 90° to the + U axis, the phasor can be expressed as $(U + jV)$. This is called the NTSC line. But on the alternate (next) line when the V phase is switched to -90° , the phasor becomes $(U - jV)$ and the corresponding line is then called the PAL line.
- As shown in Fig. a delay line and, adding and subtracting circuits are interposed between the chrominance amplifier and demodulators.
- The object of the delay line is to delay the chrominance signal by almost exactly one line period of $64 \mu\text{s}$. The chrominance amplifier feeds the chrominance signal to the adder, the subtractor and the delay line.

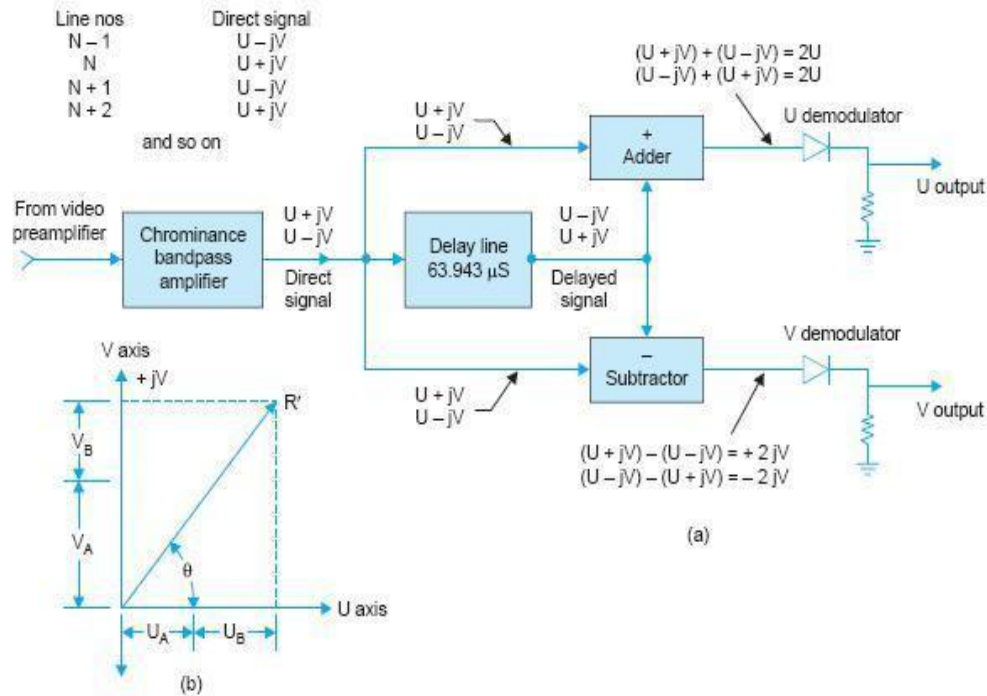


Figure. Basic principle of Pal-D demodulation. (b) Summation of consecutive line phasors in a PAL-D receiver.

- The delay line in turn feeds its output to both the adder and subtractor circuits. The adder and subtractor circuits, therefore, receive the two signals simultaneously. These may be referred to at any given time as the direct line and delay line signals.
- For the chosen hue, if the present incoming line is an NTSC line, the signal entering the delay-line and also reaching the adder and subtractor is $(U + jV)$. But then the previous line must have been the PAL line i.e., $(U - jV)$ and this signal is simultaneously available from the delay line. The result is (see Fig. 26.14 (a)) that the signal information of two picture lines, though transmitted in sequence, are presented to the adder and subtractor circuits simultaneously.
- The adder yields a signal consisting of U information only but with twice the amplitude ($2U$). Similarly, the subtraction circuit produces a signal consisting only of V information, with an amplitude twice that of the 'V' modulation product.
- To permit precise addition and subtraction of direct and delayed line signals, the delay line must introduce a delay which is equivalent to the duration of an exact number of half cycles of the chrominance signal.
- This requirement would not be met if the line introduced a delay of exactly $64 \mu s$. At a frequency of 4.43361875 MHz the number of cycles which take place in $64 \mu s$ are $4.43361875 \times 10^6 \times 64 \times 10^{-6} = 283.7485998 \text{ Hz}$, 283.75 Hz .
- A delay line which introduces a delay equal to the duration of 283.5 subcarrier cycles is therefore suitable. This is equal to a time delay of $63.943 \mu s$ ($1/f_{sc} \times 283.5$). The

addition and subtraction of consecutive line phasors can also be illustrated vectorially by phasor diagrams.

- Figure is such a phasor diagram pertaining to the phase error illustration of Fig. The U and V signals thus obtained are fed to their respective synchronous demodulators for recovery of the colour difference signals. Choice of Colour Subcarrier Frequency If the sub-carrier frequency is chosen on the half-line offset basis as is done in the NTSC system, an annoying vertical line-up of dots occurs on certain hues. This is due to phase reversal of the sub-carrier at line frequency.
- To overcome this difficulty, a quarter-line offset is given instead and f_{sc} is made an odd multiple of one quarter of the line frequency. For optimum results this is slightly modified by adding 25 Hz to it, to provide a phase reversal on each successive field.
- Thus the actual relationship between f_{sc} , f_h and f_v can be expressed as

$$f_{sc} = f_h$$

- This on substituting the values of f_h and f_v gives $f_{sc} = 4.43361875$ MHz.
- It may be mentioned that though formation of any dot pattern on the screen must be suppressed by appropriate choice of sub-carrier frequency, it is of low visibility and appears only when colour transmission is received on a monochrome receiver. Since the chrominance signal disappears on grey or white details in a picture, the interference appears only in coloured areas of the scene. All colours appear as shades of grey on a monochrome receiver and thus the dot effect is visible only in those coloured parts of the picture which are reproduced in lighter shades of grey.

Colour Subcarrier Generation

- The colour subcarrier frequency of 4.43361875 MHz is generated with a crystal controlled oscillator. In order to accomplish minimum raster disturbance through the colour subcarrier it is necessary to maintain correct frequency relationships between the scanning frequencies and the subcarrier frequency.
- It is therefore usual to count down from the subcarrier frequency to twice the line frequency ($2f_h$) pulses which are normally fed to monochrome sync pulse generators. There are several ways in which frequency division can be accomplished. In the early days of colour television it was necessary to choose frequencies which had low-order factors so that division could take place in easy stages, but such constraints are no longer necessary.
- The PAL subcarrier frequency is first generated directly. Then the 25 Hz output obtained from halving the field frequency is subtracted from the subcarrier frequency.
- The frequency thus obtained is first divided by 5 and then by 227. Such a large division is practicable by using a chain of binary counters and feeding back certain of the counted down pulses to earlier points of the chain that the count down is changed from a division of 28 to a division of the pal coder
- The gamma corrected R, G and B signals are matrixed to form the Y and the weighted colour difference signals. The bandwidths of both (B – Y) and (R – Y) video signals are

restricted to about 1.3 MHz by appropriate low-pass filters. In this process these signals suffer a small delay relative to the Y signal. In order to compensate for this delay, a delay line is inserted in the path of Y signal.

- The weighted colour difference video signals from the filters are fed to corresponding balanced modulators. The sinusoidal sub-carrier is fed directly to the U modulator but passes through a $\pm 90^\circ$ phase switching circuit on alternate lines before entering the V modulator.

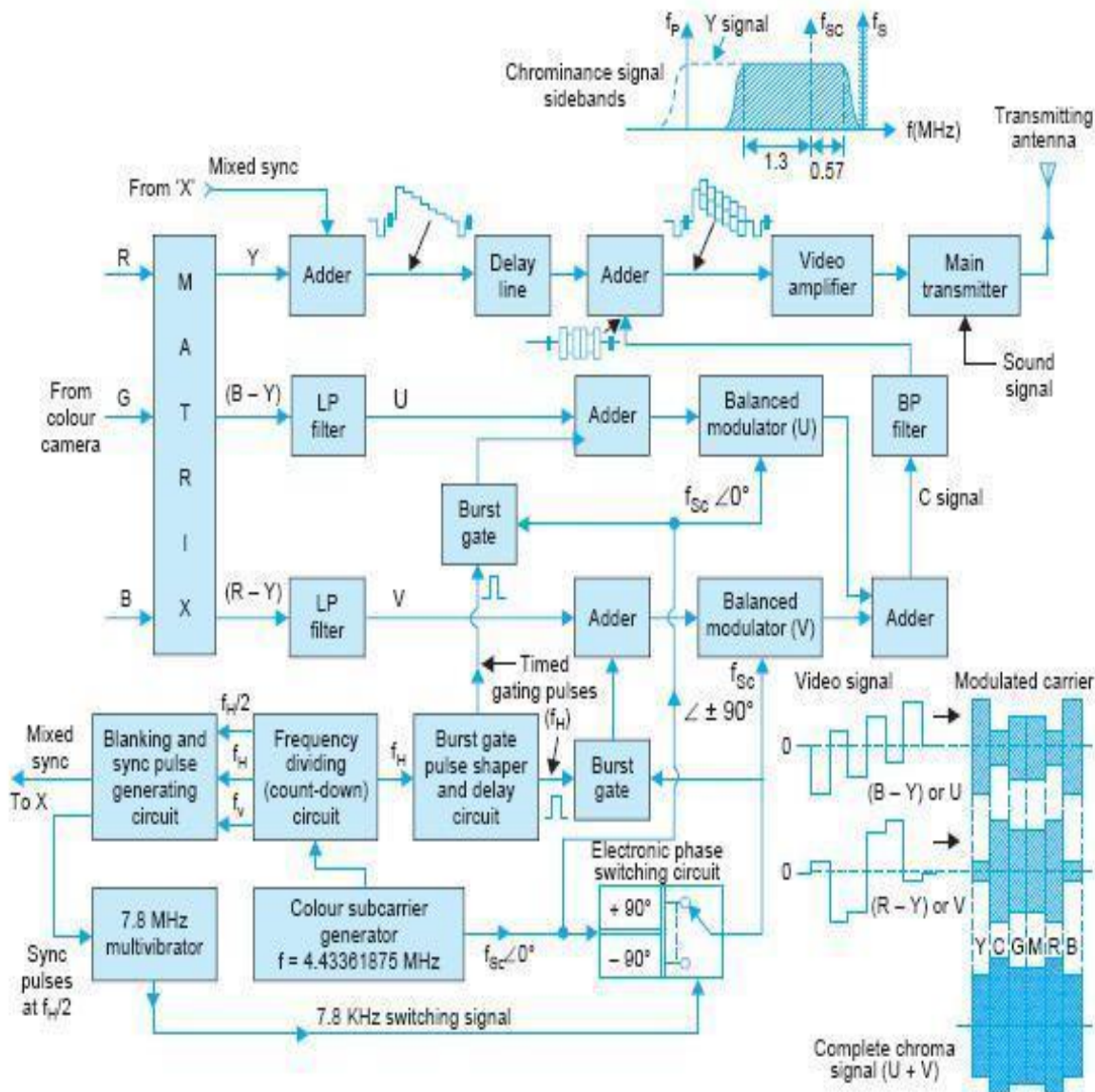


Figure. Basic organization of the PAL coder.

- Since one switching cycle takes two lines, the squarewave switching signal from the multivibrator to the electronic phase switch is of half-line frequency i.e., approximately 7.8 KHz.
- The double sideband suppressed carrier signals from the modulators are added to yield the quadrature amplitude modulated (Q.A.M.) chrominance (C) signal. This passes through a filter which removes harmonics of the subcarrier frequency and restricts the upper and lower sidebands to appropriate values.
- The output of the filter feeds into an adder circuit where it is combined with the luminance and sync signals to form a composite colour video signal. The bandwidth and location of the composite colour signals (U and V) is shown along with the Y signal in Fig Notice that the colour burst signal is also fed to the modulators along with the U and V signals through the adders.
- The burst signals are obtained from the circuits that feed the colour subcarrier signal to the two modulators. However, before feeding the burst signals to the U and V adders these are passed through separate burst gates.
- Each burst gate is controlled by delayed pulses at f_H rate obtained from the frequency dividing circuit. The gating pulses appear during the back porch period.
- Thus, during these intervals the (B – Y) i.e., U modulator yields a subcarrier burst along – U while the (R – Y) i.e., V modulator gives a burst of the same amplitude but having a phase of $\pm 90^\circ$ on alternate lines relative to the – U phasor. At the outputs of the two modulators, the two burst components combine in the adder to yield an output which is the vector sum of the two burst inputs.
- This is a subcarrier sinewave (10 cycles) at $+45^\circ$ on one line and -45° on the next line with reference to – U phasor. The colourplexed composite signal thus formed is fed to the main transmitter to modulate the station channel picture carrier in the normal way.
- The sound signal after being frequency modulated with the channel sound carrier frequency also forms part of the RF signal that is finally radiated through the transmitter antenna system.

4.7. PAL-D COLOUR RECEIVER

- Various designs of PAL decoder have been developed. The one shown in the colour receiver block diagram of Fig. is a commonly used arrangement.
- It will be noticed that the general pattern of signal flow is very close to that of the NTSC receiver. Necessary details of various sections of the receiver are discussed.

1. Tuner

- It is necessary to maintain local oscillator frequency at the correct value to obtain exact colour burst frequency for proper reproduction of different colours in the picture.
- Therefore, colour receiver tuners employ an additional circuit known as automatic frequency tuning (AFT). This circuit actually controls the local oscillator frequency to obtain a picture IF of exactly 38.9 MHz at the converter output.

- The discriminator in the AFT circuit measure the intermediate frequency and develops a dc control voltage proportional to the frequency deviations if any.

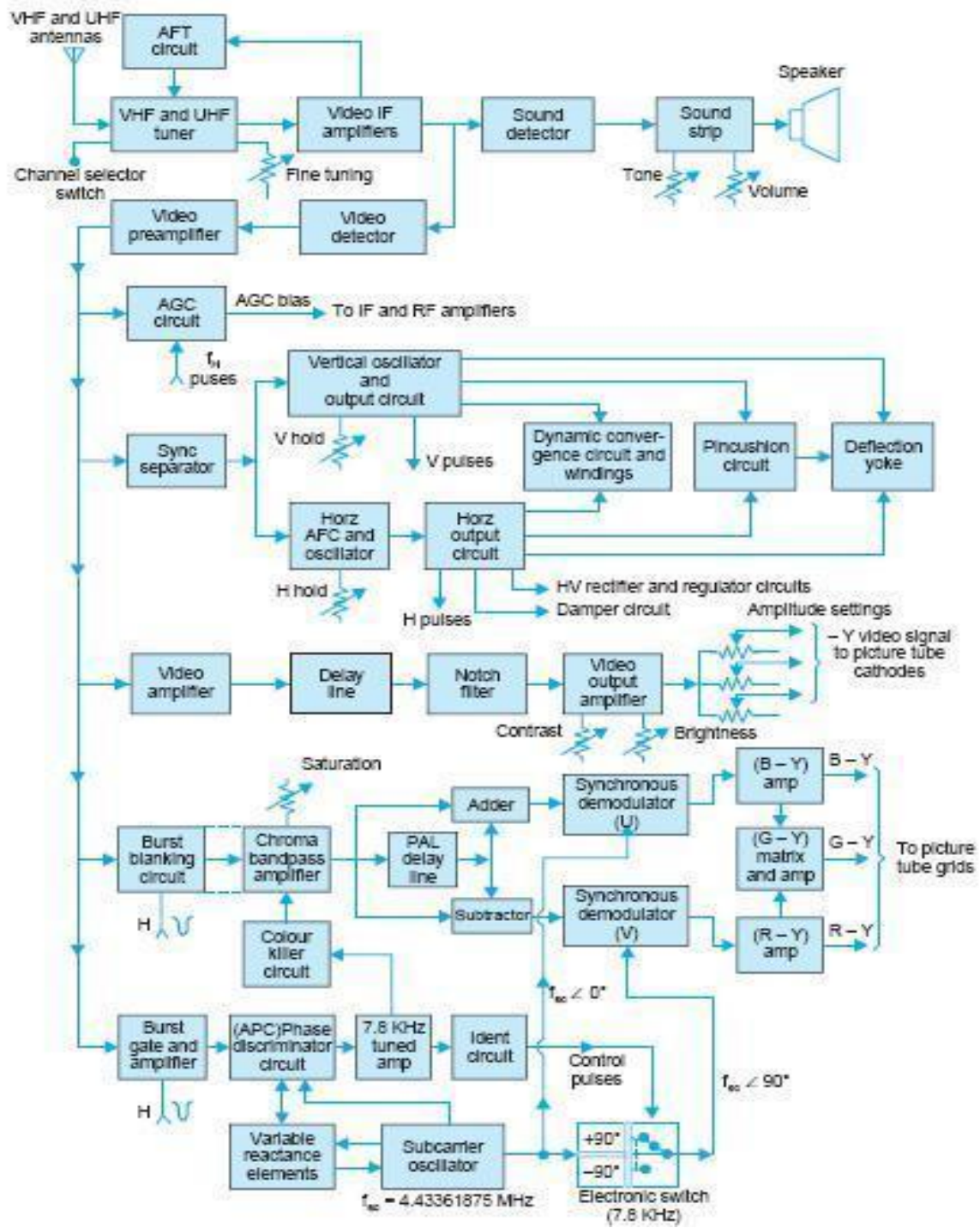


Figure. Block diagram of a PAL-D colour receiver.

- This error voltage is applied to the reactance section of the local oscillator to maintain its frequency at the correct value. More details of AFT are given in the next chapter along with other special circuits.
2. Sound Strip.
 - The frequency modulated sound IF signal is processed in the usual way to obtain audio output. The volume and tone controls are associated with the audio amplifier, the output of which feeds into the loudspeaker.
 - Thus the sound strip of a colour receiver is exactly the same as in a black and white receiver.
 3. AGC, Sync-separator and Deflection Circuits
 - The AGC and sync-separator circuits function in the same way as in a monochrome receiver. However, the deflection circuits, besides developing normal horizontal and field scanning currents also provide necessary wave-forms for dynamic convergence and pincushion correction.
 - In addition, pulses from the horizontal output transformer are fed to several circuits in the colour section of the receiver.
 4. Luminance Channel
 - The video amplifier in the luminance channel is dc coupled and has the same bandwidth as in the monochrome receiver. It is followed by a delay line to compensate for the additional delay the colour signal suffers because of limited bandpass of the chrominance. This ensures time coincidence of the luminance and chrominance signals. The channel also includes a notch filter which attenuates the subcarrier by about 10 db. This helps to suppress the appearance of any dot structure on the screen along with the colour picture. The inverted composite video signal available at the output of luminance channel is fed to the junction of three cathodes of the picture tube. This part of the circuit also includes drive adjustment necessary for setting of the black level and obtaining correct reproduction of colours.
 5. Colour Signal Processing
 - The signal available at the output of video detector is given some amplification (video preamplifier) before feeding it to the various sections. All modern receivers use ICs for processing the colour signal. However, for a better understanding, the operation of each stage is described with the help of discrete component circuitry.
 - (a) Chrominance bandpass amplifier.
 - As noted previously the chroma bandpass amplifier selects the chrominance signal and rejects other unwanted components of the composite signal.

