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INTRODUCTION TO TELEVISION

INTRODUCTION

The aim of a television system is to extend the sense of sight beyond its natural limits and to transmit sound associated with the scene. The picture signal is generated by a TV camera and sound signal by a microphone. In the 625 line CCIR monochrome and PAL-B colour TV systems adopted by India, the picture signal is amplitude modulated and sound signal frequency modulated before transmission. The two carrier frequencies are suitably spaced and their modulation products radiated through a common antenna. As in radio communication, each television station is allotted different carrier frequencies to enable selection of desired station at the receiving end.

The TV receiver has tuned circuits in its input section called 'tuner'. It selects desired channel signal out of the many picked up by the antenna. The selected RF band is converted to a common fixed IF band for convenience of providing large amplification to it. The amplified IF signals are detected to obtain video (picture) and audio (sound) signals. The video signal after large amplification drives the picture tube to reconstruct the televised picture on the receiver screen. Similarly, the audio signal is amplified and fed to the loudspeaker to produce sound output associated with the scene.

1.1 PICTURE TRANSMISSION

The picture information is optical in character and may be thought of as an assemblage of a large number of tiny areas representing picture details. These elementary areas into which picture details may be broken up are known as 'picture elements' or 'pixels', which when viewed together represent visual information of the scene. Thus, at any instant there are almost an infinite number of pieces of information that need to be picked up simultaneously for transmitting picture details. However, simultaneous pick-up is not practicable because it is not feasible to provide a separate signal path (channel) for the signal obtained from each picture element. In practice, this problem is solved by a method known as 'scanning' where conversion of optical information to electrical form is carried out element by element, one at a time and in a sequential manner to cover the entire picture. Besides, scanning is done at a very fast rate and repeated a large number of times per second to create an illusion (impression at the eye) of simultaneous reception from all the elements, though using only one signal path.

Black and White Pictures

In a monochrome (black and white) picture, each element is either bright, some shade of grey or dark. A TV camera, the heart of which is a camera tube, is used to convert this optical information into corresponding electrical signal, the amplitude of which varies in accordance with variations of brightness. Fig. 1.1 shows very elementary details of one type of camera tube (vidicon) and associated components to illustrate the principle. An optical image of the scene to be transmitted is focused by a lens assembly on the rectangular glass face-plate of the camera tube. The inner side of the glass face-plate has a transparent conductive coating on which is laid a very thin layer of photoconductive material. The photolayer has very high resistance when no light falls on it, but decreases depending on the intensity of light falling on it. Thus depending on light intensity variations in the focused optical image, the conductivity of each element of photolayer changes accordingly. An electron beam is used to pick-up picture information now available on the target plate in terms of varying resistance at each point.

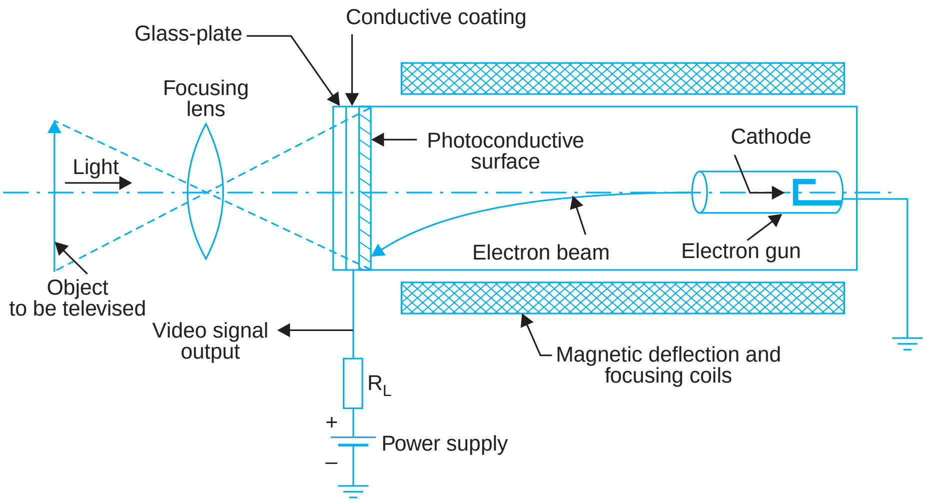

Fig. 1.1. Simplified cross-sectional view of a Vidicon camera tube and associated components.

