The very basics of Television

- Part one -

In this new century we are all looking forward to getting our (television) lives digitised. CCTV is slowly but surely going towards a complete digitisation. It is very wrong though to assume that we don't need and that we will completely bypass the analogue standards. Understanding how analogue television works is in the very essence of understanding the new digital trends. Unfortunately, there are still too many sales people, consultants and installers that don't understand the very basic concepts of television. This is perhaps because they are not reading the right publications. Unlike other quasi-technical magazines dedicated to security and CCTV, we at "CCTV focus," have always given our readers real and valuable information about products and technologies. This article, and the ones to follow, are dedicated to them.

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There are a few different television standards used worldwide today. CCIR/PAL recommendations are used throughout most of Europe, Australia, New Zealand, most of Africa and Asia. A similar concept is used in the EIA/NTSC recommendations for the television used in the US, Japan and Canada, as well as in the SECAM recommendations used in France, Russia, Egypt, some French colonies and Eastern European countries. The major difference between these standards is in the number of scanning lines and frame frequency.

Before we begin the television basics, let's first explain the abbreviation terminology used in various technical literature discussing television:

CCIR stands for Committée Consultatif International des Radiotelecommuniqué. This is the committee that recommended the standards for B/W television accepted by most of Europe, Australia and others. This is why we call equipment that complies with the B/W TV standards CCIR compatible. The same type of standard, but later extended to colour signals, was called PAL. The name comes from the concept used for the colour reproduction by alternate phase changes of the colour carrier at each new line, hence, phase alternate line (PAL).

EIA stands for Electronics Industry Association, an association that created the standard for B/W television in the US, Canada and Japan, where it is often referred to as RS-170, the recommendation code of the EIA proposal. When B/W TV was upgraded to colour, it was named by the group that created the recommendation: National Television Systems Committee (NTSC).

SECAM comes from the French "Sequentiel à mémoire" which actually describes how the colour is transmitted, by a sequence of chrominance colour signals and the need for a memory device in the TV receiver when decoding the colour information.

All of the TV standards' recommendations have accepted the picture ratio of the TV screen to be 4:3 (4 units in width by 3 units in height). This is mostly due to the similar film aspect ratio of the early days of television.

The different number of lines used in different TV standards dictates the other characteristics of the system.

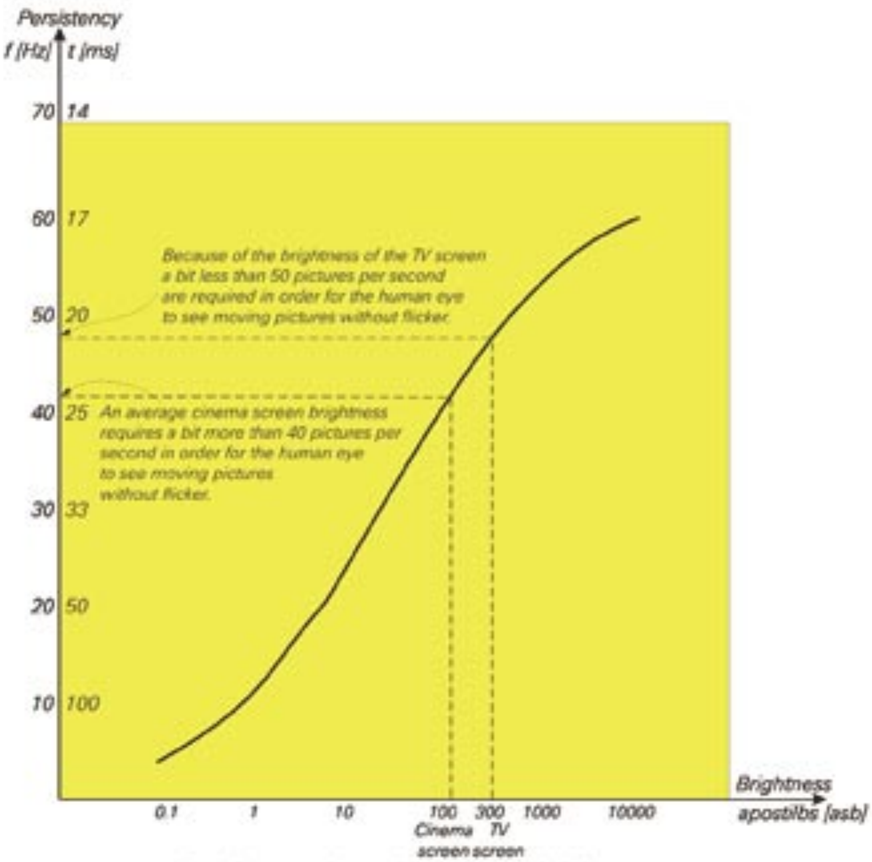
EIA recommends 525 lines, and PAL and SECAM use 625 (SECAM used to have 819 lines in the earlier versions).