- The burst blanking, colour level control and colour killer switch also form part of this multistage amplifier. (i) Burst Blanking.
- The output from the video preamplifier is fed to the first stage of chroma bandpass amplifier through an emitter follower stage (Q 1). Negative going horizontal blanking pulses are coupled to the base of Q 1 through diode D 1 . The pulses drive Q 1 into cut-off during colour burst intervals and thus prevent it from reaching the demodulators. (ii) Bandpass Stage.
- The emitter follower output is fed to the bandpass stage through a tuned circuit consisting of L 1 and C 3 . The necessary bandwidth centered around 4.43 MHz is adjusted by R 5 and R 6 . The tuning of L 1 also incorporates necessary correction on account of vestigial sideband transmission of the chrominance signal. (iii) Automatic Colour Control (ACC). The biasing of amplifier (Q 2) in Fig. 26.17 is determined by the dc control voltage fed to it by the ACC circuit.
- The ACC circuit is similar to the AGC circuit used for automatic gain control of RF and IF stages of the receiver. It develops a dc control voltage that is proportional to the amplitude of colour burst. This voltage when fed at the input of Q 2 shifts its operating point to change the stage gain. Thus net overall chroma signal output from the bandpass amplifier tends to remain constant.

iv) Manual Colour (Saturation) Control.

- As shown in Fig. the chroma signal from the first stage is applied through R 1 and R 2 to the emitter of Q 3 and cathode of D 2 , the colour control diode. The diode is forward biased by a voltage divider formed by R 3 , R 4 and R 5 the colour control potentiometer.
- When the diode is excessively forward biased (R 5 at + 30 V position) it behaves like a short circuit. Under this condition the chroma signal gets shorted via C 1 to ground and there is no input to the demodulators. As a result, a black and white picture is produced on the screen. If R 5 is so adjusted that forward bias on D 1 is almost zero, the diode would present a very high impedance to the signal.
- Under this condition all the available signal feeds into the amplifier and a large signal voltage appears at the output of the chroma bandpass amplifier. This in turn produces a picture with maximum saturation.
- At other settings of R 5 , conductance of D 1 would cause the signal current to divide between the emitter of Q 3 and C 1 resulting in intermediate levels of picture colour saturation.
- No tint or hue control is provided in PAL receivers because of the inbuilt provision for phase shift cancellation. In some receiver designs the saturation control is combined with the contrast control.

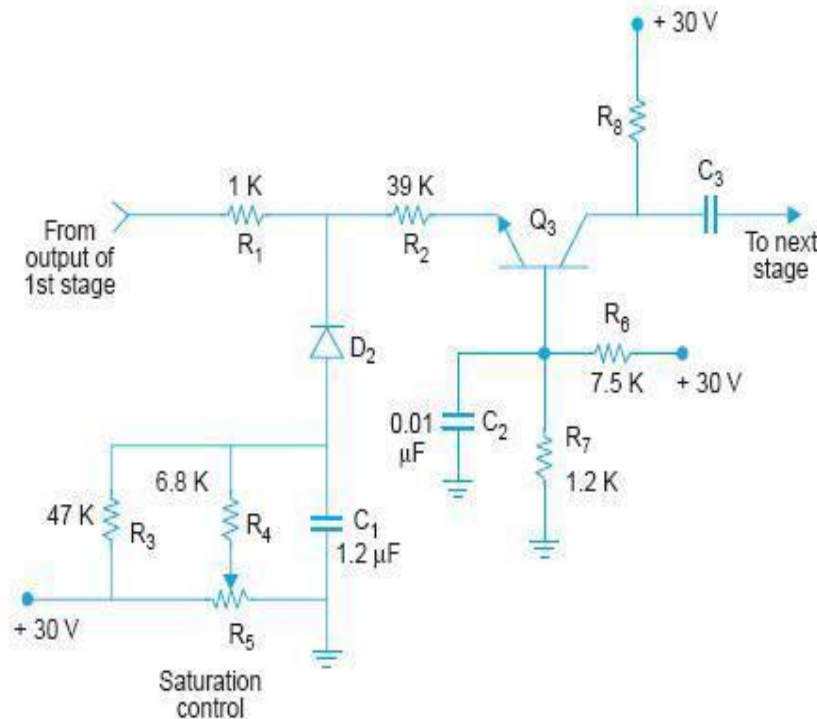


Figure. Saturation control in the chroma bandpass amplifier.

(v) Colour Killer Circuit.

- The colour killer and associated circuits are shown in Fig. The forward bias of Q 5 , the last stage of bandpass amplifier depends on the state of the colour killer circuit.
- When a colour signal is being received, the 7.8 KHz (switching rate of the (R – Y) signal) component is available at the APC (automatic phase control) circuit of the reference subcarrier oscillator. It is applied via C 1 to the base of tuned amplifier Q 6 . The amplified 7.8 KHz signal is ac coupled to Q 7 .
- Diode D 3 conducts on negative half cycles charges the capacitor C 2 with the polarity marked across it.
- The discharge current from this capacitor provides forward bias to Q 7 , the emitter follower. Such an action results in a square wave signal at the output of Q 7 .
- It is coupled back via a 680 ohm resistor to the tuned circuit in the collector of Q 6 . This provides positive feedback and thus improves the quality factor of the tuned circuit.
- The colour killer diode D 4 rectifies the square-wave output from the emitter of Q 7 . The associated RC filter circuit provides a positive dc voltage at point ‘A’ and this serves a source of forward bias to the chrominance amplifier Q 5 . Diode D 5 is switched on by

this bias and so clamps the voltage produced at 'A' by the potential divider (3.3 K and 680 ohm) across the + 15 V line.

- When a monochrome transmission is received there is no 7.8 KHz input to the colour killer diode D 4 and no positive voltage is developed at its cathode (point A). Both D 5 and the base emitter junction of Q 5 are now back biased by the - 20 V potential returned at 'A' via the 220 K resistor.
- The chrominance signal channel, therefore, remains interrupted.

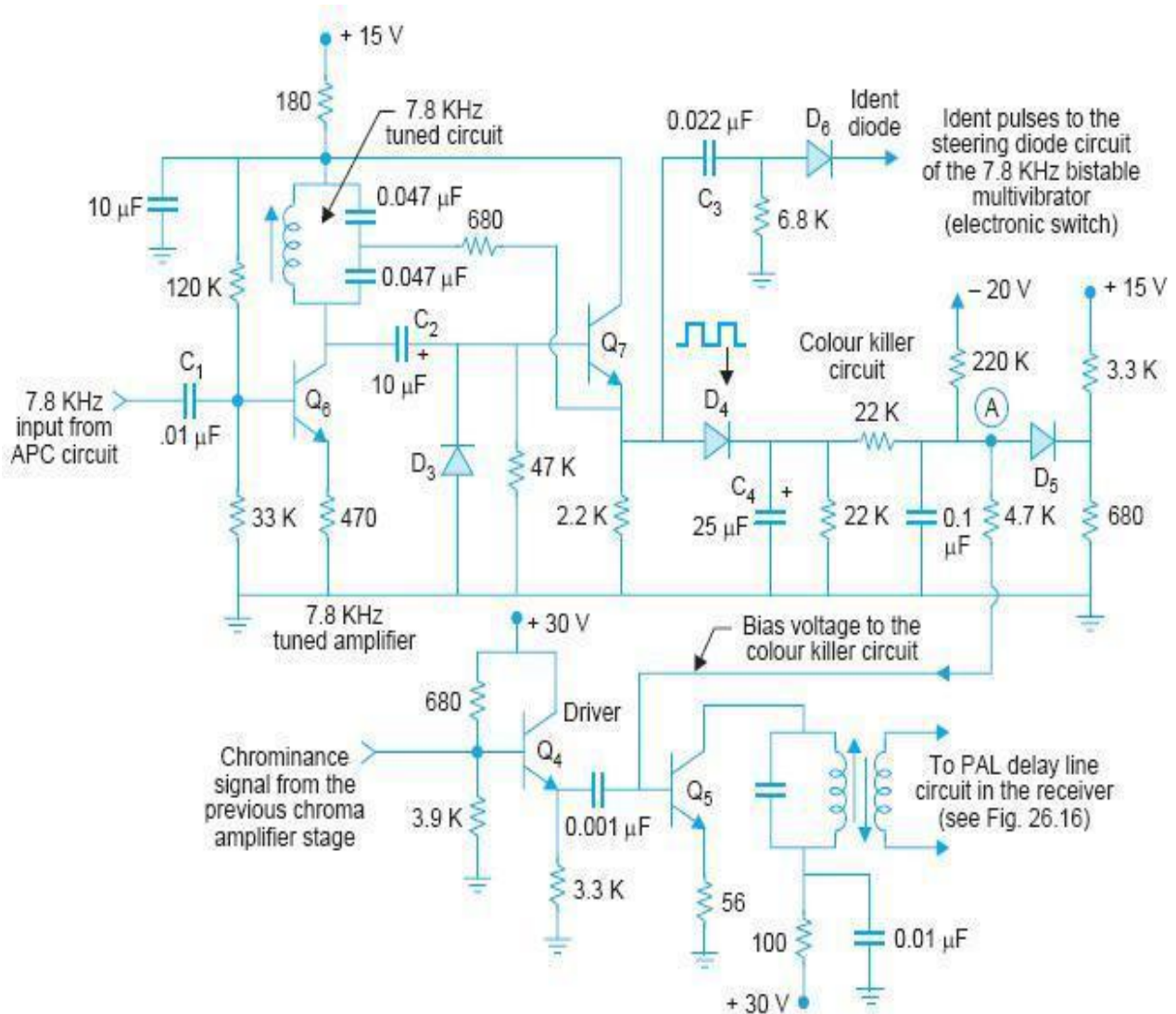


Figure. Colour killer and allied circuits.

(b) Separation of U and V modulation products.

- The addition of two picture lines radiated in sequence but presented to the adder circuit simultaneously yields a signal consisting of only U information but with an amplitude equal to twice the amplitude of the chrominance signal's U modulation product. Similarly the subtraction of the two lines produces a signal consisting of V information with an amplitude equal to twice that of the V modulation product.

Synchronous Demodulators.

- The output from the adder and subtractor consists of two independent double sideband, suppressed carrier RF signals. These are the U modulation product and the line-by-line phase inverted V modulation product. The two individual RF signals are fed to their respective demodulators.
- Each of the demodulators also receives a controlled subcarrier of correct phase to allow recovery of the colour difference signal waveforms. It may be noted that the demodulators do not have to handle Q.A.M. ($u \pm jv$) RF signals as is the case in the NTSC system.
- Therefore, it is not absolutely necessary to employ synchronous demodulators. However, synchronous demodulators are preferred in practice because they yield an accurate and constant no-colour zero voltage level above and below which (sometimes positive and sometimes negative) the colour difference signal voltage varies. (c) Colour difference amplifiers and matrixing.
- There are two approaches to driving the colour picture tube. In one scheme, the three colour difference signals are amplified and fed to the appropriate grids of the picture tube. The $-Y$ signal is fed to the junction of three cathodes for matrixing. In another approach R, G, and B video signals are obtained directly by a suitable matrix from the modulator outputs. Each colour signal is then separately amplified and applied with negative polarity ($-R, -G, -B$) to the respective cathodes.
- The grids are then returned to suitable negative dc potentials. This, i.e., R, G, B method is preferred in transistor amplifiers because less drive voltages are necessary when R, G, and B are directly fed to the picture tube.
- The use of dc amplifiers would involve difficulties, especially in maintaining a constant 'no colour' voltage level at the picture tube grids. It is usual to employ ac amplifiers and then establish a constant no-colour level by employing dc clamps. The clamping is affected during line blanking periods by pulses derived from the line time base circuitry.
- Thus the dc level is set at the beginning of each active line period. The discharge time constants of the ac coupling networks are chosen to be quite large so that the dc level does not change significantly between the beginning and end of one active line period.

6. Subcarrier Generation and Control

- The primary purpose of this section is to produce a subcarrier of correct frequency to replace the subcarrier suppressed in the two chrominance signal balanced modulators at the transmitter end encoder. N

- It not only must the generated subcarrier be of exactly the right frequency but it must also be of the same phase reference as the original subcarrier. A crystal oscillator is used in the receiver and this is forced to work at the correct frequency and phase by the action of an automatic frequency and phase control circuit.
- This is usually called the APC circuit. The APC circuit compares the burst and locally generated reference subcarrier to develop a control voltage. The burst signal is obtained through the burst gate amplifier circuit.
- The identification circuit and electronic switch for line switching the subcarrier to the V modulator also form part of the subcarrier generation circuitry. (a) Burst gate amplifier. The burst gate or burst amplifier as it is often called separates

UNIT 5 ADVANCED TELEVISION SYSTEMS

TELEVISION BROADCASTING

- Broadcasting means transmission in all directions by electromagnetic waves from the transmitting station. Broadcasting that deals mostly with entertainment and advertising is probably the most familiar use of television. Millions of television sets in use around the world attest to its extreme popularity.
- Most programmes produced live in the studio are recorded on video tape at a convenient time to be shown later. Initially television transmission was confined to the VHF band only but later a large number of channel allocations were made in the UHF band also. The distance of transmission, as explained earlier, is confined to line of the sight between the transmitting and receiving antennas.
- The useful service range is up to 120 km for VHF stations and about 60 km for UHF stations. Television broadcasting initially started with monochrome picture but around 1952 colour transmission was introduced.
- Despite its complexity and higher cost, colour television has become such a commercial success that it is fast superseding the monochrome system.

CABLE TELEVISION

- In recent year's master antenna (MATV) and community antenna (CATV) television systems have gained widespread popularity. The purpose of a MATV system is to deliver a strong signal (over 1 mV) from one or more antennas to every television receiver connected to the system.
- Typical applications of a MATV system are hotels, motels, schools, apartment buildings and so on. The CATV system is a cable system which distributes good quality television signal to a very large number of receivers throughout an entire community.
- In general, this system feeds increased TV programmes to subscribers who pay a fee for this service. A CATV system may have many more active (VHF and UHF) channels than a receiver tuner can directly select. This requires use of a special active converter in the head-end.

(a) MATV

- The block diagram of a basic MATV system is shown in Fig. One or more antennas are usually located on roof top, the number depending on a available telecasts and their direction.
- Each antenna is properly oriented so that all stations are received simultaneously. In order to allow a convenient match between the coaxial transmission line and components that make up the system, MATV systems are designed to have a 75 Ω impedance. Since most antennas have a 300 Ω impedance, a balun is used to convert the impedance to 75 ohms.

- As shown in the figure, antenna outputs feed into a 4-way hybrid. A hybrid is basically a signal combining linear mixer which provides suitable impedance matches to prevent development of standing waves.
- The standing waves, if present, result in ghosts appearing in an otherwise good TV picture. The output from the hybrid feeds into a distribution amplifier via a preamplifier. The function of these amplifiers is to raise the signal amplitude to a level which is sufficient to overcome the losses of the distribution system while providing an acceptable signal to every receiver in the system.
- The output from the distribution amplifier is fed to splitters through coaxial trunk lines. A splitter is a resistive-inductive device which provides trunk line isolation and impedance match. Coaxial distribution lines carry television signals from the output of splitters to points of delivery called subscriber tap-offs.
- The subscriber taps, as shown in Fig, can be either transformer coupled, capacitive coupled or in the form of resistive pads. They provide isolation between receivers on the same line thus preventing mutual interference. The taps look like ac outlets and are normally mounted in the wall.
- Wall taps may be obtained with 300 Ω output 75 Ω output and a dual output. The preferred method is to use a 75 Ω type with a matching transformer. The matching transformer is usually mounted at the antenna terminals of the receiver and will have a VHF output and a UHF output.
- Since improperly terminated lines will develop standing waves, the end of each 75 Ω distribution cable is terminated with a 75 Ω resistor called a terminator.

(b) CATV

- Formerly CATV systems were employed only in far-fringe areas or in valleys surrounded by mountains where reception was difficult or impossible because of low level signal conditions.
- However, CATV systems are now being used in big cities where signal-level is high but all buildings render signals weak and cause ghosts due to multipath reflections. In either case, such a system often serves an entire town or city.
- A single antenna site, which may be on top of a hill, mountain or sky-scraper is chosen for fixing antennas. Several high gain and properly oriented antennas are employed to pick up signals from different stations. In areas where several signals are coming from one direction, a single broad based antenna (log-periodic) may be used to cover those channels.
- Most cable television installations provide additional services like household, business and educational besides commercial TV and FM broadcast programmes. These include news, local sports and community programmes, burglar and fire alarms, weather reports, commercial data retrieval, meter reading, document reproduction etc.
- Educational services include computer aided instructions, centralized library services and so on. Many of the above options require extra subscription fee from the subscriber.

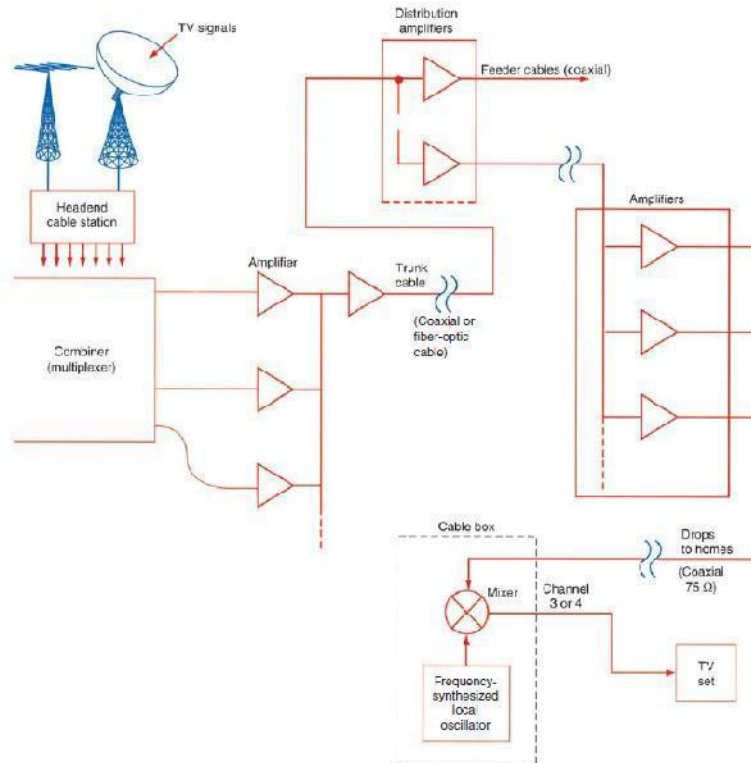


Figure. The modern cable TV system

- Since several of the above mentioned services need two-way communication between the subscriber and a central processor, the coaxial distribution network has a large number of cable pairs, usually 12 or 24.
- This enables the viewer to choose any channel or programme out of the many that are available at a given time. CATV Plan. Figure 10.2 shows the plan of a typical CATV system. The signals from various TV channels are processed in the same manner as in a MATV system. In fact, a CATV system can be combined with a MATV set-up.
- When UHF reception is provided in addition to VHF, as often is the case, the signal from each UHF channel is processed by a translator. A translator is a frequency converter which heterodynes the UHF channel frequencies down to a VHF channel.
- Translation is advantageous since a CATV system necessarily operates with lengthy coaxial cables and the transmission loss through the cable is much greater at UHF than at VHF frequencies. As in the case of MATV, various inputs including those from translators are combined in a suitable mixer.
- The set-up from the antennas to this combiner is called a head-end. Further, as shown in the figure the CATV outputs from the combiner network are fed to a number of trunk cables

through a broadband distribution amplifier. The trunk cables carry signals from the antenna site to the utilization site (s) which may be several kilometers away. Feeder amplifiers are provided at several points along the line to overcome progressive signal attenuation which occurs due to cable losses.