The beam is formed by an electron gun in the TV camera tube. On its way to the inner side of glass face-plate, it is deflected by a pair of deflecting coils mounted on the glass envelope and kept mutually perpendicular to each other to achieve scanning of the entire target area. Scanning is done in the same way as one reads a written page to cover all the words in one line and all the lines on the page (see Fig. 1.2). To achieve this, the deflecting coils are fed separately from two sweep oscillators which continuously generate suitable waveform voltages, each operating at a different desired frequency. Magnetic deflection caused by the current in one coil gives horizontal motion to the beam from left to right at uniform rate and then brings it quickly to the left side to commence trace of the next line. The other coil is used to deflect the beam from top to bottom at a uniform rate and for its quick retrace back to the top of the plate to start this process over again. Two simultaneous motions are thus given to the

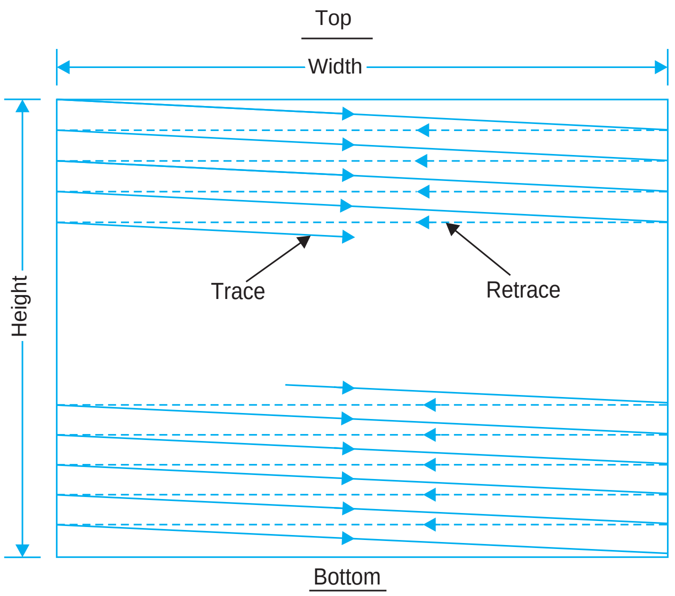

Fig. 1.2. Path of scanning beam in covering picture area.

beam, one from left to right across the target plate and the other from top to bottom thereby covering entire area on which electrical image of the picture is available. As the beam moves from element to element, it encounters a different resistance across the target-plate, depending on the resistance of photoconductive coating. The result is a flow of current which varies in magnitude as the elements are scanned. This current passes through a load resistance R_L, connected to the conductive coating on one side and to a dc supply source on the other. Depending on the magnitude of current, a varying voltage appears across resistance R_L and this corresponds to optical information of the picture.

If the scanning beam moves at such a rate that any portion of the scene content does not have time to change perceptibly in the time required for one complete scan of the image, the resultant electrical signal contains true information existing in the picture during the time of scan. The desired information is now in the form of a signal varying with time and scanning may thus be identified as a particular process which permits conversion of information existing in space and time co-ordinates into time variations only. The electrical information thus obtained from the TV camera tube is generally referred to as video signal (video is Latin for 'see').

Colour Pictures

It is possible to create any colour including white by additive mixing of red, green and blue colour lights in suitable proportions. For example, yellow can be obtained by mixing red and green colour lights in intensity ratio of 30 : 59. Similarly, light reflected from any colour picture element can be synthesised (broken up) into red, green and blue colour light constituents. This forms the basis of colour television where Red (R), Green (G) and Blue (B) colours are called primary colours and those formed by mixing any two of the three primaries as complementary colours. A colour camera, the elements of which are shown in Fig. 1.3, is used to develop signal voltages proportional to the intensity of each primary colour light.