Irrespective of these differences, all of the systems use the same concept of composing pictures with electron beam scanning lines, one after another.

When a video signal, as produced by a camera, comes to the monitor input, the voltage fluctuations are converted into current fluctuations of electrons in the electron beam that bombards the phosphor coating of the CRT as it is scanning line by line. The phosphor coating produces light proportional to the amount of electrons, which is proportional to the voltage fluctuation. This is, of course, proportional to the light information falling onto the CCD chip.

The phosphor coating of the monitor has some persistency as well, i.e., light produced by the beam does not immediately disappear with the disappearance of the beam. It continues to emit light for another few milliseconds. This means the TV screen is lit by a bright stripe that moves downwards at a certain speed.

This is obviously a very simplified description of what happens to the video signal when it comes to the monitor. We will discuss monitor operation in one of our next issues of CCTV focus, but we will use the previous information as an introduction to the television principles for the readers who haven't got the technical background.



Persistency dependence on the brightness

Many factors need to be taken into account when deciding the number of lines and picture refresh rate to be used. As with many things in life, these decisions have to be a compromise – a compromise between as much information as possible, in order to see a faithful reproduction of the real objects, and as little information as possible in order to be able to transmit it economically and receive it by a large number of users who can afford to buy such a TV receiver.

The more lines used, combined with the number of pictures per second, the wider the frequency bandwidth of the video signal will be, thus dictating the cost of the cameras, processing equipment, transmitters and receivers.

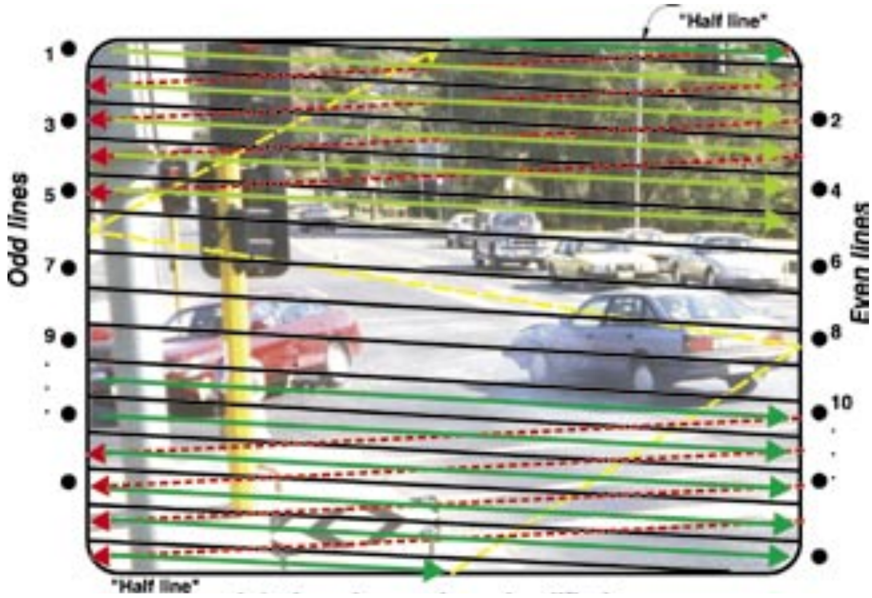
The refresh rate, i.e., the number of pictures composed in 1 second, was decided on the basis of the persistency characteristic of the human eye and the luminance of the CRT. Theoretically, 24 pictures per second would have been ideal because of the compatibility between cinematography and television (used widely at the time of television's beginning). Practically, however, this was impossible because of the very high luminance produced by the phosphor of the CRT, which led to the flicker effect (relative to the viewing distance, see the diagram below).

