Raster Scanning and Interlacing

TV and video pictures are made up of a number of images (frames) that are sequentially displayed on your screen to give the illusion of movement. The rate at which the frames are displayed is fixed at 25 frames-per second (fps) in the PAL system, and 30 fps in the NTSC system.

In order to send these pictures over the air, or along a cable, each frame is split up into a number of horizontal strips (lines), rather like the slats of a Venetian blind. Each line is transmitted separately to your TV tube where they are 'painted' (scanned) in sequence on the viewing screen, to recreate the original frame images.

The frame rate talked of above is actually quite low for our eyes to view without being aware of a disturbing flicker, even if the image is stationary. (This has a lot to do with the fact that the picture is scanned onto the tube screen, rather than being projected like a photographic slide).

To overcome this, a technique known as interlacing is used. What happens is that each frame is divided into two parts (fields) by taking even numbered lines as one field, and odd numbered lines as the other. These two fields are then transmitted in sequence (odd, then even), instead of the original frame. The rate at which these fields are produced on our TV tube is now twice the frame rate, which reduces the perceptible flicker substantially.

The reason why 50 fields/sec (60 NTSC) is used is to minimise the visual disturbance caused by mains-power interference which would show as a wobble in the picture. Wherever you are in the world, if you want to know what the mains-power frequency is, just enquire which TV standard is in use there. (Ok, so you'd be faced with a blank expression if you asked either of these questions)

Incidentally, computer monitors, which also use the line-scanning method of producing screen pictures, rarely use the interlace method for reasons that will become apparent shortly. In this application the frame rate is also often higher than that used with TV because there is no tight restriction on the quantity of data that can be sent to the monitor through its direct wiring connection.

Want to know more?
The lines that are scanned on the tube screen are produced by a narrow electron beam that is focused into a small 'spot' which is repeatedly moved across the screen, then progressively down it until the entire area has been covered (this is referred to as a 'raster'). The inside of the tube face is coated with a special phosphor that emits a bright light when bombarded with electrons. By varying the strength of the beam the luminance of the spot can be controlled, thereby reproducing the various levels of contrast in our images. Colour television operates on the same principle, except that there are three separate beams and three colour phosphors, one for each of the primary colours Red Blue Green. This is a complication we do not need to be bothered with here, as all beams are scanned together and work in unison to provide the equivalent of the spot described above.

The spot is driven horizontally and vertically by two circuits called timebases. The Line Timebase moves the spot from left to right and the Field Timebase, from the top to the bottom. The video signal itself resets the timebases at the appropriate times to make the spot fly back from right to left and from the bottom to the top. This part of the raster scanning is called, appropriately, the flyback. The spot is turned off, or 'blanked' during flybacks. The Field Timebase scans very much slower than the Line Timebase.

The illustration below shows how the interlaced raster is created. At the beginning of a frame the two timebases are both reset so that the spot is at position (A). Both timebases then start scanning. The video signal triggers line flybacks at the appropriate time until the end of the first field (odd) is reached.

Half-way through the last line (B), the field timebase is reset. The spot then flies back to (C), and continues with the remainder of the line, then scans all the even lines in a similar manner. Because the field timebase was reset half way through a line, the even field naturally interlaces between the lines of the odd field.
When the spot reaches the end of the final line (D), both timebases are reset, and the spot flies back to (A), ready for the next frame.

This diagram gives the impression that the scan lines are at an angle. That is because so few lines are shown for clarity. In fact the angle is much less than 1 degree in reality, and is easily corrected by twisting the coils on the tube that deflect the electron beam.

The diagram also shows that the visible part of the screen is smaller than the area of the scanned raster. This is because it actually takes several line-scans for the frame timebase to fly back to the beginning (rather than the instantaneous paths shown for clarity on the diagram). The slight 'overscan' on the lines themselves also allows the spot time to stabilise before starting its active scan.

The PAL system comprises 625 lines, of which 574 are active. NTSC has 525 lines, of which 485 are active. During the time of inactive lines, it is customary to find non-image data stored in digital form. Examples of this are Teletext (Europe) and VITC timecode.

Interlacing then, is a very effective way of reducing the flicker on the picture without increasing the amount (known as 'bandwidth') of transmitted information. The problem is, it can sometimes produce an undesirable vertical 'bounce' on images that have strong horizontal detail. Look at the illustration below, which shows a magnified capital F, as it may appear on the screen.
As you can see, the non-interlaced character is stationary, whilst the interlaced version (separated here into its two fields) will appear to bounce up and down at the frame rate.

This is not a great problem with domestic televisions, because the viewing distance is so great and the spot is relatively 'soft'. On a video monitor at close quarters however, the effect is quite pronounced. That is why computer monitors are invariably non-interlaced.

Producers of TV graphics often attempt to minimise this effect by avoiding lots of horizontal detail and, where it is unavoidable, they use an odd number of lines for narrow horizontal features. This replaces the 'bounce' with a less obvious modulation in height.