# Electronic systems — 8

## The transmission and reception of pictures

In previous articles we have seen how audio information may be communicated over vast distances. We are now going to consider the mechanisms for transmitting and receiving visual data, typically in the form of pictures. This important area is manifested in the many forms of television, and also in facsimile — for the transmission of press photographs and pictures from satellites showing weather situations.

WHILE this article is particularly relevant to television, it is perhaps more correct to use the term video to describe the graphic data and signals. Theoretically, a visual scene (picture) is composed of an infinite amount of detail. However, by using artificial aids such as the microscope and the telescope, more of this detail can be seen.

To represent this theoretical picture in all its detail would require an infinite number of picture elements, each capable of varying through a very wide range of intensities. In practice, the number of picture elements and the range of brightness of each element may be quite severely limited and yet still provide sufficient detail to give a satisfactory presentation of the original scene.

If the picture is to be transmitted, one way of doing it is to subdivide it into a grid pattern comprising a finite number of picture elements, as in Fig. 1. The average brightness of each element can be individually measured by a photosensor (light cell) and the output of each sensor connected to a receiver which produces a light output corresponding in position and intensity to that element in the original scene. To transmit a picture, a large number of sensors and receivers (each with their own transmission connection) would be needed, requiring a large number of parallel transmission paths. Consequently, this system is readily rejected at least on the grounds of the physical bulk of the equipment and its sheer cost.

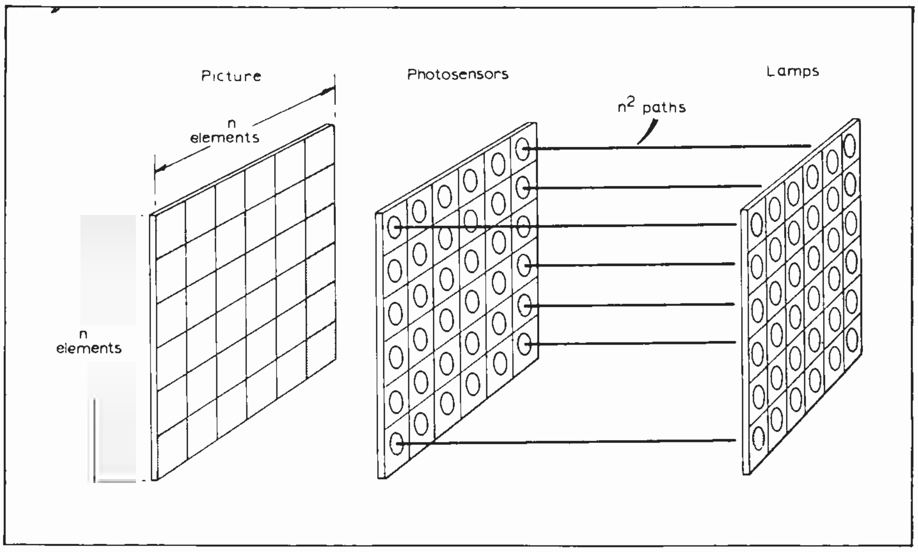


*FIG. 1. Representation of parallel video transmission. Each element is independently sensed, transmitted and recreated.*