With many experiments it was found that at least 48 pictures per second were required for the flicker to be eliminated. This would have been a good number to use because it was identical to the cinema projector frequency, and would be very practical when converting movies into television format. Still, this was not the number that was accepted. The television engineers opted for 50 pictures per second in CCIR, and 60 in EIA recommendations. These numbers were sufficiently high for the flicker to be undetectable with the human eye, but more importantly they coincided with the mains frequency of 50 Hz used all over Europe, and 60 in the US, Canada and Japan. The reason for this lies in the electronic design of the TV receivers that were initially very dependent on the main frequency. Should the design with 48 pictures have been accepted, the 2-Hz difference for CCIR and 12-Hz for EIA, would have caused a lot of interference and irregularities in the scanning process.

The big problem, though, was how to produce 50 (PAL) or 60 (NTSC) pictures per second, without really increasing the initial camera scan rate of 25 (i.e. 30) pictures per second. Not that the camera scan rate could not be doubled, but the bandwidth of the video signal would have to be increased, thus increasing the electronics cost, as mentioned previously. Plus, broadcasting channels were taken into account, which would have to be wider and therefore fewer channels would be available for use, without interference, in a dedicated frequency area.

All of the above forced the engineers to use a trick, similar to the Maltese Cross used in film projection, where 50 (60) pictures would be reproduced without really increasing the bandwidth. The name of this trick is interlaced scanning.

Instead of composing the pictures with 625 (525) horizontal lines by progressive scanning, the solution was found in the alternate scanning of odd and even lines. In other words, instead of a single TV picture being produced by 625 (525) lines in one progressive scan, the same picture was broken into two halves, where one half was composed of only odd lines and the other of only even lines. These were scanned in such a way that they precisely fitted in between the lines of each other. This is why it is called interlaced scanning. All of the lines in each half, in the case of the CCIR signal 312.5 and in NTSC 262.5, form a so-called TV field.



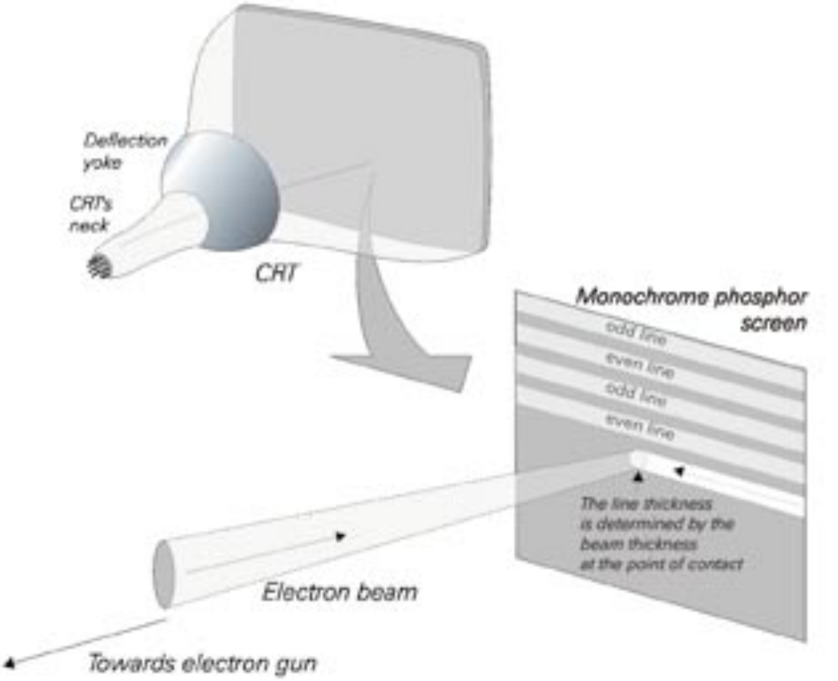
A simplified representation of interlaced scanning

There are 25 odd fields, and 25 even fields in the CCIR and SECAM systems, and 30 in the EIA system – a total of 50 fields per second, or 60 in EIA, flicking one after the other, every second.