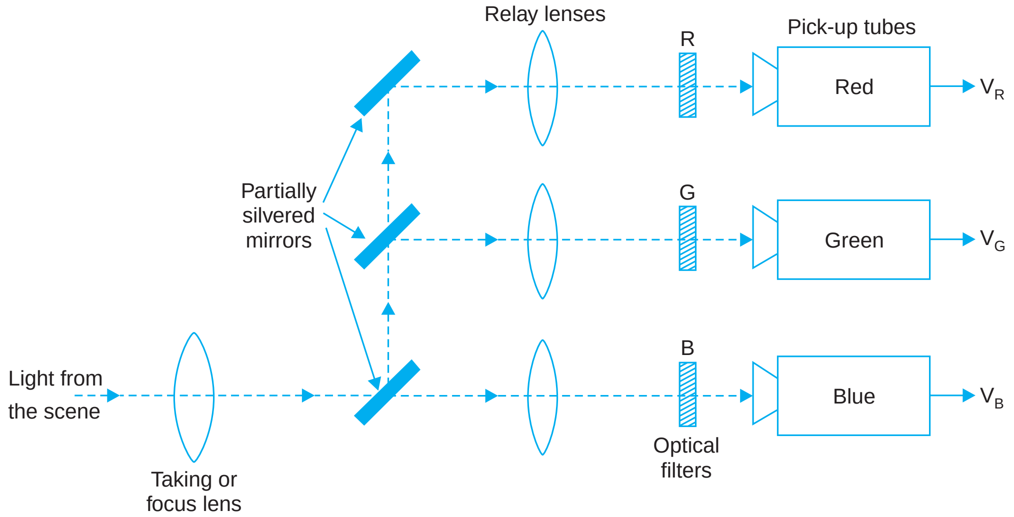

Fig. 1.3. Simplified block diagram of a colour camera.

It contains three camera tubes (vidicons) where each pick-up tube receives light of only one primary colour. Light from the scene falls on the focus lens and through that on special mirrors.

Colour filters that receive reflected light via relay lenses split it into R, G and B colour lights. Thus, each vidicon receives a single colour light and develops a voltage proportional to the intensity of one of the primary colours. If any primary colour is not present in any part of the picture, the corresponding vidicon does not develop any output when that picture area is scanned. The electron beams of all the three camera tubes are kept in step (synchronism) by deflecting them horizontally and vertically from common driving sources.

Any colour light has a certain intensity of brightness. Therefore, light reflected from any colour element of a picture also carries information about its brightness called luminance. A signal voltage (Y) proportional to luminance at various parts of the picture is obtained by adding definite proportions of V_R, V_G and V_B (30:59:11). This then is the same as would be developed by a monochrome (black and white) camera when made to scan the same colour scene. This *i.e.*, the luminance (Y) signal is also transmitted alongwith colour information and used at picture tube in the receiver for reconstructing the colour picture with brightness levels as in the televised picture.

1.2 TELEVISION TRANSMITTER

An oversimplified block diagram of a monochrome TV transmitter is shown in Fig. 1.4. The luminance signal from the camera is amplified and synchronizing pulses added before feeding it to the modulating amplifier. Synchronizing pulses are transmitted to keep the camera and picture tube beams in step. The allotted picture carrier frequency is generated by a crystal controlled oscillator. The continuous wave (CW) sine wave output is given large amplification before feeding to the power amplifier where its amplitude is made to vary (AM) in accordance with the modulating signal received from the modulating amplifier. The modulated output is combined (see Fig. 1.4) with the frequency modulated (FM) sound signal in the combining network and then fed to the transmitting antenna for radiation.