- Since cable losses are greater at higher frequencies it is evident that high-band attenuation will be greater than low-band attenuation. Therefore, to equalize this the amplifiers and signal splitters are often supplemented by equalizers. An equalizer or tilt control consists of a band pass filter arrangement with an adjustable frequency response. It operates by introducing a relative low-frequency loss so that outputs from the amplifiers or splitters have uniform relative amplitude response across the entire VHF band.
- The signal distribution from splitters to tap-off points is done through multicore coaxial cables in the same way as in a MATV system. In any case the signal level provided to a television receiver is of the order of 1.5 mV.
- This level provides good quality reception without causing accompanying radiation problems from the CATV system, which could cause interference to other installations and services.

Signal Processing

- The TV signals to be redistributed by the cable company usually undergo some kind of processing before they are put on the cable to the TV set. Amplification and impedance matching are the main processes involved in sending the signal to remote locations over what is sometimes many miles of coaxial cable. However, at the head end, other types of processes are involved. (Coaxial or fiber-optic cable) Frequency synthesized local oscillator

Straight-Through Processors.

- In early cable systems, the TV signals from local stations were picked up with antennas, and the signal was amplified before being multiplexed onto the main cable. This is called *straight-through processing*. Amplifiers called *strip amplifiers* and tuned to the received channels pass the desired TV signal to the combiner.
- Most of these amplifiers include some kind of gain control or attenuators that can reduce the signal level to prevent distortion of strong local signals. This process can still be used with local VHF TV stations, but today heterodyne processing is used instead.

Heterodyne Processors.

- *Heterodyne processing* translates the incoming TV signal to a different frequency. This is necessary when satellite signals are involved.
- Microwave carriers cannot be put on the cable, so they are down-converted to some available 6-MHz TV channel.

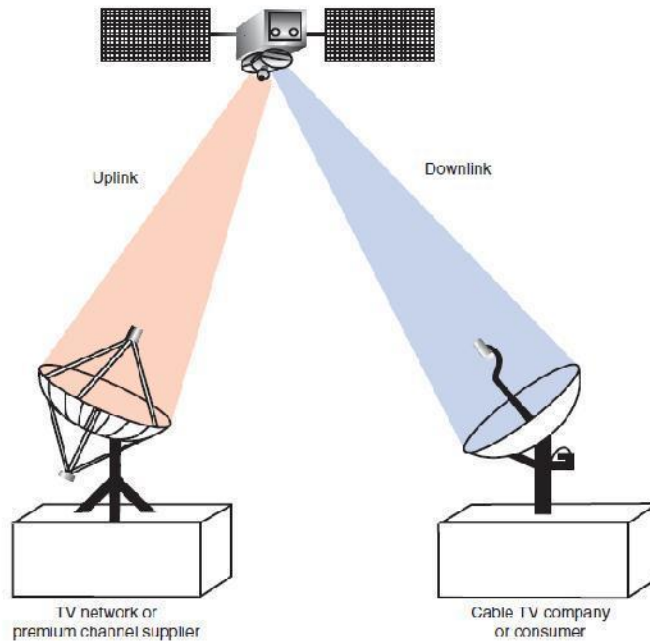
- In addition, heterodyne processing gives the cable companies the flexibility of putting the signals on any channel they want to use.
- The cable TV industry has created a special set of non-broadcast TV channels, some of the frequency assignments correspond to standard TV channels, but others do not. Since all these frequencies are confined to a cable, there can be duplication of any frequency that might be used in radio or TV broadcasting.
- Note that the spacing between the channels is 6 MHz.

Satellite TV

- One of the most common methods of TV signal distribution is via communication satellite. A communication satellite orbits the equator about 22,300 mi out in space. It rotates in synchronism with the earth and therefore appears to be stationary. The satellite is used as a radio relay station.
- The TV signal to be distributed is used to modulate a microwave carrier, and then it is transmitted to the satellite. The path from earth to the satellite is called the uplink. The satellite translates the signal to another frequency and then retransmits it back to earth. This is called the downlink. A receive site on earth picks up the signal.
- The receive site may be a cable TV company or an individual consumer. Satellites are widely used by the TV networks, the premium channel companies, and the cable TV industry for distributing signals nationally.
- A newer form of consumer satellite TV is direct broadcast satellite (DBS) TV. The DBS systems are designed specifically for consumer reception directly from the satellite. The new DBS systems feature digitally encoded video and audio signals, which make transmission and reception more reliable and provide outstanding picture and sound quality.
- By using higher-frequency microwaves, higher-power satellite transponders, and very low-noise GaAs FETs in the receiver, the customer's satellite dish can be made very small. These systems typically use an 18-in dish as opposed to the 5- to 12-ft-diameter dishes still used in older satellite TV systems.

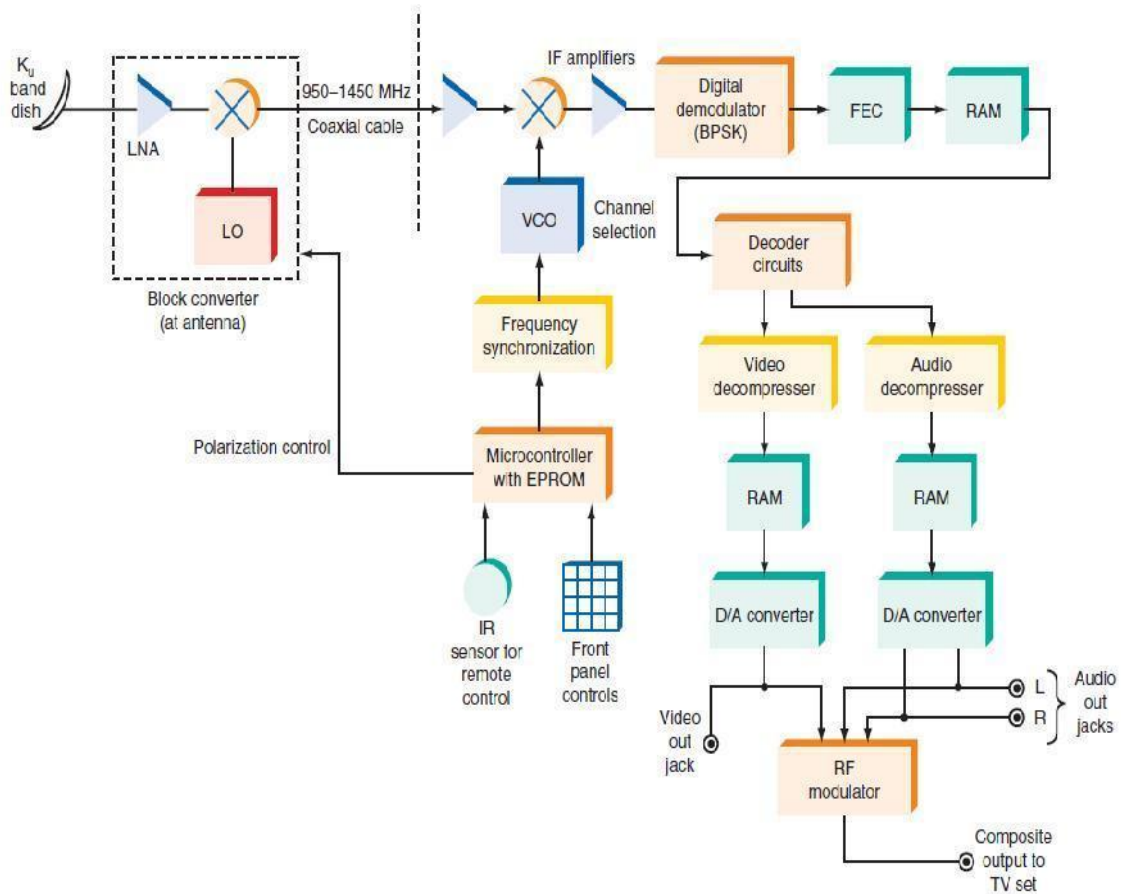
Direct Broadcast Satellite Systems

- The direct broadcast satellite (DBS) system was designed specifically to be an all-digital system. Data compression techniques are used to reduce the data rate required to produce high-quality picture and sound.
- The DBS system features entirely digital uplink ground stations and satellites. Since the satellites are designed to transmit directly to the home, extra high-power transponders are used to ensure a satisfactory signal level.
- To receive the digital video from the satellite, a consumer must purchase a satellite TV receiver and antenna.

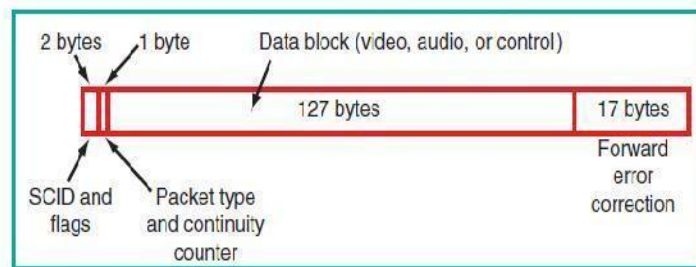


- These satellite receivers operate in the band. By using higher frequencies as well as higher-power satellite transponders, the necessary dish antenna can be extremely small. The new satellite DBS system antennas have only an 18-in diameter.
- Several special digital broadcast satellites are in orbit, and two of the direct satellite TV sources are DirecTV and DISH Network. They provide full coverage of the major cable networks, and the premium channels usually distributed to homes by cable TV and can be received directly.
- In addition to purchasing the receiver and antenna, the consumer must subscribe to one of the services supplying the desired channels. Satellite Transmission. The video to be transmitted must first be placed into digital form. To digitize an analog signal, it must be sampled a minimum of 2 times per cycle for sufficient digital data to be developed for reconstruction of the signal.
- Assuming that video frequencies of up to 4.2 Mbps are used, the minimum sampling rate is twice this, or 8.4 Mbps. For each sample, a binary number proportional to the light amplitude is developed. This is done by an A/D converter, usually with an 8-bit output. The resulting video signal, therefore, has a data rate of 8 bits, 8.4 Mbps, or 67.2 Mbps. This is an extremely high data rate.
- However, for a color TV signal to be transmitted in this way, there must be a separate signal for each of the red, green, and blue components making up the video. This translates to a total data rate of or 202, Mbps. Even with today's technology, this is an extremely high data rate that is hard to achieve reliably.
- To lower the data rate and improve the reliability of transmission, the new DBS system uses compressed digital video. Once the video signals have been put into digital form, they are processed by digital signal processing (DSP) circuits to minimize the full amount of data to be transmitted.

- Digital compression greatly reduces the actual transmitting speed to somewhere in the 20- to 30-Mbps range. The compressed serial digital signal is then used to modulate the uplinked carrier using BPSK.
- The DBS satellite uses the band with a frequency range of 11 to 14 GHz. Uplink signals are usually in the 14- to 14.5-GHz range, and the downlink usually covers the range of 10.95 to 12.75 GHz. The primary advantage of using the band is that the receiving antennas may be made much smaller for a given amount of gain.
- However, these higher frequencies are more affected by atmospheric conditions than are the lower microwave frequencies. The biggest problem is the increased attenuation of the downlink signal caused by rain.
- Any type of weather involving rain or water vapor, such as fog, can seriously reduce the received signal. This is so because the wavelength of band signals is near that of water vapor. Therefore, the water vapor absorbs the signal.
- Although the power of the satellite transponder and the gain of the receiving antenna are typically sufficient to provide solid reception, there can be fadeout under heavy downpour conditions.
- Finally, the digital signal is transmitted from the satellite to the receiver by using circular polarization. The DBS satellites have right-hand and left-hand circularly polarized (RHCP and LHCP) helical antennas.
- By transmitting both polarities of signal, frequency reuse can be incorporated to double the channel capacity. DBS Receiver. A block diagram of a typical DBS digital receiver is shown in Fig. The receiver subsystem begins with the antenna and its low-noise block converter.
- The horn antenna picks up the band signal and translates the entire 500-MHz band used by the signal down to the 950- to 1450-MHz range, as explained earlier. Control signals from the receiver to the antenna select between RHCP and LHCP. The RF signal from the antenna is sent by coaxial cable to the receiver.
- A typical DBS downlink signal occurs in the 12.2- to 12.7-GHz portion of the band. Each transponder has a bandwidth of approximately 24 MHz. The digital signal usually occurs at a rate of approximately 27 Mbps. Figure shows how the digital signal is transmitted. The digital audio and video signals are organized into data packets.
- Each packet consists of a total of 147 bytes. The first 2 bytes (16 bits) contain the service channel identification (SCID) number. This is a 12-bit number that identifies the video program being carried by the packet. The 4 additional bits are used to indicate whether the packet is encrypted and, if so, which decoding key to use.
- One additional byte contains the packet type and a continuity counter. The data block consists of 127 bytes, either 8-bit video signals or 16-bit audio signals. It may also contain digital data used for control purposes in the receiver.
- Finally, the last 17 bytes are the error detection check codes. These 17 bytes are developed by an error-checking circuit at the transmitter. The appended bytes are checked at the receiver to detect any errors and correct them.



Digital data packet format used in DBS TV.



- The received signal is passed through another mixer with a variable-frequency local oscillator to provide channel selection. The digital signal at the second IF is then

demodulated to recover the originally transmitted digital signal, which is passed through a forward error correction (FEC) circuit.

- This circuit is designed to detect bit errors in the transmission and to correct them on the fly. Any bits lost or obscured by noise during the transmission process are usually caught and corrected to ensure a near-perfect digital signal.
- The resulting error-corrected signals are then sent to the audio and video decompression circuits. Then they are stored in random access memory (RAM), after which the signal is decoded to separate it into both the video and the audio portions.
- The DBS TV system uses digital compression-decompression standards referred to as *MPEG2* (*MPEG* means *Moving Picture Experts Group*, which is a standards organization that establishes technical standards for movies and video).
- MPEG2 is a compression method for video that achieves a compression of about 50 to 1 in data rate. Finally, the signals are sent to D/A converters that modulate the RF modulator which sends the signals to the TV set antenna terminals.
- Although the new DBS digital systems will not replace cable TV, they provide the consumer with the capability of receiving a wide range of TV channels. The use of digital techniques provides an unusually high-quality signal.

Digital TV (DTV)

- Digital TV (DTV), also known as high-definition TV (HDTV), was designed to replace the National Television Standards Committee (NTSC) system, which was invented in the 1940s and 1950s.
- The goal of HDTV is to greatly improve the picture and sound quality. After more than a decade of evaluating alternative HDTV systems, the FCC has finalized the standards and decreed that HDTV will eventually become the U.S. TV standard by April 2009.
- The first HDTV stations began transmission in the 10 largest U.S. cities on September 1, 1998. HDTV sets can now be purchased by the consumer, but they are still expensive. As more HDTV stations come online and as more HDTV programming becomes available, more consumers will buy HDTV receivers and the cost will drop dramatically.
- The HDTV system is an extremely complex collection of digital, communication and computer techniques.
- A full discussion is beyond the scope of this book. However, this section is a brief introduction to the basic concepts and techniques used in HDTV. HDTV Standards HDTV for the United States was developed by the Advanced Television Systems Committee (ATSC) in the 1980s and 1990s.
- HDTV uses the scanning concept to paint a picture on the CRT, so you can continue to think of the HDTV screen in terms of scan lines, as you would think of the standard NTSC analog screen. However, you should also view the HDTV screen as being made up of thousands of tiny dots of light, called pixels.
- Each pixel can be any of 256 colors. These pixels can be used to create any image. The greater the number of pixels on the screen, the greater the resolution and the finer the detail that can be represented.

- Each horizontal scan line is divided into hundreds of pixels. The format of a HDTV screen is described in terms of the numbers of pixels per horizontal line by the number of vertical pixels (which is the same as the number of horizontal scan lines).
- One major difference between conventional NTSC analog TV and HDTV is that HDTV can use progressive line scanning rather than interlaced scanning. In progressive scanning each line is scanned one at a time from top to bottom.
- Since this format is compatible with computer video monitors, it is possible to display HDTV on computer screens. Interlaced scanning can be used on one of the HDTV formats. Interlaced scanning minimizes flicker but complicates the video compression process. Progressive scanning is preferred and at a 60-Hz frame rate, flicker is not a problem.

Standard	Aspect Ratio	Pixels/ Horizontal Line	Vertical Pixels*	Scan Rate, Hz
480p	4:3	640	480	24, 30, 60 [†]
480i/p	4:3 or 16:9	704	480	24, 30, 60
720p	16:9	1280	720	24, 30, 60
1080i	16:9	1920	1080	24 or 30

*Number of scan lines.

[†]Standard PC VGA format.

- The FCC has defined a total of 18 different formats for HDTV. Most are variations of the basic formats as given in Table. Most plasma, LCD and larger screens only display these formats. The 480p (the *p* stands for “progressive”) standard offers performance comparable to that of the NTSC system. It uses a 4:3 aspect ratio for the screen.
- The scanning is progressive. The vertical scan rate is selectable to fit the type of video being transmitted. This format is fully compatible with modern VGA computer monitors.
- The format can use either progressive or interlaced scanning with either aspect ratio at the three vertical scan rates shown in Table.
- The 720p format uses a larger aspect ratio of 16:9 (a 4:3 format is optional at this resolution also). This format is better for showing movies. Figure shows the difference between the current and new HDTV aspect ratios.
- The 1080i format uses the 16:9 aspect ratio but with more scan lines and more pixels per line. This format obviously gives the best resolution. The HDTV set should be able to detect and receive any available format. The 720p at 60 Hz and 1080i formats are those designated HDTV.

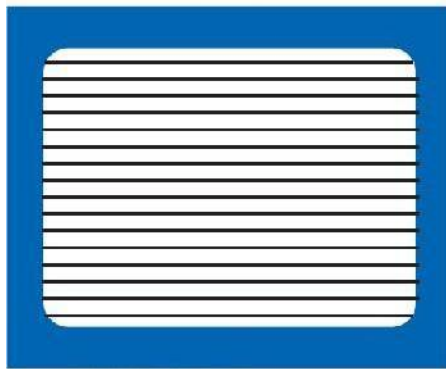
HDTV Transmission Concepts

- In HDTV both the video and the audio signals must be digitized by A/D converters and transmitted serially to the receiver.