An odd field together with the following even field composes a so-called TV frame. Every CCIR/PAL and SECAM signal is thus, composed of 25 frames per second, or 50 fields. Every EIA/NTSC signal is composed of 30 frames per second, which is equivalent to 60 fields.

The actual scanning on the monitor screen starts at the top left-hand corner with line 1, then goes to line 3, leaving a space in between 1 and 3 for line 2, which is due to come when even lines start scanning. Initially, with the very first experiments, it was hard to achieve precise interlaced scanning. The electronics needed to be very stable in order to get such oscillations that the even lines fit exactly in between the odd lines. But a simple and very efficient solution was soon found in the selection of an odd


A basic measuring tool in television and CCTV - Oscilloscope. Without it - it is impossible to see the video signal levels and synchronisation pulses. On the photo above, horizontal sycnhronisation



The operation of any CCTV monitor screen is based on interlaced scan-

A CCTV technician or installer should have at least the following basic instruments: a Test chart, a Test signal generator and an

number of lines, where every field would finish scanning with half a line. By preserving a linear vertical deflection (which was much easier to ensure), the half line completes the cycle in the middle of the top of the screen, thus finishing the 313th line for CCIR (263th for EIA), after which the exact interlace was ensured for the even lines.

When the electron beam completes the scanning of each line (on the right-hand side of the CRT, when seen from the front), it receives a horizontal synchronisation pulse (commonly known as horizontal sync). This sync is embedded in the video signal and comes after the line video information. It tells the beam when to stop writing the video information and to quickly return back to the left at the beginning of the new line. Similarly, when a field finishes a vertical sync pulse, it "tells" the beam when to stop "writing" the video information and to quickly return back to the beginning of the new field. The fly-back period of the electron beam scanning is faster than the actual active scanning, and it is only positional, i.e., no electrons are ejected during these periods of the picture synthesis.

In reality, even though the scanning system is called 525 TV lines (or 625 for PAL), not all of the lines are active, i.e., visible on the screen.

Some of the lines are used for vertical sync equalization, some are not used and others are practically invisible because of the overscanning effect (remember, no monitor or TV shows 100% of the camera video signal, except for the special broadcasting monitors).

If we take into account the errors in the beam interlace, the thickness of the beam and so on in the CCIR system (and again, a similar logic applies to the other standards), we can hardly count more than 570 active TV lines in PAL, and not more than 480 in NTSC.

Some of the "invisible" lines are used for other purposes quite efficiently. In the PAL Teletext concept, for example, the CCIR recommends lines 17, 18, 330 and 331, where 8-bit digital information is inserted. The Teletext decoder in your TV or VCR can accumulate the fields' digital data, which contain information about the weather, exchange rates, Lotto, etc.

In some NTSC systems line 21 carries closed captioning, i,e., subtitling information. Some of the other invisible lines are used for specially shaped video insertion test signals, known as VITS, which when measured at the receiving end, give valuable information on the quality of the transmission and reception in a particular area.

In CCTV, some manufacturers use the invisible lines to insert camera ID, time and date, or similar information. When recorded on a VCR, these lines are also recorded but they are not visible on the monitor screen. However, the information is always there, embedded in the video signal. This type of information is more secure and harder to tamper with. It can be retrieved with a special TV line decoder and used whenever necessary, revealing the camera ID together with the time and date of the particular signal and, for example, the intruder in the picture. [][][]

In the next issue -
The spectrum of a video signal

The RGB structure of a CRT monitor screen