Elements of a Television System
The fundamental aim of a television system is to extend the sense of sight beyond its natural limits, along with the sound associated with the scene being televised. Essentially then, a TV system is an extension of the science of radio communication with the additional complexity that besides sound the picture details are also to be transmitted.

In most television systems, as also in the C.C.I.R. 625 line monochrome system adopted by India, the picture signal is amplitude modulated and sound signal frequency modulated before transmission. The carrier frequencies are suitably spaced and the modulated outputs radiated through a common antenna. Thus each broadcasting station can have its own carrier frequency and the receiver can then be tuned to select any desired station. Figure 1.1 shows a simplified block representation of a TV transmitter and receiver.

### 1.1 PICTURE TRANSMISSION

The picture information is optical in character and may be thought of as an assemblage of a large number of bright and dark areas representing picture details. These elementary areas into which the picture details may be broken up are known as ‘picture elements’, which when viewed together, represent the visual information of the scene. Thus the problem of picture transmission is fundamentally much more complex, because, at any instant there are almost an infinite number of pieces of information, existing simultaneously, each representing the level of brightness of the scene to the reproduced. In other words the information is a function of two variables, time and space. Ideally then, it would need an infinite number of channels to transmit optical information corresponding to all the picture elements simultaneously. Presently the practical difficulties of transmitting all the information simultaneously and decoding it at the receiving end seem insurmountable and so a method known as scanning is used instead. Here the conversion of optical information to electrical form and its transmission are carried out element by element, one at a time and in a sequential manner to cover the entire scene which is to be televised. Scanning of the elements is done at a very fast rate and this process is repeated a large number of times per second to create an illusion of simultaneous pick-up and transmission of picture details.

A TV camera, the heart of which is a camera tube, is used to convert the optical information into a corresponding electrical signal, the amplitude of which varies in accordance with the variations of brightness. Fig. 1.2 (a) shows very elementary details of one type of camera tube (vidicon) to illustrate this 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 a very high resistance when no light falls on it, but decreases depending on the intensity of light falling on it. Thus depending on the light intensity variations in the focused optical image, the conductivity of each element of the photolayer changes accordingly. An electron beam is used to pick-up the picture information now available on the target plate in terms of varying resistance at each point. The beam is formed by an electron gun in the TV camera tube. On its way to the inner side of the 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 (b)). To achieve this the deflecting coils are fed separately from two sweep oscillators which continuously generate saw-tooth waveforms, each operating at a different desired frequency. The magnetic deflection caused by the current in one coil gives horizontal motion to the beam from left to right at a uniform rate and then brings it quickly to
the left side to commence the trace of 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 all over again. Two simultaneous motions are thus given to the beam, one from left to right across the target plate and the other from top to bottom thereby covering the entire area on which the 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 the 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 the current a varying voltage appears across the resistance $R_L$ and this corresponds to the optical information of the picture.

**Fig. 1.2 (a) Simplified cross-sectional view of a Vidicon TV camera tube.**

**Fig. 1.2 (b) Path of scanning beam in covering picture area.**
If the scanning beam moves at such a rate that any portion of the scene content does not have time to move perceptibly in the time required for one complete scan of the image, the resultant electrical signal contains the true information existing in the picture during the time of the 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 the conversion of information existing in space and time coordinates into time variations only. The electrical information obtained from the TV camera tube is generally referred to as video signal (video is Latin for ‘see’). This signal is amplified and then amplitude modulated with the channel picture carrier frequency. The modulated output is fed to the transmitter antenna for radiation along with the sound signal.

1.2 SOUND TRANSMISSION

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 the carrier signal is held constant, whereas its frequency is varied in accordance with amplitude variations of the modulating signal. As shown in Fig. 1.1 (a), 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 PICTURE RECEPTION

The receiving antenna intercepts the radiated picture and sound carrier signals and feeds them to the RF tuner (see Fig. 1.1 (b)). The receiver is of the heterodyne type and employs two or three stages of intermediate frequency (IF) amplification. The output from the last IF stage
is demodulated to recover the video signal. This signal that carries the 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. 1.3 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 the picture tube in the same way and rate as the beam scans the target in the camera tube. The amplitudes of the 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.

The video signal is fed to the grid or cathode of the 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 the brightness. If the grid voltages 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 the brightness changes encountered by the electron beam of the camera tube while scanning the 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 the storage capability of the human eye.

### 1.4 SOUND RECEPTION

The path of the sound signal is common with the picture signal from antenna to the 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.

### 1.5 SYNCHRONIZATION

It is essential that the same coordinates be scanned at any instant both at the camera tube target plate and at the raster of the 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 detail, 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.
1.6 RECEIVER CONTROLS

The front view of a typical monochrome TV receiver, having various controls is shown in Fig. 1.4. 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 the beam intensity of the picture tube and is set for optimum average brightness of the picture. The contrast control is actually the gain control of the video amplifier. This can be varied to obtain the desired contrast between the white and black contents of the reproduced picture. The volume and tone controls form part of the audio amplifier in the sound section, and are used for setting the volume and tonal quality of the sound output from the loudspeaker.

![Television receiver controls](image)

Fig. 1.4 Television receiver controls

1.7 COLOUR TELEVISION

Colour television is based on the theory of additive colour mixing, where all colours including white can be created by mixing red, green, and blue lights. The colour camera provides video signals for the red, green, and blue information. These are combined and transmitted along with the brightness (monochrome) signal.

Each colour TV system* is compatible with the corresponding monochrome system. Compatibility means that colour broadcasts can be received as black and white on monochrome receivers. Conversely colour receivers are able to receive black and white TV broadcasts. This is illustrated in Fig. 1.5 where the transmission paths from the colour and monochrome cameras are shown to both colour and monochrome receivers.

At the receiver, the three colour signals are separated and fed to the three electron guns of colour picture tube. The screen of the picture tube has red, green, and blue phosphors arranged in alternate dots. Each gun produces an electron beam to illuminate the three colour phosphors separately on the fluorescent screen. The eye then integrates the red, green and blue colour information and their luminance to perceive the actual colour and brightness of the picture being televised.

* The three compatible colour television systems are NTSC, PAL and SECAM.
Colour Receiver Controls

NTSC colour television receivers have two additional controls, known as Colour and Hue controls. These are provided at the front panel along with other controls. The colour or saturation control varies the intensity or amount of colour in the reproduced picture. For example, this control determines whether the leaves of a tree in the picture are dark green or light green, and whether the sky in the picture is dark blue or light blue. The tint or hue control selects the correct colour to be displayed. This is primarily used to set the correct skin colour, since when flesh tones are correct, all other colours are correctly reproduced.

It may be noted that PAL colour receivers do not need any tint control while in SECAM colour receivers, both tint and saturation controls are not necessary. The reasons for such differences are explained in chapters exclusively devoted to colour television.

\[ v = 0.3 v_R + 0.59 v_G + 0.11 v_B \]

**Fig. 1.5.** Signal transmission paths illustrating compatibility between colour and monochrome TV systems. R, G and B represent three camera tubes which develop video signals corresponding to the red, green and blue contents of the scene being televised.

**Review Questions**

1. Why is scanning necessary in TV transmission? Why is it carried out at a fast rate?
2. What is the basic principle of operation of a television camera tube?
3. What is a raster and how is it produced on the picture tube screen?
4. Why are synchronizing pulses transmitted along with the picture signal?
5. Why is FM preferred to AM for sound signal transmission?
6. Describe briefly the functions of various controls provided on the front panel of a TV receiver.
7. Describe the basic principle of colour television transmission and reception.
8. Describe the function of saturation and hue controls in a NTSC colour TV receiver.