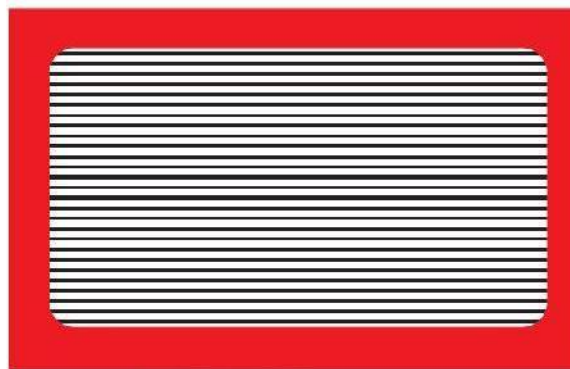
- Because of the very high frequency of video signals, special techniques must be used to transmit the video signal over a standard 6-MHz-bandwidth TV channel.
- And because both video and audio must be transmitted over the same channel, multiplexing techniques must be used. The FCC's requirement is that all this information be transmitted reliably over the standard 6-MHz TV channels now defined for NTSC TV. Assume that the video to be transmitted contains frequencies up to 4.2 MHz.
- For this signal to be digitized, it must be sampled at least 2 times per cycle or at a minimum sampling rate of 8.4 MHz. If each sample is translated to an 8-bit word (byte) and the bytes are transmitted serially, the data stream has a rate of , or 67.2 MHz.
- Multiply this by 3 to get $67.2 \times 3 = 201.6$ MHz. Add to this the audio channels, and the total required bandwidth is almost 300 MHz. To permit this quantity of data to be transmitted over the 6-MHz channel, special encoding and modulation techniques are used.

HDTV Transmitter

6 TV picture standards. (a) Current standard. (b) HDTV standard.

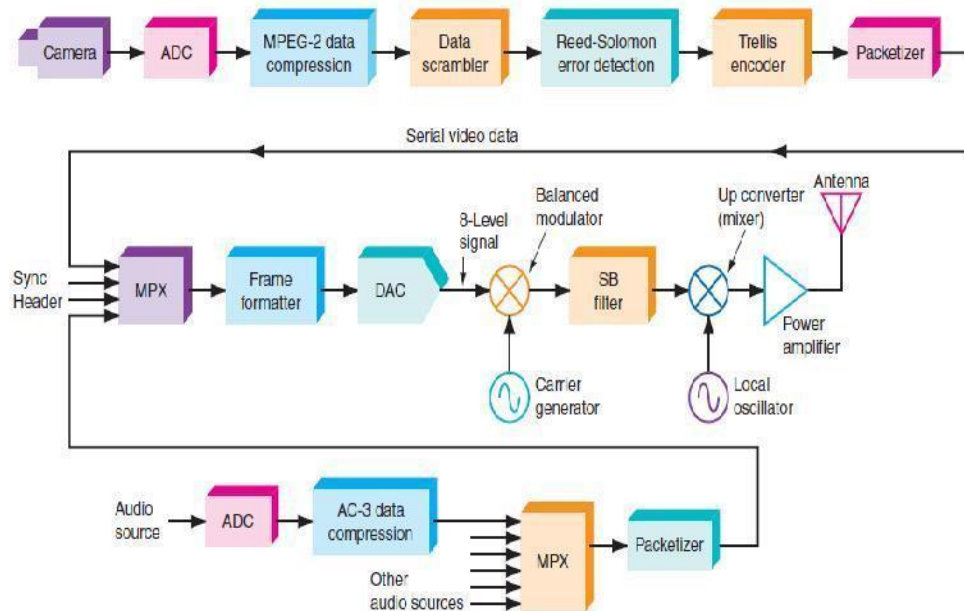


Aspect ratio = 4:3
Number of lines = 525 (interlaced scanning)
(a)



Aspect ratio = 16:9
Number of lines = 1080 (interlaced scanning)
Number of lines = 720 (progressive scanning)
(b)

Figure 23-27 HDTV transmitter.



- Figure shows a block diagram of an HDTV transmitter. The video from the camera consists of the R , G , and B signals that are converted to the luminance and chrominance signals. These are digitized by A/D converters. The luminance sampling rate is 14.3 MHz, and the chroma sampling rate is 7.15 MHz.
- The resulting signals are serialized and sent to a data compressor. The purpose of this device is to reduce the number of bits needed to represent the video data and therefore permit higher transmission rates in a limited-bandwidth channel. MPEG-2 is the data compression method used in HDTV.
- The MPEG-2 data compressor processes the data according to an algorithm that effectively reduces any redundancy in the video signal. For example, if the picture is one-half light blue sky, the pixel values will be the same for many lines.
- All this data can be reduced to one pixel value transmitted for a known number of times. The algorithm also uses fewer bits to encode the color than to encode the brightness because the human eye is much more sensitive to brightness than to color.
- The MPEG-2 encoder captures and compares successive frames of video and compares them to detect the redundancy so that only differences between successive frames are transmitted. The signal is next sent to a data randomizer. The randomizer scrambles or randomizes the signal.
- This is done to ensure that random data is transmitted even when no video is present or when the video is a constant value for many scan lines. This permits clock recovery at the receiver.
- Next the random serial signal is passed through a Reed-Solomon (RS) error detection and correction circuit. This circuit adds extra bits to the data stream so that transmission errors

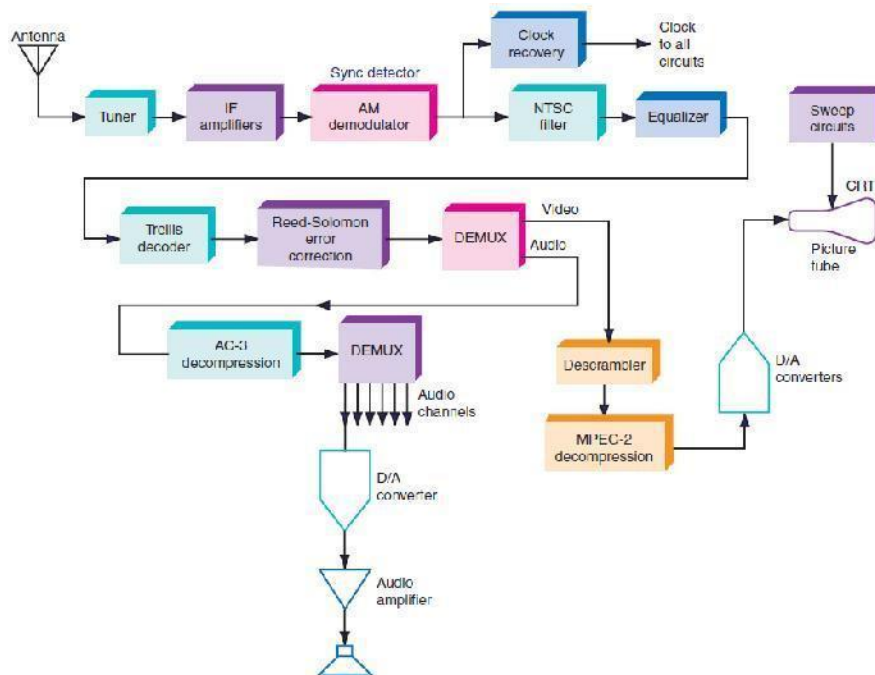
can be detected at the receiver and corrected. This ensures high reliability in signal transmission even under severe noise conditions.

- In HDTV, the RS encoder adds 20 parity bytes per block of data that can provide correction for up to 10 byte errors per block. The signal is next fed to a trellis encoder. This circuit further modifies the data to permit error correction at the receiver. Trellis encoding is widely used in modems.
- Trellis coding is not used in the cable TV version of HDTV. The audio portion of the HDTV signal is also digital. It provides for compact disk (CD) quality audio. The audio system can accommodate up to six audio channels, permitting monophonic sound, stereo, and multichannel surround sound.
- The channel arrangement is flexible to permit different systems. For example, one channel could be used for a second language transmission or closed captioning. Each audio channel is sampled at a 48-kbps rate, ensuring that audio signals up to about 24 kHz are accurately captured and transmitted.
- Each audio sample is converted to an 18-bit digital word. The audio information is time-multiplexed and transmitted as a serial bit stream at a frequency of A data compression technique designated AC-3 is used to speed up audio transmission.
- Next the video and audio data streams are packetized; i.e., they are converted to short blocks of data bytes that segment the video and audio signals.
- These packets are multiplexed along with some synchronizing signals to form the final signal to be transmitted. The result is a 188-bit packet containing both video and audio data plus 4 bytes of synchronizing bytes and a header. See Fig.
- The header identifies the number of the packet and its sequence as well as the video format. Next the packets are assembled into frames of data representing one frame of video. The complete frame consists of 626 packets transmitted sequentially. The final signal is sent to the modulator.
- The modulation scheme used in HDTV is 8-VSB, or eight-level vestigial sideband, amplitude modulation. The carrier is suppressed, and only the upper sideband is transmitted.
- The serial digital data is sent to a D/A converter where each sequential 3-bit group is converted to a discrete voltage level. This system encodes 3 bits per symbol, thereby greatly increasing the data rate within the channel. An example is shown in Fig. Each 3-bit group is converted to a relative level of or This is the signal that amplitude-modulates the carrier.
- The resulting symbol rate is 10,800 symbols per second. This translates to a data rate of . Eliminating the extra RS and trellis bits gives an actual video/audio rate of about 19.3 Mbps. A modified version of this format is used when the HDTV signal is to be transmitted over a cable system. Trellis coding is eliminated and 16-VSB modulation is used to encode 4 bits per symbol.
- This gives double the data rate of terrestrial HDTV transmission (38.6 Mbps). The VSB signal can be created with a balanced modulator to eliminate the carrier and to generate the sidebands.
- One sideband is removed by a filter or by using the phasing system. The modulated signal is up-converted by a mixer to the final transmission frequency, which is one of the standard

TV channels in the VHF or UHF range. A linear power amplifier is used to boost the signal level prior to transmission by the antenna.

HDTV Receiver.

- An HDTV receiver picks up the composite signal and then demodulates and decodes the signal into the original video and audio information. A simplified receiver block diagram is shown in Fig.
- The tuner and IF systems are similar to those in a standard TV receiver. From there the 8-VSB signal is demodulated (using asynchronous detector) into the original bit stream. A balanced modulator is used along with a carrier signal that is phase-locked to the pilot carrier to ensure accurate demodulation.
- A clock recovery circuit regenerates the clock signal that times all the remaining digital operations. The signal then passes through an NTSC filter that is designed to filter out any one channel or adjacent channel interference from standard TV stations.
- The signal is also passed through an equalizer circuit that adjusts the signal to correct for amplitude and phase variations encountered during transmission. The signals are demultiplexed into the video and audio bit streams.
- Next, the trellis decoder and RS decoder ensure that any received errors caused by noise are corrected. The signal is descrambled and decompressed. The video signal is then converted back to the digital signals that will drive the D/A converters that, in turn, drive the red, green, and blue electron guns in the CRT.
- The audio signal is also de multiplexed and fed to AC-3 decoders. The resulting digital signals are fed to D/A converters that create the analog audio for each of the six audio channels.



SCRAMBLING AND CONDITIONAL ACCESS SYSTEMS:

- Scrambling: It is to suppress the sync signals at transmitting end. The picture without H and V sync cannot lock into steady picture seen as rolling picture and diamond bars. For descrambling, a pilot carrier containing the sync timing information is transmitted on separate carrier.
- Another method with great security and complexity is baseband scrambling, the scrambled coded lines are decoded and it requires demodulation process.
- Scrambling is possible by digital processing of video and audio and introducing complex encryption and smart keyboard for controlled access.
- Now Addressable converters: includes tunable converters and address recognition circuitry which is controlled by computer so specific channels are turned OFF or ON to subscriber.

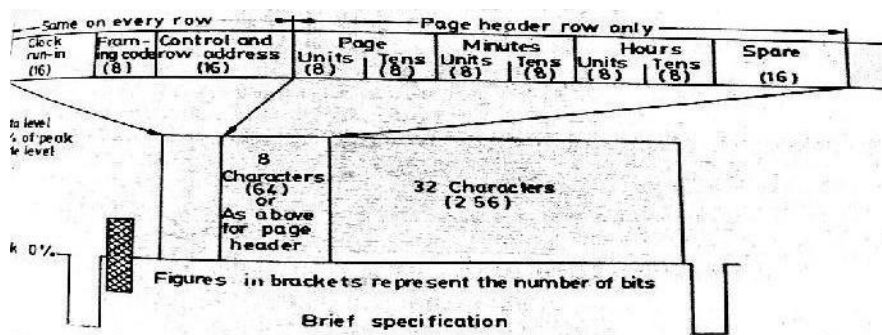
CONDITIONAL ACCESS

Features:

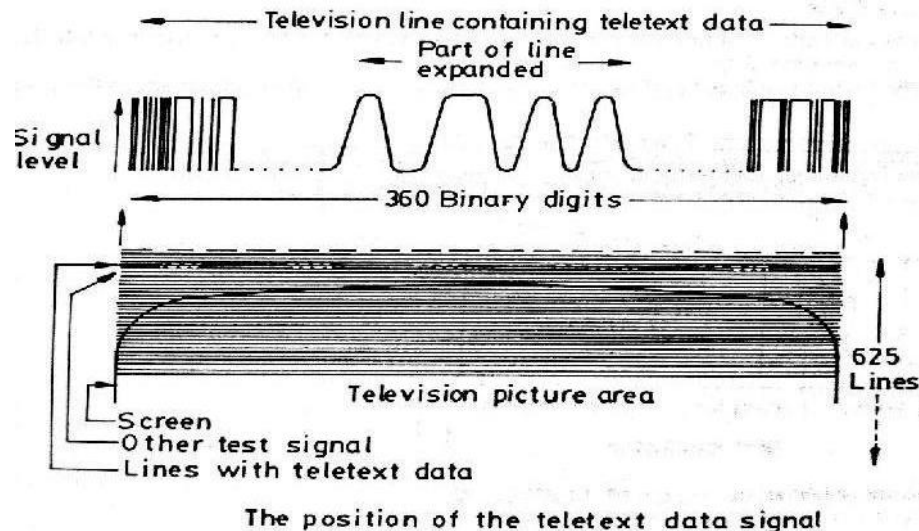
- Equipment compatibility access, support, user system interface, telephone communication module. The techniques used are scramblers and injectors upstream and descrambler modules. In cable and satellite systems, 3 different operational are projected
 1. Access to a given channel for fixed duration
 2. Pay per view with preselected choice of channel
 3. Pay per view without preselection.

TELETEXT OF VIDEO TEXT SYSTEM

- Videotext is a two-way information service as video display unit or crt terminal. This information service generally provides data in 4 major areas,
 1. Finance stock exchanges
 2. Money markets and reservation
 3. Messaging- topical news and reviews a subscriber to database can select desired information via keypad accessory.
 4. Prestel - first video text service.



- View data systems use all kinds of host computers, from minicomputers to mainframes depends upon power require for service.



View data chip (lucy)

It performs most of hardware functions of a viewdata terminal- autodialer circuit, band demodulator and asynchronous receiver, baud modulator and asynchronous transmitter. It includes a tape interface for recording and character codes. View data terminals CRT displays are used to display the information for viewing and editing. It can be an intelligent terminal or microcomputers. Intelligent terminals- equipped with microprocessor and data storage memory capacity to process the data. Microcomputers – with software for data storage and local processing capability. TV monitor is enhanced with video bandwidth to improve resolution as CRT display monitor or VDU.

DIGITAL TV SYSTEM

- Analog signals suffers degradation due to noise, crosstalk, linear and non-linear distortion. In this, analog is converted to digital by analog to digital converter ADC performs sampling, quantization and encoding.

Sampling:

- The TV signal is sampled at rate of twice the maximum band limit frequency- Nyquist criteria.
- Fourier transform of band limit signal at T seconds is scaled by $1/T$ and given by $w_0 = 2/T$.
- If input signal is not band limited or sampling frequency does not meet the requirement of sampling theorem, the various components of spectrum overlap.
- It suffers from distortion called aliasing effect and moiré patterns appear in picture.

- To avoid aliasing errors, the sampling frequency must exceed 10mhz.

Quantization:

- The sampled output, discrete in time in continuous in amplitude and assigned a discrete numerical values as ADC.
- Since DAC is reverse process.

Encoder:

- The sampled value is assign a binary code along with additional coding like parity for error detection , scrambling,etc.
- Errors occurred are eliminated by redundancy in digital signals.
- Because of this, delay may occurs in TV , so forward error correction (FEC) is obtained.
- Block coding and convolution coding are two approaches in this direction.

3DTV

For 3D picture, we have to show the depth also along with length and breadth.

$$(L + B + H)$$

Principle:

- The left and right eye of human see a different image of same object, so brain interprets these as a single composite image in 3D.
- Two different images are generated by 2 cameras, like our eyes located.
- For stereo sound transmitter, the left and right channel signals are FM at 5.5MHz audio carrier.
- The combined audio and video signals are amplitude modulated by channel carrier using separate modulators.
- USB and LSB selected and combined before final transmission.

3-D Display methods:

By using 3 set of color signals we reproduce the 3-D effect on picture tube screen.

First method:

- All green color phosphor strips excited by green(G) video signal right. Similarly red color phosphor strips excited by red(R) video signal left.
- Blue (B) color phosphor strips are not excited at all.
- If viewer wears, G filter at right eye and R filter at left eye, than brain combined to form various Y shades.

Second method:

- Two video display units(VDU) are used, to create 3D pictures in natural colors.
- A polarizing film is fitted in front of VDU and light outputs are reflected using a mirror arrangement on screen.

Third method:

- This is known as ABDY 3D system.
- In this, R color information are delayed by nearly 600ns and it is obtain by using delay circuits.
- So, double image is formed on screen of picture tube.

**VCR- VIDEO CASSETTE RECORDER
INTRODUCTION**

- The main purpose of the video recorder is recording and replaying video and audio signals. Although built-in tuners and timers have become integral parts of the average video recorder, they are not prerequisites for reaching the main goal: audio and video registration and playback.

THE HELICAL SCAN SYSTEM

- In an audio cassette deck, which only registers audio signals, the tape passes over a static recording/playback head at constant speed.
- The higher the speed of the tape, the more tape particles pass the head opening and the higher the frequencies that can be registered. Thanks to the extremely narrow head opening, it is possible to record and play back the entire tone range, up to 18,000 or 20,000 Hz, despite a slow tape speed of no more than 4.75 centimeters per second.
- However, to register video signals, a range of 3.2 MHz is required and so a tape speed of approximately 5 meters per second is a prerequisite. This is over 100 times as fast as the tape speed for an audio cassette deck.
- The required high recording speed for video recorders is realized by the helical scan system without such high tape speeds. The system basically consists of a revolving head drum, that has a minimum of two video heads.
- The head drum has a diameter of approximately 5 cm and rotates at a speed of 1500 revolutions per minute. The 1/2" (12.65 mm) wide videotape is guided around half the surface of this drum, in a slightly oblique manner. This is achieved by positioning the head drum at a slight angle.
- The tape guidance mechanism then ensures that the tape is guided through the device at a speed of approximately 2 cm per second (half of the low tape speed that is used in audio cassette decks).