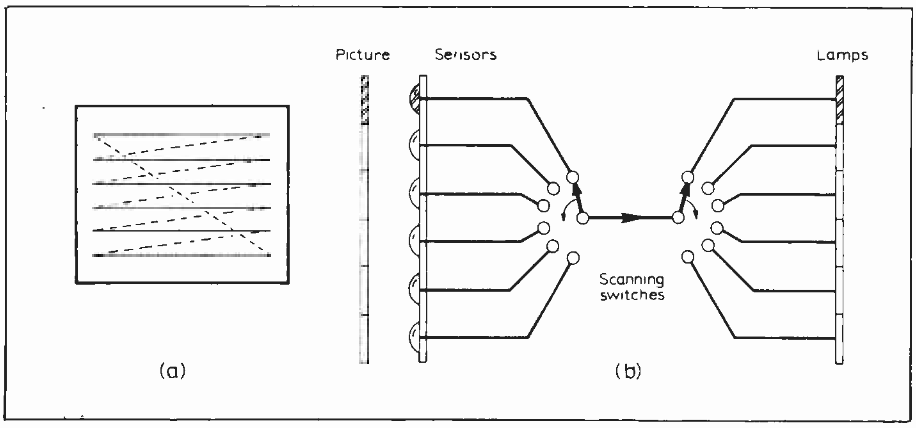


*FIG. 2. Simple illustrations of raster scanning. (a) shows the raster scan on a display. Dotted lines indicate a rapid jump. (b) shows the vertical scanning of a sequential video-transmission system. Switches on the sensors and lamps run in synchronism. Similar switches are required for the horizontal scan.*

In practical visual systems, the picture elements are transmitted sequentially over a single intercommunication between transmitter and receiver by using a method called scanning. A simple illustration of this is given in Fig. 2. During a scan, the sensors for each picture element are interrogated one after the other in a regular manner which is typically of the form used with the written word, i.e. from left-to-right and top-to-bottom. At the end of each horizontal line there is a jump to the start of the next and at the end of the picture (bottom, right) the scan jumps back to the top left-hand corner to restart. The zig-zag path traced out during the scan is called a raster. The picture is reconstituted at the receiving end of the link by presenting the sequential brightness signal to an array of light generators in synchronism with the scan at the transmitting end.

One disadvantage of this transmission system is that it takes a considerable length of time to transmit a full picture and if a succession of pictures are required to convey the impression of motion, as in cine, it cannot be transmitted faster than a certain rate.

Television and cine rely on an important feature of the human eye, namely, persistence of vision. This permits the impression of continuous motion without jerks or flicker when a section of pictures are presented in rapid succession to the eye. Indeed, each picture may be in a scanned form, as in television, such that even though the line structure traced by the scan may be clearly visible, the sequential addressing of the picture elements will be quite undetectable, providing the scan is sufficiently rapid.

### Spatial resolution

If a picture is made up of ten horizontal lines, each containing ten elements, the resultant 100-element picture would have a very low resolution. For good results, a figure of at least 500 lines, with an equivalent horizontal definition, is considered necessary, but it is important to remember that the picture resolution required is a function of viewing distance and the screen size. It is only at and beyond a certain distance from the picture that the individual elements are unresolved and appear to give a continuous effect. Likewise, it is unnecessary and uneconomic to provide a higher definition than prescribed by a situation where a fixed or minimum viewing distance is dictated.

### Scanning rate

Associated with the phenomenon of persistence of vision, there is a certain frequency at which a light may be flashed below which the light is seen to blink or flicker, and above which the light appears to be of constant intensity. This frequency is called the flicker-fusion frequency. Although its value depends on the intensity of the light source and varies from person to person, it is usually within the range 30 to 35Hz under normal television viewing conditions. See previous article, Part 7. Its relevance to visual systems lies in the fact that a scan must be performed at a rate above the flicker-fusion frequency to avoid a flickering image, which can be most irritating to the viewer. For this reason, a scanning rate of greater than 40 scans per second—often written as "scanning at 40Hz"—is ideal.

Although in Part 7 it was stated that the flicker-fusion frequency is approximately 70Hz, this figure is the worst case achieved under the conditions of intensity and ambient illumination which yield the highest figure. Visual presentation of information is highly subjective and a scanning rate of 40Hz does, under normal viewing conditions, prove to be acceptable.

### Interlacing

We therefore have two requirements for the raster scan. It must comprise at least 500 scanning lines, and the total scan should be completed at least 40 times per second. The current European standards are in fact 625 lines at a scanning rate of 50Hz.

Here the use of the 50Hz mains frequency is intentional since the effect of any mains-borne interference such as hum tends to be minimised.