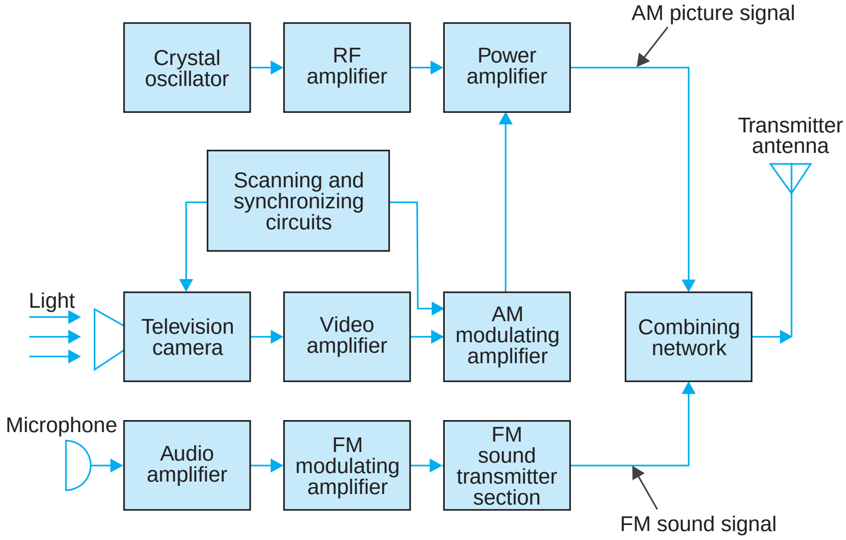

Fig. 1.4. Elementary block diagram of a monochrome television transmitter.

Colour Transmitter

A colour TV transmitter is essentially the same as the monochrome transmitter except for the additional need that colour (chroma) information is also to be transmitted. Any colour system is made compatible with the corresponding monochrome system. Compatibility means that the colour TV signal must produce a normal black and white picture on a monochrome receiver and a colour receiver must be able to produce a normal black and white picture from a monochrome TV signal. For this, the luminance (brightness) signal is transmitted in a colour system in the same way as in the monochrome system and with the same bandwidth. However, to ensure compatibility, the colour camera outputs are modified to obtain (B-Y) and (R-Y) signals. These are modulated on the colour sub-carrier, the value of which is so chosen that on combining with the luminance signal, the sidebands of the two do not interfere with each other *i.e.*, the luminance and colour signals are correctly interleaved. A colour sync signal called 'colour burst' is also transmitted for correct reproduction of colours.

Sound Transmission

There is no difference in sound transmission between monochrome and colour TV systems. The microphone converts the sound associated with the picture being televised into proportionate electrical signal, which is normally a voltage. This electrical output, regardless of the complexity of its waveform, is a single valued function of time and so needs a single channel for its transmission. The audio signal from the microphone after amplification is frequency modulated, employing the assigned carrier frequency. In FM, the amplitude of carrier signal is held constant, whereas its frequency is varied in accordance with amplitude variations of the modulating signal. As shown in Fig. 1.4, output of the sound FM transmitter is finally combined with the AM picture transmitter output, through a combining network, and fed to a common antenna for radiation of energy in the form of electromagnetic waves.

1.3 TELEVISION RECEIVER

A simplified block diagram of a black and white TV receiver is shown in Fig. 1.5. The receiving antenna intercepts radiated RF signals and the tuner selects desired channel's frequency band and

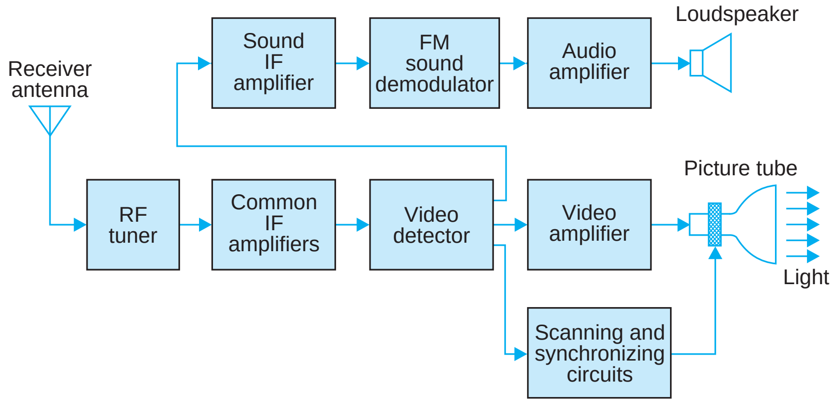

Fig. 1.5. Simplified block diagram of a black and white TV receiver.

converts it to the common IF band of frequencies. The receiver employs two or three stages of intermediate frequency (IF) amplifiers. The output from the last IF stage is demodulated to recover the video signal. This signal that carries picture information is amplified and coupled to the picture tube which converts the electrical signal back into picture elements of the same degree of black and white.