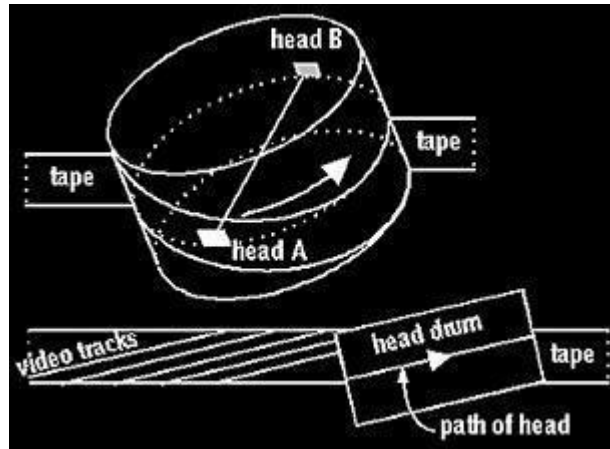


Fig: Tape guidance along the head drum with the video heads writing tracks on the tape.

- In the meantime, the rapidly revolving video heads write narrow tape tracks of no more than 0.020 to 0.050 mm wide on the tape, next to each other, diagonally. Every half revolution, each of the two heads writes one diagonal track which equals half an image. The first head writes one track, i.e., the first field (the odd numbered scanning lines).
- The second head writes a second track, i.e., the other half of the image (the second field: the even numbered scanning lines), which precisely fits in the first image. This corresponds to the interlacing principle, as applied in television.
- One full revolution of both heads results in two diagonal tracks right next to each other, together forming one entire image scan (a frame). This means that two apparently contradictory requirements can be realized simultaneously: low tape speed of only 2 cm per second and at the same time a high registration speed (relative tape speed) of no less than 5 meters per second.
- These two requirements make it possible to record the high video frequencies up to 3.2 MHz. At the same time, the low tape speed gives a time capacity up to three hours.

SYNCHRONIZATION TRACK

- The revolutionary speed of the head drum and the video heads needs to maintain a constancy within strict parameters. Moreover, the tracks must be scanned during playback in precisely the same way as they were recorded.
- Each tape track is synchronized at the recording stage by means of field synchronization pulses. These pulses are generated in the video recorder by a separate head which are recorded on a separate narrow track at the side of the video tape.
- This is called the synchronization, servo or control track.

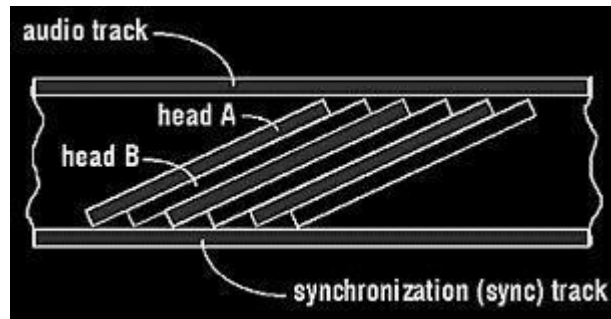


Fig: Position of the video, audio and synchronization tracks on the tape.

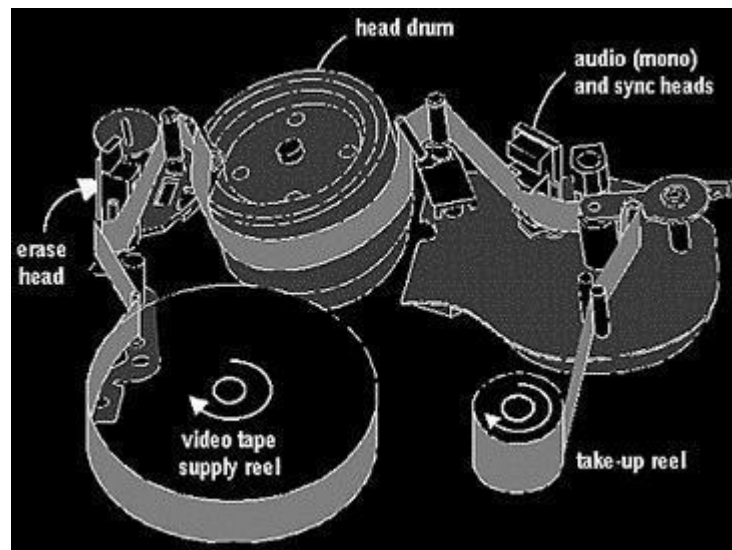


Fig: Position of the audio, sync and erase heads inside the VCR.

VIDEO DISC SYSTEMS

There are three major video systems in use today:

1. Video Home System (VHS)
 2. Betamax
 3. Video Hi8
- When the video recorders were first introduced, Philips also developed a system called V2000. Despite the fact that it was a high quality system, it was not successful in the market.
 - Although Betamax was reasonably successful at first, its popularity waned and VHS was adopted as the world standard.

BETAMAX

- The Sony Betamax System, launched in 1975, was based on the pre-existing professional Sony U-matic-system. In the Betamax system, the video tape is guided along the head drum in a U-shape for all tape guidance functions, such as recording, playback and fast forward/backward.
- When the cassette is inserted, the tape is guided around the head drum (called threading). Threading the tape takes a few seconds, but once the tape is threaded, shifting from one tape function to another can be achieved rapidly and smoothly.

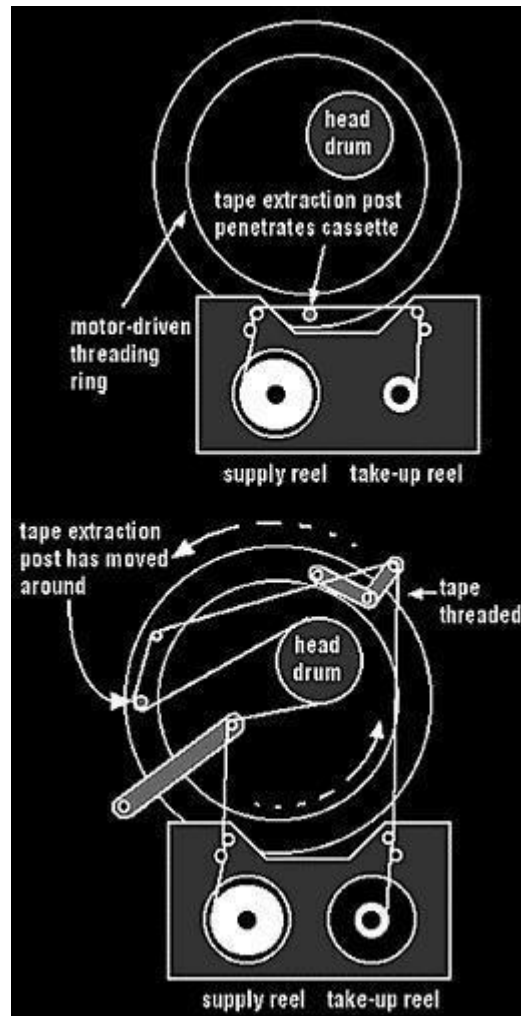


Fig: The Betamax U-system before (top) and after (bottom) threading.

VIDEO HOME SYSTEM (VHS)

- JVC's VHS System was introduced one year after the launch of Betamax. In VHS, the tape is guided through in an M-shape; the so-called M-tape guidance system.

- It is considered simpler and more compact than the U-system. Threading is faster and is done every time the tape guidance function is changed. It is therefore somewhat slower and noisier than the U-system.
- This problem is being solved by "Quick-start" VHS video recorders, which allow fast and silent changes in tape guidance functions. To avoid excessive wear, M-tape guidance system recorders are provided with an automatic switch-off feature, activated some minutes after the recorder is put on hold, which automatically unthreads the tape.
- An improvement of the basic VHS system is HQ (High Quality) VHS.
- In the VHS system different starting points were used than in Betamax, such as track size and relative speed. VHS has rather wide video tracks, but a slightly lower relative tape speed, and that also counts for the audio track. In general, the advantages of one aspect are tempered by the disadvantages of the other.
- The end result is that there is not too much difference between the sound and image qualities of both systems.

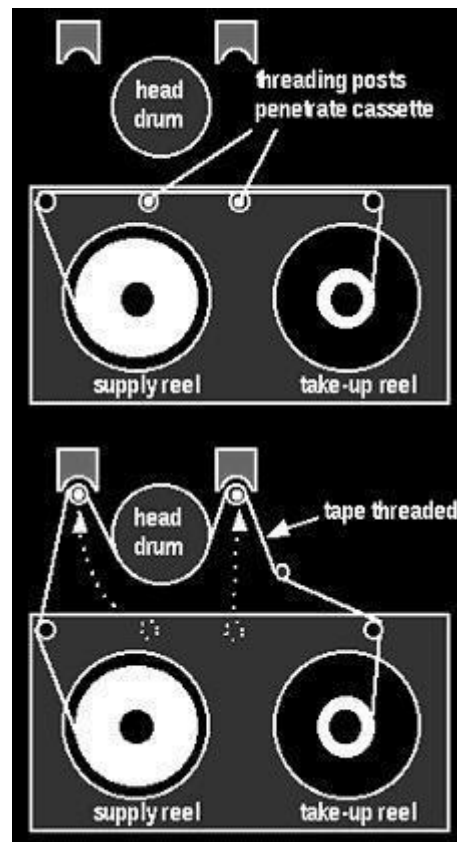


Fig: The VHS M-system before (top) and after (bottom) threading.

VIDEO HI8

- As a direct addition to the Video-8 camcorders, there is a third system: Video Hi8, which uses a smaller cassette than VHS and Betamax.
- The sound recording takes place digitally, making its sound quality very good. When using the special Hi8 Metal Tape, the quality of both image and sound are equivalent to that of Super-VHS.
- The Video-Hi8-recorder can also be used to make audio recordings (digital stereo) only. Using a 90 minute cassette, one can record 6 x 90 minutes, making a total of 18 hours of continuous music.
- The video Hi8-system also allows manipulating digital images, such as picture-in-picture and editing. Video Hi8 uses a combination of the M- and U-tape guidance system.

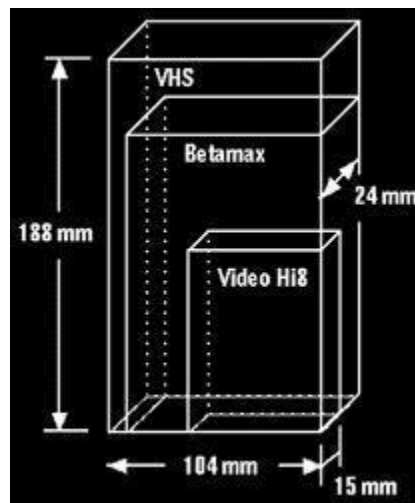


Fig: Cassette sizes compared.

FLAT PANEL DISPLAYS.

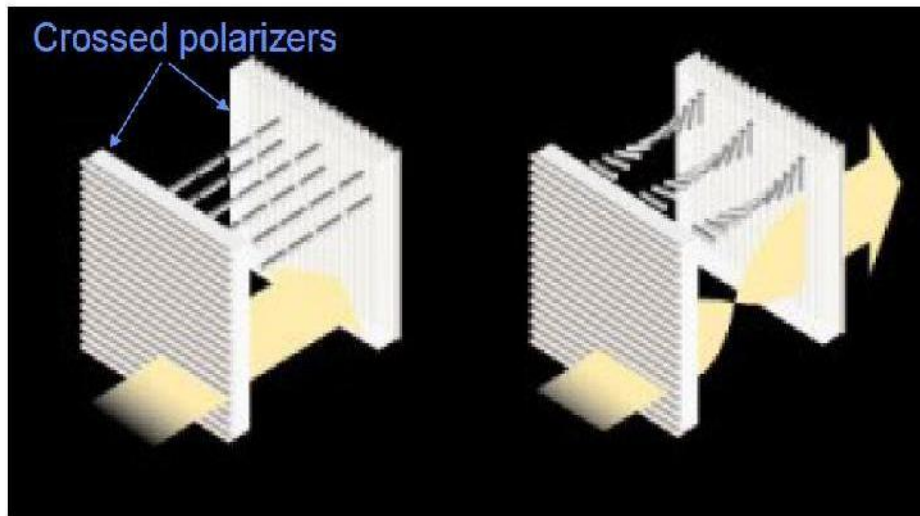
Liquid Crystal Display (LCD) technology

- blocking light rather than creating it.
- Require less energy, emit less radiation.

Light-Emitting Diode (LED) and Gas Plasma light up display screen positions based on voltages at grid intersections. Require more energy.

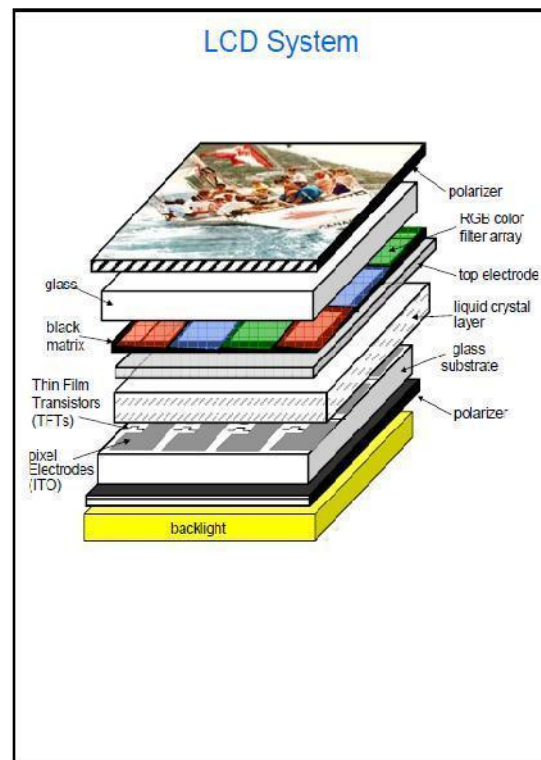
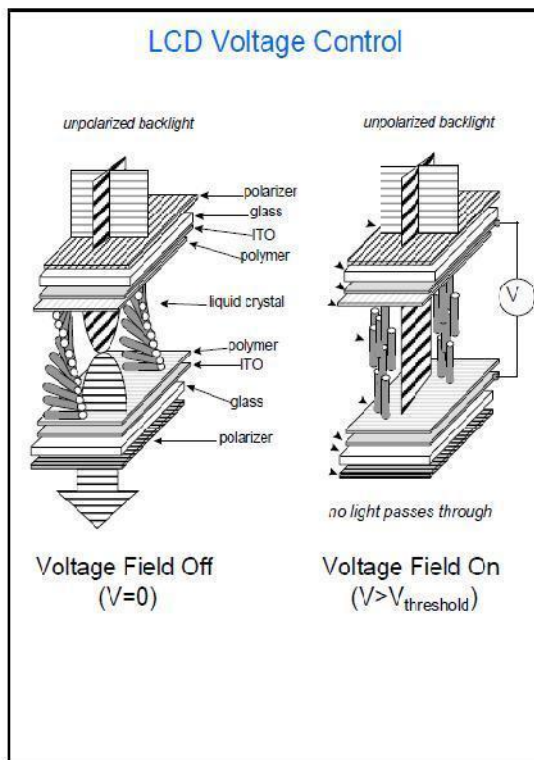
Liquid Crystal Display (LCD)

- Liquid crystals (LC) are complex, organic molecules – fluid characteristics of a liquid and the molecular orientation order properties of a solid – exhibit electric, magnetic and optical anisotropy
- Many different types of LC optical configurations– nematic materials arranged in a twisted configuration most common for displays Below are shown three of the common LC phases

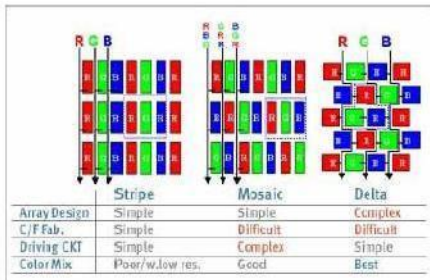


Liquid crystal (off state)

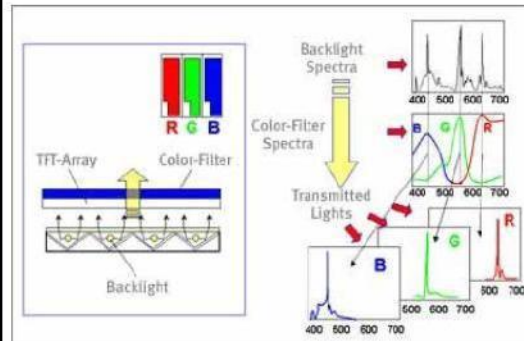
Liquid crystal (on state)



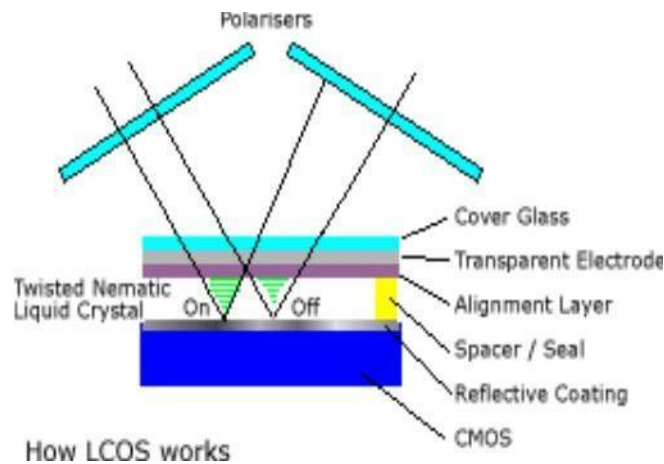
Color Array Organization Options



Color Pixels in LCD Devices



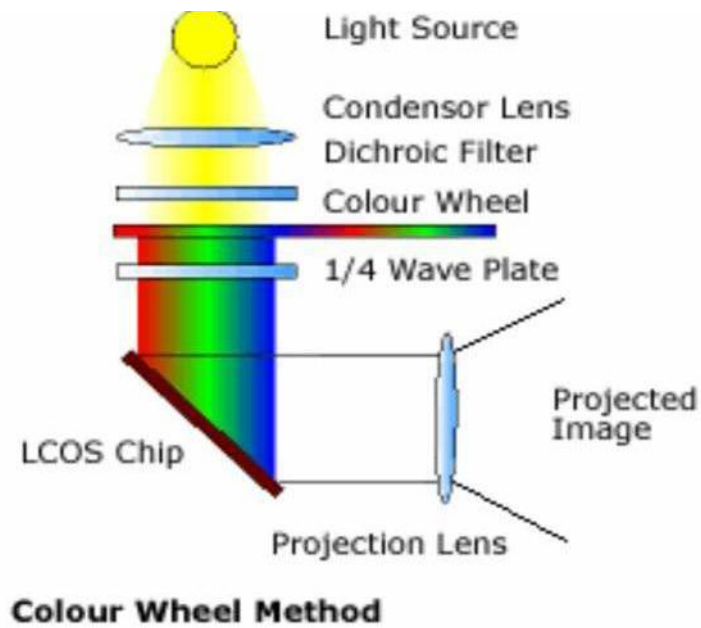
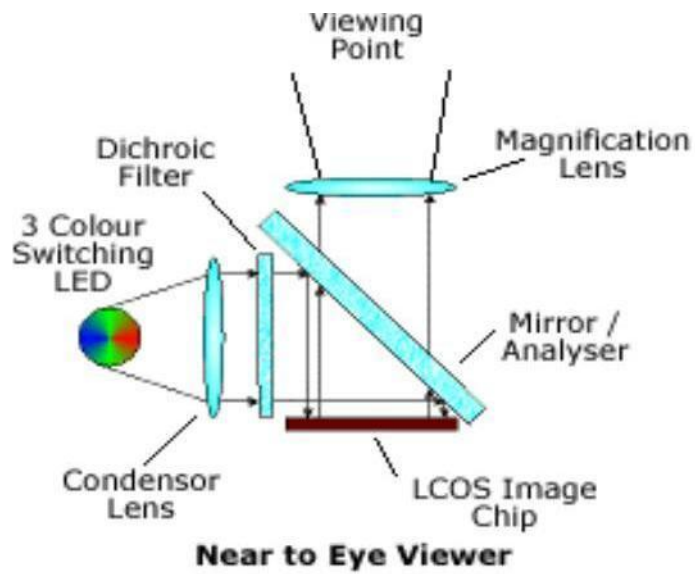
- Instead of the crystals and electrodes sandwiched between polarized glass plates, in LCOS devices the crystals are coated over the surface of a **silicon chip**.
- The electronic circuits are etched into the chip, which is coated with a reflective surface. **Polarizers** are in the light path before and after the light bounces off the chip.