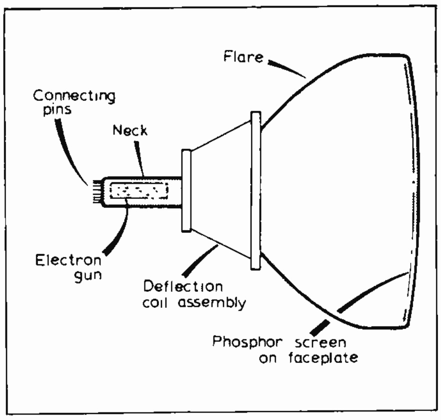


*FIG. 3. Structure of cathode-ray tube.*

Although the bandwidth requirements of television signals are considered later in this section, it is necessary at this stage to point out that the bandwidth of a tv signal characterised by 625 lines at 50Hz is approximately 12MHz. This high figure obviously limits the number of broadcast television channels and places severe performance requirements on the electronic circuitry. It would be advantageous on these counts to be able to reduce the bandwidth by, for example, reducing the scanning rate—provided that problems regarding flicker were not encountered. This may be achieved by a process called interlacing.

In an interlaced presentation the complete raster is produced by two successive scans, each providing half of the total number of picture lines. In a 2:1 interlaced scan, the scanning lines of one field interlace in the spaces between the lines of the other field. Each vertical scan of half the total number of lines is called a field, while each full picture, consisting of two fields, is called a frame. The field frequency is retained at 50Hz (in Europe) while the frame frequency, the total picture repetition rate, is now 25Hz. As a result the bandwidth of the video signal is halved to a figure of approximately 6MHz.

Interlacing allows the transmission and reception of good quality pictures within a practical bandwidth at an effectively flicker-free scanning rate. Although only half the picture information is presented at a 50Hz rate by interlacing, this 50Hz figure represents the flicker frequency in spite of the fact that the full frames are produced at the lower rate of 25Hz. Persistence of vision is such that each field is sustained for a short interval before totally decaying and the two fields are seen simultaneously in spite of the fact that they occur at intervals of 20 ms.

### Visual display

The requirements for a display for a visual system are as follows. The display surface should ideally consist of a flat screen and, for most applications, should have a rectangular format. An exception is the radar display, of course. The screen should be capable of resolving a large number of picture elements (typically 500 × 500), addressable by horizontal and vertical scanning signals. Since the individual elements need not be defined, the active screen surface may be continuous. The light output from each element should be controllable by an intensity signal through a brightness range from total extinction to a maximum intensity appropriate to the application. If the visual system is to be commercially viable, the display, and its associated components, should be inexpensive and reliable.

### The Cathode-ray tube

The cathode-ray tube (c.r.t.) satisfies the above requirements and has been recognised as the established visual display over the last few decades. A c.r.t. assembly consists of three integral parts: the screen, neck and flare, as shown in Fig. 3.

The screen, which is nearly rectangular, is coated on its inner surface with phosphor, a compound which emits light when it is bombarded by high velocity electrons. A narrow beam of electrons is generated in the electron gun housed in the tube neck and are accelerated to a very high velocity by connecting the phosphor screen to a high potential (16 to 20kV) relative to the electron gun.

When the electron beam strikes the phosphor screen it produces a bright spot, the intensity of which is controlled by the beam current (rate of flow of electrons) which is, in turn, sensitive to variations in the control potentials associated with the electron gun. For television and most other display purposes, the screen is rectangular in format with an aspect ratio (width-to-height) of 4:3, corresponding to the standard aspect ratio of television pictures. Earlier tubes had a 5:4 aspect ratio, for ease of manufacture, but a complete picture could not be correctly displayed without underscanning in at least one direction. Screen size is described by the diagonal dimension of the screen. □

This series of articles is based on an Advanced Level course for schools and is prepared in consultation with Professor G. B. B. Chaplin, University of Essex.