The picture tube shown in Fig. 1.6 is very similar to the cathode-ray tube used in an oscilloscope. The glass envelope contains an electron-gun structure that produces a beam of electrons aimed at the fluorescent screen. When the electron beam strikes the screen, light is emitted. The beam is deflected by a pair of deflecting coils mounted on the neck of picture tube in the same way as the beam of camera tube scans the target plate. The amplitudes of currents in the horizontal and vertical deflecting coils are so adjusted that the entire screen, called raster, gets illuminated because of the fast rate of scanning.

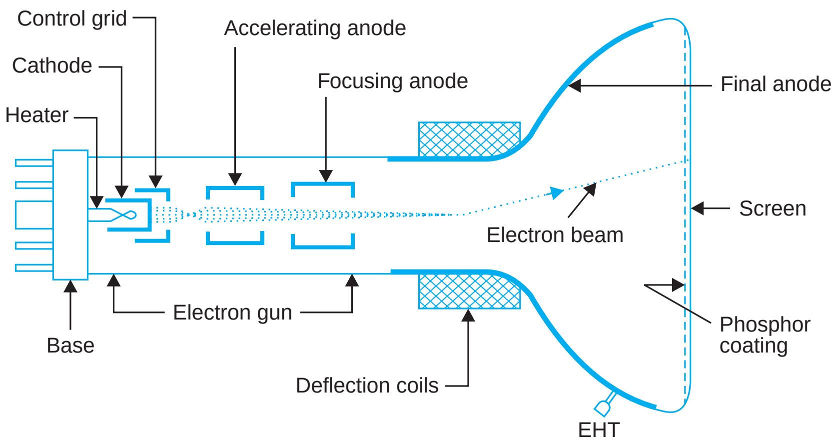

Fig. 1.6. Elements of a picture tube.

The video signal is fed to the grid or cathode of picture tube. When the varying signal voltage makes the control grid less negative, the beam current is increased, making the spot of light on the screen brighter. More negative grid voltage reduces brightness. If the grid voltage is negative enough to cut-off the electron beam current at the picture tube, there will be no light. This state corresponds to black. Thus the video signal illuminates the fluorescent screen from white to black through various shades of grey depending on its amplitude at any instant. This corresponds to brightness changes encountered by the electron beam of the camera tube while scanning picture details element by element. The rate at which the spot of light moves is so fast that the eye is unable to follow it and so a complete picture is seen because of storage capability of the human eye.

Sound Reception

The path of sound signal is common with the picture signal from antenna to video detector section of the receiver. Here the two signals are separated and fed to their respective channels. The frequency modulated audio signal is demodulated after at least one stage of amplification. The audio output from the FM detector is given due amplification before feeding it to the loudspeaker.

Colour Receiver

A colour receiver is similar to the black and white receiver as shown in Fig. 1.7. The main difference between the two is the need of a colour or chroma subsystem. It accepts only the colour signal and processes it to recover (B-Y) and (R-Y) signals. These are combined with the Y signal to obtain V_R, V_G and V_B signals as developed by the camera at the transmitting end. V_G becomes available as it is contained in the Y signal. The three colour signals are fed after sufficient amplification to the colour picture tube to produce a colour picture on its screen.