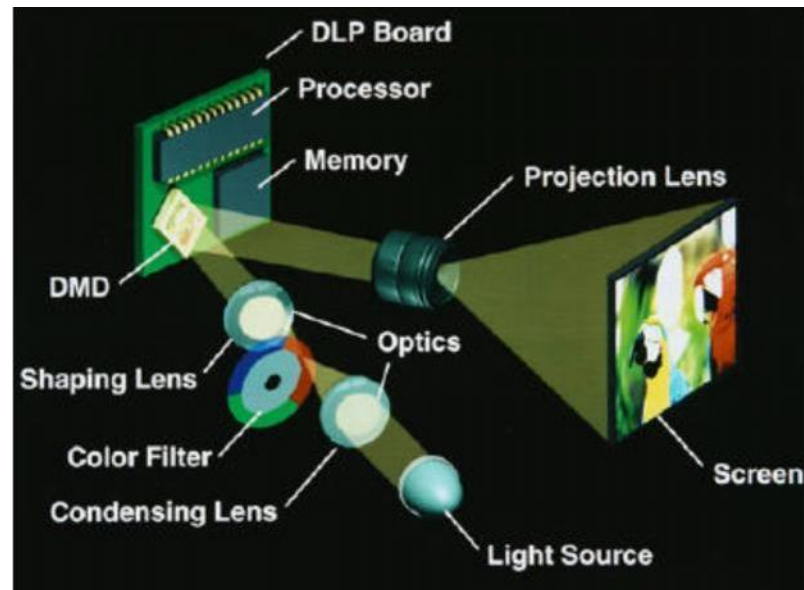


Advantages over conventional LCD Displays:

- Easier to manufacture.
- Have **higher resolution** because several million pixels can be etched onto one chip.
- Can be much **smaller**.

Projection Displays.





Principle of DLP

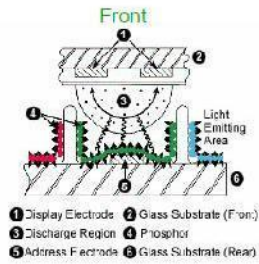
- Micromirrors can tilt toward the light source (ON) or away from it (OFF) - creating a light or dark projected pixel.
- The bit-streamed image code entering the chip directs each mirror to switch on and off up to several thousand times a sec. Frequency of on vs off determines gray level (upto 1024).
- A color filter wheel is inserted between the light and the DMD, and by varying the amount of time each individual DMD mirror pixel is on, a full-color, digital picture is projected onto the screen.

Plasma display

- Gas Plasma Display = An array of cells (pixels) composed of 3 sub pixels: red, green & blue. An inert (inactive) gas surrounding these cells is then subjected to voltages representing the changing video signal; causing the gas to change into a plasma state, generating ultra-violet light which reacts with phosphors in each sub pixel. The reaction generates colored light.

Gas Plasma Displays

Emissive rather than transmissive



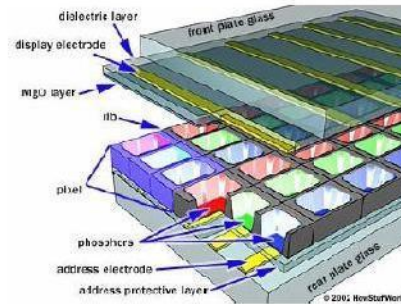
- Step 1:** Address electrode causes gas to change to plasma state.
- Step 2:** Gas in plasma state reacts with phosphors in discharge region.
- Step 3:** Reaction causes each subpixel to produce red, green, and blue light.

Gas Plasma

- Extremely thin (3"-6" typically), & produce sharp images because do not use complicated optics & lens assemblies.
- Images are relatively bright with very high contrast ratios.
- Have nearly a 180 degree viewing angle with no light drop-off! (LCD and DLP Televisions approx 160 deg).
- Technology is highly complex & relatively expensive.
- Relatively weighty and consumes more power than typical video displays. Sometimes require internal cooling fans (like LCD, DLP, & CRT projectors).



Gas Plasma Displays



The **Address electrodes** sit behind the cells, along the rear glass plate in horizontal rows.
 The **Display electrodes**, which are transparent, are mounted above the cell, along the front glass plate in vertical columns.

Plasma vs LCD

Advantages Of Plasma Displays Over LCDs

- Viewing angle of Plasma: 160 degrees+, ~ 90 degrees vertically vs. LCDs: up to or less than 160 degrees horizontally
- Size much larger Plasma 32-61 inches vs LCD 2-28 inches.
- Plasma is Emissive (internal) vs LCDs are Transmissive (External backlight).
- Switching speeds: Plasma <20ms (video rates) vs LCDs >20ms (may have image lag at video rates)
- Color technology: Plasma uses Phosphors (Natural TV colors) vs LCDs use Color Filters (Not the same color system as TV).



EC 2034 / TELEVISION AND VIDEO ENGINEERING**UNIT I****FUNDAMENTALS OF TELEVISION****PART A**

1. Mention some important characteristics of human eye?
 - Visual acuity,
 - persistence of vision,
 - brightness and color sensation.

2. Why is scanning necessary in television system?
 - Scanning is the important process carried out in a television system in order to obtain continuous frames and provides motion of picture. The scene is scanned both in the horizontal and vertical directions simultaneously in a rapid rate.
 - As a result sufficient number of complete picture of frames per second is obtained to give the illusion of continuous motion.

3. What is the main function of the blanking pulses?
 - The composite video signal consists of blanking pulses to make the retrace lines invisible by increasing the signal amplitude little above the black level of 75 percent during the time scanning the circuits develop retrace.

4. How is interlaced scanning different from sequential scanning?(Dec 2013)
 - Sequential scanning is the process in which both horizontal and vertical directions are scanned simultaneously to provide complete pictures. Here horizontal lines are scanned one by one. So, complete picture will be scanned through this type of scanning. But the drawback is that the time taken to complete the cycle is high. Also flicker will be produced, because of the low scanning rate.
 - In interlaced scanning, all the odd-numbered lines in the entire frame are scanned first, and then the even numbered lines. This process produces two distinct images per frame, representing two distinct samples of the image sequence at different points in time. The set of odd-numbered lines constitute the odd field, and the even-

numbered lines make up the even field.

- Interlace cleverly preserves the high-detail visual information and, at the same time, avoids visible large-area flicker at the display due to temporal post filtering by the human eye.
5. What is known as flicker? (*May 2013*)
- The result of 24 pictures per second in motion pictures and that of scanning 25 frames per second in television pictures is enough to make an illusion of continuity.
 - But, they are not rapid enough to permit the brightness of one picture or frame to blend smoothly in the next through the time when the screen is blanked between successive frames.
 - This develops in a definite flicker of light that is very irritating to the observer when the screen is made alternately bright and dark.
6. Why is the number of scanning lines in a frame always odd?(Dec 2012)
- For half line separation between the two fields only the topmost and the extreme bottom lines are then half lines whereas the remaining lines are all full lines.
 - If there are x number of full lines per field, where x may be even or odd, the total number of full lines per frame is then $2x$, an even number.
 - To this, when the two half lines get added the total number of lines per frame becomes odd. Thus for interlaced scanning the total number of lines in any TV system must be odd.
7. What is the significance of choosing the number of lines as 625 and not 623 or 627 and the frame reception rate as 25 and not 24 as in motion pictures?(Dec 2007)
- In motion illusion the minimum refresh rate is 24 frames / sec.
 - To avoid flicker and brightness blends smoothly by showing each frame twice.
 - For half line separation between the two fields only the topmost and the extreme bottom lines are then half lines whereas the remaining lines are all full lines.
 - If there are x number of full lines per field, where x may be even or odd, the total number of full lines per frame is then $2x$, an even number.
 - To this, when the two half lines get added the total number of lines per frame becomes odd. Thus for interlaced scanning the total number of lines in any TV system must be odd.

8. What is photoconductivity? (Dec 2012)

- Since the conductivity of the material varies in accordance with the light falling on it, the magnitude of the current represents the brightness variations of the scene. This varying current completes its path under the influence of an applied dc voltage through a load resistance connected in series with path of the current.

9. Why back porch is longer than front porch? (May 2013)

- It is longer enough to complete the flyback(retrace) period. It also permits the time for reverse the current to start next time scanning.

10. List out the frequency bands of TV broadcast channels. (May 2013)

- | | | |
|-------------------|-----|-------------|
| • Lower UHF range | I | 41-68 MHZ |
| • Upper VHF range | III | 174-230 MHZ |
| • UHF range | IV | 470-582 MHZ |
| • UHF range | V | 606-790 MHZ |

11. Why the neck of the picture tube is made narrow? (May 2013)

- For the compactness it is designed with a narrow neck and a large deflection angle of the beam.
- Horizontal deflection coil and Vertical deflection coil for deflecting the Electron beam is positioned at the Neck of the picture tube. For this reason the tubes are made with a narrow neck to put the deflection yoke closer to the electron beam.

12. List out the CCIR-B standards of a V-blanking pulses. (May 2013)

- The duration of the vertical blanking period is equal to 20 line periods
- $VB = 20 H = 1280 \mu s$
- Pre-equalizing(2.5 H) + vertical sync(15 H) + Post equalizing(2.5 H) = 20 H = 1280 μs

13. Calculate the width and height of the TV screen for 60 cm size TV when the aspect ratio is 4:3.(May 2013)

- Total length in diagonal is 60 cm // hyp of the triangle which has the width to height ratio of 4:3.
- Now the actual length of diagonal is calculated by Pythagoras theorem. i.e. 12 cm
- And actual width is $4 * 12 = 48$ cm / height is $3 * 12 = 36$ cm

14. Define picture resolution.(May 2013)

- The ability of the system to resolve maximum number of picture elements along the scanning lines over the frame determines picture resolution.

15. Justify the choice of negative modulation for TV transmission. (May 2012)

What are the advantages of negative modulation? (May 2013)

- The negative polarity of modulation permits a large increase in peak power output and for a given setup in the final transmitter stage the output increases by about 40%.
- In negative system of modulation, amplitude level is the peak of sync pulses which remains fixed at 100 per cent of signal amplitude and is not affected by picture details. This level may be selected simply by passing the composite video signal through a peak detector. In the positive system of modulation the corresponding stable level is zero amplitude at the carrier and obviously zero is no reference, and it has no relation to the signal strength.
- In negative modulation the noise pulses would tend to produce black spots which are less noticeable against a grey background. This merit of lesser noise interference on picture information with negative modulation has led to its use in most TV systems.

16. Give the list of semiconductor materials coated on the target plates of Image orthicon and vidicon.(Dec 2011)

- Image orthicon – Cesium silver
- Vidicon – Antimony, Sb₂ S₃ / Selenium

17. What is potential well? (Dec 2011)

- The application of small positive potentials to the gate electrodes results in the

development of depletion regions just below them. These are called potential wells.

The depth of each well (depletion region) varies with the magnitude of the applied potential. The gate electrodes operate in groups of three, with every third electrode connected to a common conductor. The spots under them serve as light sensitive elements. When any image is focused onto the silicon chip, electrons are generated within it, but very close to the surface.

- The number of electrons depends on the intensity of incident light. Once produced they collect in the nearby potential wells. As a result the pattern of collected charges represents the optical image.

18. Define aspect ratio. (May 2015)

Aspect ratio can be defined as the ratio of width to height of the picture frame. For television, it is standardized as 4:3.

19. Why is an aluminized coating provided on the phosphor screen? (May 2015)

In older picture tubes a magnetic beam, bender commonly known as 'ion-trap' was employed to deflect the heavy ions away from the screen. In present day picture tubes having a thin metal coating on the screen, it is no longer necessary to provide an ion-trap. This is because the ions on account of their greater mass fail to penetrate the metal backing and do not reach the phosphor screen.

Thus an aluminized coating when provided on the phosphor screen, not only improves screen brightness and contrast but also makes the use of 'ion-traps' unnecessary.

Advantages of aluminum layer:

1. It increases the light output from the phosphor to the viewer.
2. It protects the phosphor coating from damage due to ions by absorbing their energy.
3. Since it is connected to high voltage, it helps in collecting the secondary emission electron at the screen.

20. Define positive and negative modulation. (May 2015)

- When the intensity of picture brightness causes increase in amplitude of the modulated envelope, it is called 'positive' modulation.

- When the polarity of modulating video signal is so chosen that sync tips lie at the 100 per cent level of carrier amplitude and increasing brightness produces decrease in the modulation envelope, it is called 'negative modulation'.

21. What is composite video signal?(Dec 2014)

- A signal that contains all three of these components intensity information, horizontal-retrace signals, and vertical-retrace signals is called a composite video signal.

22. What are the IF of video and sound of TV? (Dec 2014)

- Video IF ---- 38.9 MHz
- Sound IF ---- 33.4 MHz

23. Compare between the number of scanning lines of PAL and NTSC systems.(Dec 2014)

Compare between the number of scanning lines and frames of Indian and American TV systems. (May 2013)

- PAL -- British (Indian) 625 lines system / 50 frames per sec.
- NTSC -- American 525 lines system / 60 frames per sec.

24. Distinguish between hue and saturation. (Dec 2014) & (Dec 2013)

- Hue or tint can be defined as the predominant spectral color of the received light. The color of any object is distinguished by its hue or tint.
- Saturation refers to the spectral purity of the color light. It indicates the degree by which the color is diluted by white.

UNIT II**MONOCHROME TELEVISION TRANSMITTER AND RECEIVER****PART A**

1. State the main function of UHF tuners. (May 2015)
 - The purpose UHF tuner unit is to amplify both picture and sound signals picked up the antenna and to convert the carrier frequencies and their associated side bands into intermediate frequencies.

2. What is dipole array? (May 2015)
 - Dipole antenna is used for band I&III transmitters. It consists of dipole panels mounted on the four sides at the top of the antenna tower.
 - Each panel has an array of full wave dipoles mounted in front of reflectors. To get a unidirectional pattern, the four panels mounted on the four sides of the tower are so fed that the current in each lags behind the previous by 90 degree.
 - This is done by changing the field cable length by $\lambda/4$ to the two alternate panels and by reversal of polarity of the current.

3. State the application of a diplexer. (Dec 2011)
Mention the need for diplexer? (Dec 2013)
What is a diplexer? (May 2013)
 - The outputs of both the video and the audio transmitter are combined by the diplexer circuit and given to a common broadcast transmitting antenna.

4. Why is de-emphasis done in TV receivers? (Dec 2011)
 - To eliminate the high frequency noises present in the received signal can be the LPF is used as the De-emphasis circuit in TV receiver.

5. List the functions of TV tuner. (May 2013)
 - The purpose tuner unit is to amplify both picture and sound signals picked up the antenna and to convert the carrier frequencies and their associated side bands into intermediate frequencies.

6. Mention the use of ACC amplifier. (Dec 2013)

- The ACC circuit is similar to the AGC circuit used for automatic gain control of RF and IF stages of the receiver. It develops a dc control voltage that is proportional to the amplitude of the color burst.

7. What are the requirements of TV broadcast transmission? (May 2013)

- Height of the transmitting antenna
- Transmitter power
- Transmission bandwidth(7 MHz)

8. What are the advantages of AGC? (May 2013)

- AGC circuit is used to control the gain of RF and IF amplifiers .The changes in gain is
- Achieved by shifting the operating point of transistors used in the amplifiers.
- The Operating point is changed by a bias voltage that is developed in the AGC circuit.

9. Why EHT is needed in TV circuits? (Dec 2014)

- The EHT (Extra High Tension or HV to the CRT) is generated from a secondary winding on the flyback transformer having several thousand turns of very fine wire.
- If the EHT voltage drops, then the electrons will be accelerated less and will move through the deflection field at a lower velocity. As a result they will be easier to deflect by the magnetic field, and the picture size will grow. Without special measures, brighter pictures will be larger. The measure is to feed some EHT information or beam current information to the deflection circuits, reducing the deflection current amplitude a bit for bright pictures.
- The EHT information is also used to protect the flyback transformer from overload. As the load increases, the average primary current rises. Ultimately it may reach a level where the transformer core may go into saturation. This causes large peak currents in the HOT which might lead to destruction.

10. Mention the use of ACC amplifier. (Dec 2013)

- The ACC circuit is similar to the AGC circuit used for automatic gain control of RF and IF stages of the receiver. It develops a dc control voltage that is proportional to the amplitude of the color burst.

11. Define luminance and hue. (May 2013)

- Luminance can be defined as the quantity of light intensity emitted per square centimeter of an illuminated area.
- Saturation refers to the spectral purity of the color light. It indicates the degree by which the color is diluted by white.

12. What is the purpose of an AGC circuit in a TV receiver? (Dec 2012)

- AGC circuit controls the gain of RF and IF stage to enable almost constant signal voltage at the output of video detector, despite changes in the signal picked up by the antenna. The change in gain is achieved by shifting the operating point of transistors used in the amplifiers. The operating point is changed by a bias voltage that is developed in the bias circuit.

13. Define contrast ratio. (Dec 2013)

- The ratio of maximum to minimum brightness relative to the original picture is called contrast ratio.
- In broad daylight the variations in brightness are very wide with ratio as high as 10000 : 1

14. Why is AM preferred over FM broadcasting the picture signal?

- If FM is adopted for picture transmission, the changing beat frequency between the multiple paths delayed with respect to each other would develop a bar interference in the image with a shimmering effect as the bars continuously changes as the beat frequency changes therefore, no study picture is produced.
- Apart from that, circuit complexity and BW requirements are much less in AM than FM. Hence AM is preferred to FM for broadcasting the picture signal.

15. List any three requirements to be satisfied for compatibility in television systems.

- It should have the same bandwidth as the corresponding monochrome signal.
- The color signal should have the same brightness information as that of monochrome signal.
- The location and spacing of the picture and sound carrier frequencies should remain the same.

16. What do you mean by automatic frequency tuning?

- AFT is used to improve the stability of the oscillator circuit, some drift does occur on account of ambient temperature changes, component aging, power supply voltage fluctuation and so on. The fine tuning control is adjusted to get a sharp picture.

17. List the requirements of receiving antenna. (Dec 2013)

- It must pick up the desired signal and develop maximum signal voltage from the available field strength.
- It must discriminate against unwanted signals like EMI, ghost signals, co-channel interferences.
- It must be capable of wide band operation.

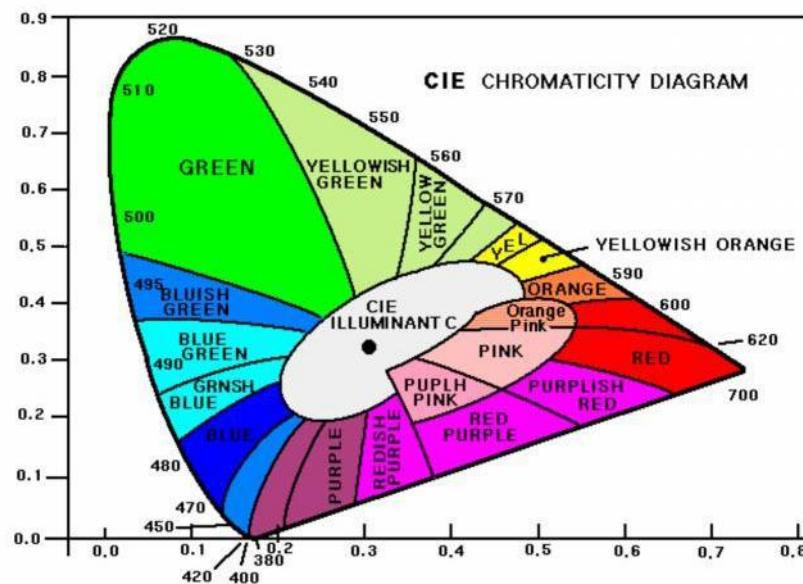
UNIT III ESSENTIALS OF COLOUR TELEVISION

PART A

1. What is ghost interference? (Dec 2012)
 - Ghost interference arises as a result of discrete reflections of the signal from the surface of buildings, bridges, hills, towers etc. Since reflected path is longer than the direct path, the reflected signal takes a longer time to arrive at the receiver.
 - The direct signal is usually stronger and assumes control of the synchronizing circuitry and so the picture, due to the reflected signal that arrives late, appears displaced to the right. On rare occasions, direct signal may be the weaker of the two and the receiver synchronization is now controlled by the reflected signal.

2. Why is a SAW filter preferred over conventional trap circuits for IF band shaping? (Dec 2013)/ What are the advantages of SAW filter? (May 2013)
 - The mechanical acoustic waves are created on a piezoelectric surface by suitable electrodes; frequency selective filtering action can be arranged by interference effects produced by waves. The output of SAW filter is maximum with half wavelength equal to the pitch. At other wavelengths, cancellation takes place.
 - Saw filters are compact, rigid and cost effective than conventional trap circuits Used for video IF selection of TV receivers on a mass production scale, to replace the LC filters by solid state block filters.

3. Draw the chromaticity diagram. (May 2013)



4. What is descrambler? (*Dec 2013*)

- Descramble in Cable television context is the act of taking a scrambled or encrypted Video Signal one that has been processed by a scrambler and provided by a Cable Television company for Premium television services and is then supplied over a Coaxial cable and delivered to the household where a Set-top box reprocesses the signal, thus descrambling it making it available for viewing on the Television set.
- A descrambler is a device that restores the picture and sound of a scrambled channel.
- A descrambler must be used with a Cable converter box to be able to decrypt all the premium & pay-per-view channels of a Cable Television System.

5. What are the basic elements of any projection system? (*Dec 2013*) & (*Dec 2012*)

- High illuminated light assembly
- Camera tube
- Focusing and projecting lens system
- Prism or semi mirror for converge the light

6. What are the primary colors? Why are they called so? (*May 2013*)

- The additive mixing of Red, Green, and Blue produce all the colors encountered in everyday life. Hence they are called primary colors.

7. What is the cause for ghost image in TVs? (*May 2013*)

- Multi path propagation (the reflected signals from the large objects like hills, buildings is received little later w.r.t. direct signal) causes Ghost image.

8. How does the higher definition television differ from a conventional television? (*May 2015*)

- Improvement in both vertical and horizontal resolution of the reproduced Picture by approximately 2:1 over existing standards.
- Much improved color rendition
- Higher aspect ratio of at least 5:3
- Stereophonic sound

9. What is Wobbuloscope? (May 2015)

- This instrument combines a sweep generator, a marker generator and an oscilloscope all in one.
- It is a very useful single unit for alignment of RF, IF and video sections of a TV receiver.
- It may not have all the features of a high quality sweep generator but is an economical and compact piece of equipment specially designed for television servicing.
- The oscilloscope usually has provision for TV-V and TV-H sweep modes. A RF output down to 1 MHz is also available for video amplifier testing

10. What is the application of degaussing circuit? (Dec 2014)

What do you understand by degaussing? (Dec 2013)

- Degaussing means demagnetizing. It is the process of removal magnetic flux forms the magnetized parts in the TV.
- The steel chassis and internal frame that hold mask are subject to induced magnetization whenever the picture tube is switched on.
- This induced magnetic field can affect the electron beam path and produce errors in color purity. In order to prevent such effect the picture tubes are magnetically shielded.
- For this thin silicon steel is housed around the bell of the tube. The mask structure shield material has non-zero retention and so they get weakly magnetized the magnetic field of earth.
- When the receiver is switched on a strong current passes through the degaussing coil. After a few seconds this current is dropped to very low level.

11. What are weighting factors? (Dec 2013)

- The color plexed composite video signal's amplitude exceeds the 100% modulation. So, it is not practicable to transmit this combined signal waveform.
- If over modulation occurs, the reproduced colors will be distorted. So, to avoid over modulation the amplitude of the color difference signals should be reduced.
- Both (R-Y) and (B-Y) signals are multiplied by some factor to reduce the amplitude. This multiplying factor is known as "weighting factor".
- The weighting factor for R-Y signal is 0.877
- The weighting factor for B-Y signal is 0.493.
- The amplitude of the y signal should not be reduced. If it is done the brightness of the picture will be reduced.

12. Why is static convergence adjustment inadequate? (May 2013)

- It is very difficult to converge the three electron beams on the shadow mask for this purpose the permanent magnets are placed rear side of deflection yoke to converge the electron beams in the shadow mask.

13. Why is scrambling needed in Television systems? (Dec 2011)

- It is to suppress the sync signals at transmitting end
- The picture without H and V sync cannot lock into steady picture seen as rolling picture and diamond bars.
- For descrambling, a pilot carrier containing the sync timing information is transmitted on separate carrier.
- Another method with great security and complexity is baseband scrambling, the scrambled coded lines are decoded and it requires demodulation process.
- Scrambling is possible by digital processing of video and audio and introducing complex encryption and smart keyboard for controlled access.

14. Why is a portion of the lower sideband of the AM picture signal transmitted along with the carrier and full VSB? (Dec 2007)

- In AM, very low frequencies contain useful information. This frequencies give rise to sidebands that are very close to the carrier frequency and suppression of lower sideband will leads to objectionable phase error.
- To avoid these problems we need to transmit the full upper sideband and part of the lower sideband.

15. What kind of modulation used for sound signal? Why? (Dec 2012)

- It is possible to accommodate a large number of radio broadcast stations in the limited broadcast band. Since most of the sound signal energy is limited to lower audio frequencies, the sound reproduction is quite satisfactory.
- Frequency modulation, that is capable of providing almost noise free and high fidelity output needs a wider swing in frequency on either side of the carrier. This can be easily allowed in a TV channel, where, because of very high video frequencies a channel bandwidth of 7 MHz is allotted.
- In FM, where highest audio frequency allowed is 15 kHz, the sideband frequencies do not extend too far and can be easily accommodated around the sound carrier that lies 5.5 MHz away from the picture carrier. The bandwidth assigned to the FM sound signal is about 200 kHz of which not more than 100 kHz is occupied by

sidebands of significant amplitude. The latter figure is only 1.4 per cent of the total

channel bandwidth of 7 MHz. Thus, without encroaching much, in a relative sense, on the available band space for television transmission all the advantages of FM can be availed.

16. How pincushion error can be corrected in color picture tube? (Dec 2012)

- Since magnetic deflection of the electron beam is along the path of an arc, with point of deflection as its centre, the screen should ideally have corresponding curvature for linear deflection.
- However, in flat screen picture tubes it is not so and distances at the four corners are greater as compared to central portion of the face plate. Therefore electron beam travels farther at the corners causing more deflection at the edges. This results in a stretching effect where top, bottom, left and right edges of the raster tend to bow inwards towards the centre of the screen.
- Such a distortion is more severe with large screen picture tubes having deflection angles of 90° or more.
- Permanent magnets will solve the purity problems in color picture tube. A dynamic correction method is employed to eliminate the problem. The correction automatically increases the horizontal width and vertical size of the raster due to the pin cushion distortion.

17. What are the drawbacks of Delta gun picture tube? (Dec 2011)

- The convergence problems are very difficult to recover
- Very complex arrangements are required to make the entire electron beam incident on their corresponding phosphor dots at every part of the screen.
- The focus is not sharp over the complete screen.
- Since the electron transparency is very low, lot of energy is wasted in the receiver.

UNIT IV**COLOUR TELEVISION SYSTEMS****PART A**

1. Distinguish between S-PAL and D-PAL. (Dec 2011)
 - The use of eye as the averaging mechanism for the correct hue is the basic concept of simple 'PAL' system. Beyond a certain limit, the human eye see the effect of color changes on alternate lines hence the system needs modification.
 - Considerable improvement found in the system of a delay line is used to do the averaging first and then present the color to the eye. This is called PAL-D or delay line PAL method and is most commonly employed in PAL receivers.
2. State the type of circuits used to separate horizontal and vertical sync pulses. (Dec 2013)
 - Integrator(LPF) and differentiator(HPF)
3. What are trap circuits? (Dec 2013)
 - In the IF amplifier circuitry, provision must be made for rejection of signals from adjacent channels. For this purpose special tuned circuits, called trap circuits, are connected in the signal path in such a way that the offending frequencies are removed.
 - These trap circuits are disposed at convenient places in the IF amplifiers. Their position will vary from receiver to receiver, but generally they are placed in the input circuit of the first IF amplifier.
4. Why different bandwidths are assigned to Q and I signals? (Dec 2013)
 - NTSC system is compatible with 525 line American system. In order to maintain compatibility two new color difference signals are generated and they are represented as I and Q.
 - Since eye is capable of resolving finer details in the regions around I, it is allowed to have a maximum bandwidth of 1.5MHz. The bandwidth of Q signal is restricted to 0.5MHz.

5. What is the significance of color killer circuit? (Dec 2011)
 - The color killer is an electronic stage in color TV receiver sets which acts as a muting circuit to cut off the color amplifiers when the TV receives a monochrome signal.
 - If black and white signal is received, no burst signal is present. So, there is no need for chromo section and the output of chromo amp is zero. For provide this color killer circuit is used.

6. What are the demerits of PAL systems? (May 2015) & (Dec 2012)
 - The use of phase alteration by line technique and associated control circuitry together with the need of a delay line in the receiver makes the PAL system more complicated and expensive. The receiver cost is higher for the PAL color system.

7. Why is it necessary to employ an L-C instead of R-C filter to remove IF ripple from the detected output? (Dec 2007)
 - To avoid over attenuation of the video signal while filtering out the carrier components. So L-C component is employed.

8. Why is the color signal bandwidth requirement much less than that of Y signals? (Dec 2007)
 - By conducting many experiments with different viewers, it is found that , only the color region having an area more than 1/25 th of screen width will give useful color information.
 - So for color signal large bandwidth is not necessary.

9. Why is the color burst signal transmitted after each scanning line and why PAL color burst is often called the swinging burst? (Dec 2007)
 - In PAL system the two carrier components are suppressed in the balanced quadrature modulator it is necessary to regenerate at the receiver for demodulation.
 - For this, 8 to 10 cycles of the color subcarrier oscillator output at the encoder are transmitted along with other sync pulses. This sample of the color subcarrier called color burst and it is placed at the back porch of each horizontal blanking pulse pedestal.
 - The PAL burst phase actually swings 45 about the $-U$ axis from line to line and indicates the same sign as that of the V signal; thus the switching mode information

is the swinging burst. This is known as swinging burst.

10. Justify the choice of 3.579545 MHz as the subcarrier frequency in the NTSC system.

- The color subcarrier frequency in the NTSC system has been chosen to have an exact value equal to 3.579545 MHz.
- The reason for fixing it with such a precision is to maintain compatibility between monochrome and color systems. Any interference between the chrominance signal and higher video frequencies is minimized by employing suppressed carrier (color subcarrier) transmission and by using a notch filter in the path of the luminance signal.
- However, when a color transmission is received on a monochrome receiver a dot pattern structure appears along each raster line on the receiver screen.
- This is caused by the color signal frequencies that lie within the pass-band of the video section of the receiver.

11. List the functions of the following stages of a PAL-D color receiver mentioning their input and output. a) Burst phase discriminator b) Color killer (Dec 2007)

a) Burst phase discriminator

- The burst phase discriminator is used to compare the phase of the color burst and sub carrier frequency generated by the reference oscillator.
- If there is any phase difference which will produce DC control voltage (error voltage) which is fed to reference oscillator.
- In this way the frequency and phase are kept locked in synchronism with the color burst.

b) Color killer

- The color killer is an electronic stage in color TV receiver sets which acts as a muting circuit to cut off the color amplifiers when the TV receives a monochrome signal.
- If black and white signal is received, no burst signal is present. So, there is no need for chromo section and the output of chromo amp is zero. For provide this color killer circuit is used.

12. What are the merits of using an RF amplifier before the frequency converter? (Dec 2007)

- In areas where the signal strength is somewhat less, raising the antenna or using an antenna that is directional and has higher gain results in an acceptable picture.
- However, in deep fringe areas where the signal from the desired station is very weak and fails to produce any worthwhile picture, an additional RF amplifier external to the receiver becomes necessary. Such amplifiers are known as booster

amplifiers and are normally mounted on the antenna mast close to the antenna terminals.

- A booster amplifier is a broad-band transistor RF amplifier designed to have a reasonable gain but a very high internal signal-to-noise ratio. It may be emphasized that a booster capable of providing a high gain but incapable of providing a good signal-to-noise ratio will give a picture with a lot of snow.
- Similarly, a booster amplifier having minimum internal noise but low gain will fail to provide a satisfactory picture. Thus a booster amplifier must have both the attributes, *i.e.* reasonable gain and high signal-to-noise ratio.

13. What is gamma correction?

- A color camera is used to develop three voltages proportional to red, green and blue color contents of the picture. These voltages are represented as R,G,B and correction is applied to these voltages to compensate for any nonlinearity of the system and that of the picture tube. This is called gamma correction. *i.e.* the camera tube output voltage amplitudes are normalized to I V p-p level.

14. Give the exact color sub carrier frequency of NTSC system. (*Dec 2014*)

- Color sub carrier frequency of NTSC system is exactly 3.579545 MHz.

15. What is the use of color subcarrier oscillator?

- The function of subcarrier oscillator is to generate a carrier wave output at 3.57MHz and feed it to the demodulators. The subcarrier frequency is maintained at its correct value and phase by the APC circuit.

16. Give the sound and picture IF values of PAL-D TV receiver. (*May 2013*)

- Video IF ----- 38.9 MHz
- Sound IF ----- 33.4 MHz

17. List the features of PAL color system. (*May 2013*)

- The weighted (B-Y) and (R-Y) signals are modulated without being given a phase shift of 33° as is done in the NTSC system.
- On modulation both the color difference signals are allowed the same bandwidth of about 1.3MHz.
- The color subcarrier frequency is chosen to be 4.43MHz.
- The weighted color difference signals are quadrature modulated with the subcarrier.

UNIT V
ADVANCED TELEVISION SYSTEMS

PART A

1. List the merits of Digital TV receiver. (May 2013) / List the merits of digital TV receivers that are not achievable in a analog receiver. (Dec 2007)
 - Reduced Ghosts
 - Reduction of 50Hz flicker
 - High resolution pictures
 - Slow motion action

2. What do you mean by EDTV. (May 2013)
 - EDTV is mainly intended for direct broadcasting satellite system.
 - To improve the performance of the TV system it requires different transmission standards but it maintain the present line numbers and field rates.

3. Why FM is used in satellite TV system? (May 2013)
 - If we compare analog frequency modulation (FM) with analog amplitude modulation (AM), the FM better performance is due to the fact that the signal to noise ratio at the demodulator output is higher for wideband FM than for AM. For the transmission of a television signal over a satellite, the amplitude modulation would be severely affected by losses, various forms of interference, and nonlinearities in the transponder.
 - By the other hand frequency modulation is also more robust against signal amplitude fading phenomena. For a video signal, using the Carson's rule, the required bandwidth is 32.4 MHz, thus a bandwidth of 36 MHz was originally chosen for a satellite transponder in order to accommodate one analog FM television channel.
 - And since the FM television channel occupies the entire transponder bandwidth, this can be operated at full power without any inter modulation interference caused by the nonlinear transfer characteristic.

4. State the use of geostationary satellite for TV system. (May 2013)
 - The shear range of programmes currently available on satellite channel is very much impressive such as 24-hour music videos, news, and feature films.
 - Commercial radio, TV broadcasting, telecommunications, weather forecasting, Global positioning

- A variety of general entertainment programmes, sports, children's programmes, foreign language broadcasts and cultural programmes are all available for the keyboard dish owner.
 - Some of these come through subscription channels and others by free to watch channels which are sponsored by advertising
5. What are the advantages of HDTV? (Dec 2012)
- High quality image and sound
 - Wide screen aspect ratio for 103 cm trinitron(16 : 9)
 - The HDTV has the resolution of approximately twice the vertical and horizontal resolution of ordinary TV
6. Differentiate DVD from CD. (Dec 2013)
Distinguish between VCD and DVD. (Dec 2011)
- Programmes on DVD can be four times longer than VCD
 - DVD video disc holds over 4 hours while the VCD holds 74 minutes.
 - DVD video has up to 8 digital audio tracks. Each track can hold uncompressed audio with quality better than audio CD
 - The quality of DVD video vast exceeds that of video CD, with 4 times the resolution in normal mode and 5.5 times in wide screen mode.
7. What are the transmission principles behind digital TV? (Dec 2014)
- Sampling
 - Analog to digital conversion
 - Video / Audio signal quantizing
 - Binary Encoding
8. What is the value of characteristic impedance of coaxial cable used for CATV? (Dec 2014)
- The value of characteristic impedance of coaxial cable (RG-59U ½ inch flexible cable) used for CATV is 75
9. What are two types of video disc system?
- Laser or optical disc system
 - Capacitance disc system

10. What do you mean by longitudinal video recording?

- A method in which video signals are recorded on at least several tracks along the length of the tape.