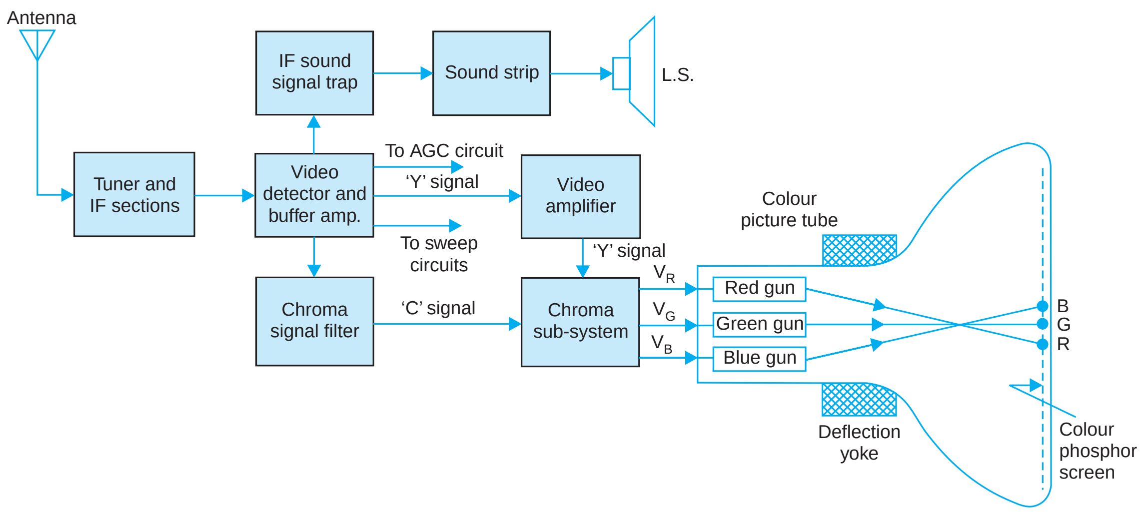

Fig. 1.7. An oversimplified block diagram of a colour receiver.

As shown in Fig. 1.7, the colour picture tube has three guns corresponding to the three pick-up tubes in the colour camera. The screen of this tube has red, green and blue phosphors arranged in alternate stripes. Each gun produces an electron beam to illuminate corresponding colour phosphor separately on the fluorescent screen. The eye then integrates the red, green and blue colour informations and their luminance to perceive actual colour and brightness of the picture being televised. The sound signal is decoded in the same way as in a monochrome receiver.

1.4 SYNCHRONIZATION

It is essential that the same co-ordinates be scanned at any instant both at the camera tube target plate and at the raster of picture tube, otherwise, the picture details would split and get distorted. To ensure perfect synchronization between the scene being televised and the picture produced on the raster, synchronizing pulses are transmitted during the retrace, *i.e.*, fly-back intervals of horizontal and vertical motions of the camera scanning beam. Thus, in addition to carrying picture details, the radiated signal at the transmitter also contains synchronizing pulses. These pulses which are distinct for horizontal and vertical motion control, are processed at the receiver and fed to the picture tube sweep circuitry thus ensuring that the receiver picture tube beam is in step with the transmitter camera tube beam.

As stated earlier, in a colour TV system additional sync pulses called colour burst are transmitted along with horizontal sync pulses. These are separated at the input of chroma section and used to synchronize the colour demodulator carrier generator. This ensures correct reproduction of colours in the otherwise black and white picture.

1.5 RECEIVER CONTROLS

Most black and white receivers have on their front panel (*i*) channel selector, (*ii*) fine tuning, (*iii*) brightness, (*iv*) contrast, (*v*) horizontal hold and (*vi*) volume controls besides an ON-OFF switch. Some receivers also provide a tone control. The channel selector switch is used for selecting the desired channel. The fine tuning control is provided for obtaining best picture details in the selected channel. The hold control is used to get a steady picture in case it rolls up or down. The brightness control varies beam intensity of the picture tube and is set for optimum average brightness of the picture. The contrast control is actually gain control of the video amplifier. This can be varied to obtain desired contrast between white and black contents of the reproduced picture. The volume and tone controls form part of the audio amplifier in sound section, and are used for setting volume and tonal quality of the sound output from the loudspeaker.

In colour receivers there is an additional control called 'colour' or 'saturation' control. It is used to vary intensity or amount of colours in the reproduced picture. In modern colour receivers that employ integrated circuits in most sections of the receiver, the hold control is not necessary and hence usually not provided.

REVIEW QUESTIONS

1. Why is it necessary to restore to scanning in TV transmission and reception? Why is it carried out at a very fast rate?
2. Explain with a suitable diagram how a vidicon pick-up tube is employed in a monochrome TV camera to develop luminance (brightness) signal.
3. Why three pick-up tubes are provided in a colour camera? Explain why it is necessary to transmit luminance (Y) signal along with chroma information in a CTV system.
4. How is a colour receiver different from a black and white receiver? Explain why separate colour sync pulses (colour burst) are needed in the CTV system.
5. Describe briefly the functions of various controls provided on the front panel of a monochrome receiver. What is the purpose of saturation (colour) control in a colour receiver?