11. Give the applications of video tape recorders.

- Smaller and lower priced video tape recorders using ½ inch tape are available for closed type circuit TV or for use in the home. They can record and playback programs on a television receiver in color and monochrome.
- In addition to that small portable cameras are provided for a complete television system with the recorder. These portable systems are also employed for taping television programs from a remote are also employed for taping television programs from a remote location for away from the TV broadcast studio.

12. Define bullet amplifier.

- The LNA low noise amplifier is provided in the middle of coaxial cable to compensate any losses in it. This LNA is often called as bullet amplifier.

13. What do you mean by helical scan recording?

- In helical scan recording, the two recording heads 'look at ' the tape surface as it is drawn past them through two tiny rectangular slits mounted on opposite sides of the drum. The heads thus trace out diagonal tracks across the tape, one track per head.

14. Why are up-link and down-link frequencies chosen to be in the GHz range and kept fairly apart from each other? (Dec 2007)

- The transponder cannot transmit and receive on same frequency, because the transmitter signal can overload the receiver and block the small up-link frequency signal and thereby prohibiting the communication.
- The frequencies used for this purpose are in microwave frequency range from (3 to 30 GHz). During UHF, the atmosphere does not act as a barrier and signals can able to travel out into space and return back without any absorption or deflection.

15. Write short notes on CATV.

- CATV stands for community antenna television systems. The CATV system is a cable system distributes good quality television signal to a very large number of receivers throughout an entire community.
- Generally this system gives increased TV programmes to subscribers who pay a fee for this service. A cable system may have many more active VHF and UHF channels than a receiver tuner can directly select.

16. What do you mean by translator?

- Translator is a frequency converter which heterodynes the UHF channel frequencies down to a VHF channel.

17. Define uplink frequency in satellite communication.

- The frequency at which the information signals are transmitted from earth station to the satellite is called uplink frequency. Most the communication satellite uses C band frequencies.

Electronics and Communication Engineering

Seventh Semester

Regulation 2008

November /December 2014

EC2034-Television and Video Engineering

Part A (10*2=20)

1. Compare between the number of scanning lines of PAL and NTSC systems.
2. What is composite video signal?
3. What are the IF of video and sound of TV?
4. Why EHT is needed in TV circuits.
5. Distinguish between Hue and Saturation.
6. What is the application of degaussing circuit?
7. Give the exact colour sub carrier frequency of NTSC system.
8. Draw the phase diagrams of the I and Q signals in the NTSC system.
9. What are the transmission principles behind digital TV?
10. What is the value of characteristic impedance of coaxial cable used for CATV?

Part B (5*16=80)

11. A.1. With neat diagrams explain the principle of interlaced scanning with clear mention about the scanning periods. Describe its scanning sequence.

2. Calculate vertical resolution, horizontal resolution and modulating frequency of F_h for a 625 line TV system with kell factor of 0.69 and a aspect ratio of 4:3.

Or

B.1. State how a solid state image scanner is constructed, and explain its operation Describe the principle of scanning of TV picture in it.

2. Explain the beam deflection principle in monochrome picture tube.

12.A.1. Draw and explain some of the TV transmitting and receiving antennas.

2. Sketch the current waveforms in the deflection yoke coils to produce full raster. Explain the basic principles of producing such waveforms.

Or

1. Describe the basic principles of AGC and explain how the control voltage is developed and applied to IF and RF amplifier stages in the receiver.

2. Draw the basic LPF and HPF configurations which are used to separate vertical and horizontal sync information and explain.

13.A.1. Describe with a diagram the construction of colour TV camera and its optical system. Why is the 'r' signal set $=0.3R+0.59G-0.11B$.

2. Explain the various pincausion correction techniques.

Or

B.1. Describe the construction details of a PLL tube and explain how its different from delta gun colour tube. What are astigmatism and errors in it?

2. Describe the formation of the chrominance signals for RGB. Black and White colours.

14.A. Draw the block diagrams of a PAL coder and decoder and explain their operations by showing waveforms at various stages.

Or

B. Explain the essentials of SECAM system and describe the working of its encoder and decoder with the help of their block diagram.

15.A.1. With the neat block diagram explain the domestic broadcast system. How does it differ from CATV?

2. Write short notes on projection television?

Or

B.1. Draw and explain the principle of DVD players. Explain the recording and playback detail with diagram.

2. State the principles of 3DTV and HDTV.

Reg. No. :

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R 3277

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2007.

Seventh Semester

(Regulation 2004)

Electronics and Communication Engineering

EC 1011 — TELEVISION AND VIDEO ENGINEERING

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the significance of choosing the number of lines as 625 and not 623 or 627 and the frame reception rate as 25 and not 24 as in motion pictures?
2. Why is a portion of the lower sideband of the AM picture signal transmitted along with the carrier and full VSB?
3. What are the merits of using an RF amplifier before the frequency converter?
4. Why is it necessary to employ an L-C instead of R-C filter to remove IF ripple from the detected output?
5. Why is the colour signal bandwidth requirement much less than that of Y signal?
6. Why is the colour burst signal transmitted after each scanning line and why PAL colour burst is often called the swinging burst?
7. Justify the choice of 3.579545 MHz as the subcarrier frequency in the NTSC system.

8. List the functions of the following stages of a PAL-D colour receiver mentioning their input and output. (a) Burst-phase discriminator (b) Colour killer.
9. Why are up-link and down-link frequencies chosen to be in the GHz range and kept fairly apart from each other?
10. List the merits of digital TV receivers that are not achievable in a analog receiver.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Show that the highest modulating frequency that needs to be handled in the 625 TV system is 5 MHz. Discuss the effect of number of lines, interlaced scanning and field frequency on bandwidth. (9)
- (ii) For the composite Video Signal explain the following :
 - (1) Why are the horizontal pulses not used as sync. pulses. (3)
 - (2) Why is it necessary to separate the broad vertical sync. pulse and why are they notched at 32 μ s interval and not at 64 μ s interval. (4)

Or

- (b) (i) Discuss the merits and demerits of positive and negative amplitude modulation and justify the choice of negative modulation in most TV systems. (8)
 - (ii) Explain how the inherent smear effect in a vidicon is overcome in a plumbicon. Explain with a suitable sketch the mechanism by which the video signal is developed from the P-I-N structure of its target. (8)
12. (a) (i) Describe briefly the factors that influenced the choice of picture IF = 38.9 MHz and sound IF = 33.4 MHz in the 625-B monochrome television system. (8)
 - (ii) What is electronic tuning? Explain with circuit diagram how different channels can be selected by this method. (8)

Or

- (b) (i) Give the constructional details of a turnstile antenna and explain by drawing radiation pattern its suitability for television transmission. (8)
 - (ii) Explain with a circuit diagram how the high voltage pulses, induced in the output transformer windings, are used to generate EHT supply. (8)
13. (a) (i) Explain how by frequency inter leaving the colour information is accommodated within the same channel bandwidth of 7 MHz. (8)
- (ii) Explain the need for pincushion distortion correction and the method employed to obtain a distortion free raster? (8)

Or

- (b) (i) What are weighting factors and why are these applied to colour-difference signals before quadrature modulation. Draw chrominance signal wave shape for a colour bar pattern and justify the scaling down of (R-Y) and (B-Y) signals. (10)
 - (ii) Describe the gun structure and focussing details of trinitron picture tube. (6)
14. (a) (i) Explain how the differential phase-error is continuously corrected in the PAL system while affecting QAM of the colour difference signals. (8)
- (ii) Show the colour kill circuit and explain how the chrominance signal remains interrupted during monochrome transmission and how Indent signal is generated? (8)

Or

- (b) (i) Explain the delay line method of separating U and V signals in a PAL receiver. (6)
- (ii) Describe the circuit of colour burst blanking and Ist stage of the chroma band-pass amplifier. Explain the circuit of the saturation control in the chroma bandpass amplifier. (10)

15. (a) (i) Draw the block diagram of a TVRO earth station receiver and explain how the converted down-link IF signal of a TV channel is processed to obtain both Video and Audio signals. (8)
- (ii) Describe how the associated signals of 3-D pictures can possibly be transmitted, received and viewed on present-day receivers. (8)

Or

- (b) (i) Describe the new TV standards for HDTV service. (6)
- (ii) Draw the functional block diagram of a digital colour receiver and explain how the audio signal is separated and processed to obtain analog sound output. (10)
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Reg. No. :

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Question Paper Code : 55320

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2011.

Seventh Semester

Electronics and Communication Engineering

EC 2034 — TELEVISION AND VIDEO ENGINEERING

(Regulation 2008)

Time : Three hours

Maximum : 100 marks

Answer ALL questions. PART

A — (10 × 2 = 20 marks)

1. Give the list of semiconductor materials coated on the target plates of Image orthicon and vidicon.
2. What is potential well?
3. State the application of a diplexer.
4. Why is deemphasis done in TV receivers?
5. State any four conditions to be fulfilled for compatibility.
6. What are the drawbacks of Delta gun picture tube?
7. Distinguish between S-PAL and D-PAL.
8. What is the significance of colour killer circuit?
9. Why is scrambling needed in Television systems?
10. Distinguish between VCD and DVD.

PART B — (5 × 16 = 80 marks)

11. (a) (i) What is kell factor? How does it affect resolution? Derive the resolution of Indian TV system for a kell factor of 0.69. (8)
- (ii) What is a composite video signal? Draw and explain its various contents. (8)

Or

- (b) Draw the cross sectional view and explain the operations of
- (i) Silicon diode array vidicon (8)
- (ii) Solid state image scanners. (8)
12. (a) (i) What are the different types of VHF tuners? Explain the various sections of a VHF tuner with block diagram. (8)
- (ii) Draw the video IF amplifier with cascaded interstage and explain its operation. (8)

Or

- (b) Draw the simplified block diagram of a TV transmitter and explain its operation and effect of noise pulses in positive and negative modulation. (16)
13. (a) (i) Discuss the relative merits of magnetic deflection and electrostatic deflection. (6)
- (ii) Describe the working of Delta gun picture tube. Why this tube is superseded by PIL picture tube? (10)

Or

- (b) (i) Write a short note on the degaussing operation in colour televisions. (6)
- (ii) Explain in detail the purity, static and dynamic convergence adjustments of colour picture tube. (10)

14. (a) Draw the block diagram and explain the operation of PAL encoder and decoder. (16)

Or

- (b) Explain the operation of SECAM encoder and decoder with neat diagrams. (16)
15. (a) (i) Draw the block diagram of satellite TV systems and explain its operation. (8)
- (ii) Explain in detail the concepts behind the digital Televisions transmission and reception. (8)
- Or
- (b) (i) Draw the layout of Teletext system and explain. How is it used in modern TV systems? (8)
- (ii) Draw the block diagram of DVD playback system and explain its working. Explain how the capacity of DVD can be increased. (8)

PART B — (5 × 16 = 80 marks)

11. (a) (i) Illustrate the working principle of Image Orthicon camera tube. List its drawback. (10)
(ii) Justify why all TV system have odd number of scanning lines. (6)
- Or
- (b) (i) Draw and explain composite video signal. (10)
(ii) Brief why negative modulation technique is used in TV system. (6)
12. (a) (i) Draw and explain the block diagram of TV transmitter. (10)
(ii) Brief the factors that decide the choice of IF in TV system. (6)
- Or
- (b) (i) List the need and types of AGC circuit used in TV system. (10)
(ii) Discuss the construction features and working principle of turnstile antenna. (6)
13. (a) Discuss the gun structure and working principle of delta gun colour picture tubes. (16)
- Or
- (b) (i) Narrate the need for pincushion distortion correction and the method employed to obtain a distortion free raster (8)
(ii) What are purity and convergence adjustments? Explain the function of degaussing coil in a colour TV receiver. (8)
14. (a) Explain the SECAM encoder and decoder with the help of a block diagram. Compare its performance with standard systems. (16)
- Or
- (b) Write short notes on :
(i) Color Killer Circuit (8)
(ii) U and V demodulators. (8)
15. (a) (i) Narrate the working of Cable TV. (8)
(ii) Illustrate the need and concept of scrambling technique. (8)
- Or
- (b) Brief the following :
(i) LCD (8)
(ii) 3DTV. (8)

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Question Paper Code : 21334

B.E./B.Tech. DEGREE EXAMINATION , MAY/JUNE 2013

Seventh Semester

Electronics and Communication Engineering

EC 2034/EC 711/EC 1007 – TELEVISION AND VIDEO ENGINEERING

(Regulation 2008)

(Common to PTEC 2034 – Television and Video Engineering For B.E. (Part Time) Sixth Semester Electronics and Communication Engineering – (Regulation 2009))

Time : Three hours

Maximum : 100 marks

Answer ALL questions

PART A – (10 X 2 = 20 marks)

1. Define picture resolution.
2. Justify the choice of negative modulation for TV transmission.
3. List the functions of TV tuner.
4. What are the advantages of AGC?
5. Define luminance and hue.
6. Draw the chromaticity diagram.
7. List the features of PAL color system.
8. Draw the circuit diagram of ACC amplifier.
9. List the merits of Digital TV receiver.
10. What do you mean by EDTV.

PART B – (5 X 16 = 80 marks)

11. (a) (i) What is interlaced scanning? Explain in detail. (10)
- (ii) Draw and explain the construction and working of vidicon camera tube. (6)

(Or)

- (b) Sketch a neat Figure of Monochromatic picture tube and explain beam deflection, picture tube screen , picture tube control. (16)

12. (a) Write short notes on :

(1) DC reinsertion

(2) ERT generation.

(16)

(Or)

(b) With the help of a neat diagram , discuss the monochrome TV receiver in detail.

13. (a) (i) Draw the Delta-Gun color picture tube and explain the operation. What are the drawbacks of Delta-Gun tube? (10)

(ii) With the help of neat diagram, explain automatic degaussing circuit. (6)

(Or)

(b) (i) Describe three color theory with suitable diagram. (8)

(ii) Write short notes on pincushion correction techniques. (8)

14. (a) Explain the concept of SECAM coder and decoder. (16)

(Or)

(b) (i) Draw and explain the function of color killer and ident circuits. (8)

(ii) Explain Burst phase discriminator with a neat diagram. (8)

15. (a) Give detailed notes on Digital TV transmission and reception. (16)

(Or)

(b) (i) With neat diagram, explain Tele text broadcast receiver. (8)

(ii) Draw and explain the concept of cable signal distribution. (8)

Question Paper Code: 31284

B.E.IB.Tech. DEGREE EXAMINATION, *MAY/JUNE* 2013.

Seventh Semester

Electronics and Communication Engineering

080290057 -TELEVISION AND VIDEO ENGINEERING

(Regulation 2008)

Time: Three hours

Maximum: 100 marks

Answer ALL questions .

.PART A --,-(10 x 2 = 20 marks)

1. Compare between the number of scanning lines and frames of Indian and American Televisions.
2. What is known as flicker?
3. Why is back porch longer than front porch?
4. List out the frequency.bands ofTY broadcast channels.
5. What are the requirements of TV broadcast transmission?
6. What is a diplexer? State its application.
7. What are the advantages of SAW filter?
8. Give the sound and picture IF values of PAL-D TV receiver.
9. What is a Wobbuloscope?
10. State the use of geostationary satellite for TV system.

11. (a) (i) What is interlaced scanning? How does it reduce flicker and conserve bandwidth? Explain. (8)
- (ii) Describe how photoemissive and photo conductive techniques are used in Camera tubes. (8)

Or

- (b) (i) Define horizontal and vertical resolutions. Show that the highest modulating frequency in 625 lines system could be' 5 MHz. (8)
- (ii) With neat diagrams, explain the operation of a CCD solid state Image scanner. (8)
12. (a) Draw the horizontal and vertical sync pulse and mark their time duration. Explain their application in scanning process in detail. (16)

Or

- (b) (i) Compare between any eight standards of NTSC, PAL and SECAM systems. (8)
- (ii) Explain the operations involved in production and master control rooms of a TV studio. (8)
13. (a) (i) Describe briefly co-channel and adjacent channel interference effects. How these can be'eliminated in fringe areas? (8)
- (ii) Describe the' operation and design specifications of Yagi-Vda antenna. (8)

Or

- (b) (i) Draw a simplified block diagram of a TV transmitter and explain. What are the differences between monochrome and' colour transmitters? (8)
- (ii) Describe an antenna set-up suitable for TV signal transmission in all directions with equal strength. (8)

14. (a) (i) Draw a VHF/UHF tuner with AFT and explain its working. (8)
- (ii) Draw the cross sectional view of a Trinitron picture tube and explain its working. (8)

Or

- (b) (i) Draw the block diagram of a PAL-b TV receiver and explain. (8)
- (ii) Explain automatic degaussing and pincushion correction operations of a colour TV picture tube. (8)
15. (a) Describe in detail the Teletext picture with its data lines. How are the teletext informations are coded? Draw and explain the teletext TV receiver. (16)

Or

- (b) (i) Describe the application of satellite communication in the domestic broadcasting systems. (8)
- (ii) Write a detailed note on HDTV. (8)

(Common to **PT** C 2034 - Television and Video [Engineering ForB'].
(partTime) SixthSemester Electronics and Communication
[Engineering- (Regulation 2009))

Part-B : 16 marks

1. Sketch a neat Figure of Monochromatic picture tube and explain beam deflection, picture tube screen, picture tube control.
2. Draw neat cross sectional view and explain the operations of (i) Silicon diode array vidicon (ii) Solid state image scanners.
3. What is Kell factor? how does it affect resolution? derive the resolution for Indian TV system for a Kell factor of 0.69.
4. Explain in detail about Interlaced Scanning.
5. With the help of a neat diagram, discuss the monochrome TV receiver in detail.
6. Draw a simplified block diagram of a TV transmitter and explain its operation and effect of noise pulses in positive and negative modulation.
7. Write short notes on: (1) DC reinsertion, (2) ERT generation.
8. Draw a neat block diagram of video IF amplifier with cascade interstages and explain its operations.
9. Draw a neat Delta-Gun color picture tube and explain the operation. What are the drawbacks of Delta-Gun tube?
10. Describe three color theory with suitable diagram.
11. Explain in detail the purity, static and dynamic convergence adjustments of colour picture tube.
12. Explain degaussing operation in color television.
13. Explain the concept of SECAM coder and decoder.
14. Draw a neat block diagram and explain the operation of PAL encoder and decoder.
15. Explain Burst phase discriminator with a neat diagram.
16. Give detailed notes on Digital TV transmission and reception.
17. Draw the block diagram of satellite TV systems and explain its operation.
18. Draw a neat block diagram of DVD playback system and explain its working. Explain how the capacity of DVD can be increased.
19. With neat diagram, explain Tele text broadcast receiver.