# Scan Methods: Progressive vs. Interlaced Scan

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## General Overview:

The aim of this document is to define the two basic concepts in video scanning, which include the progressive scan and the interlaced scan. The two techniques are compared and an explanation is given for the choice of the interlaced concept for Maradin's mirror.

## Interlaced Scan

Interlaced scan is a technique used for "painting" an image on a screen, which was originally designed for the analog NTSC television system. Interlaced scan uses two fields to create a frame. One field contains all the odd lines in the image; the second field contains all the even lines of the image. Figure 1 depicts the composed frame with its two sets of odd and even fields. For example, a television scans 60 fields every second, which are divided into 30 odd and 30 even lines. These two sets of 30 lines are combined to create a full frame every 1/30th of a second, resulting in a display of 30 frames per second (30Hz).

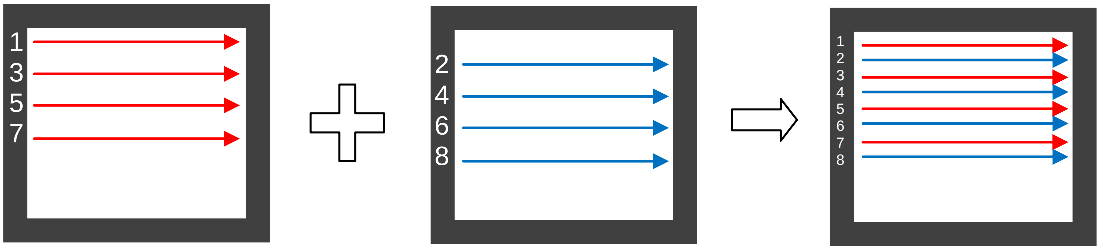


Figure 1: Interlace scan. Odd field (left), even field (middle) and the full frame (right)

The meaning of interlaced signals is that one picture is broken up into alternating fields. The total image is conjunct in the human brain such that the two fields are combined together and create a single image, even when they really are separated. Therefore, there is a minimum refresh rate for interlace scanning, otherwise flickering may be observed.  It is common to use 30Hz as such refresh rate to avoid flickering, which is the standard rate in CRT technology.

## Progressive Scan

Progressive scanning scans the entire picture line by line. This technique differs from interlaced scan in that the image is displayed on a screen by scanning each line (or row of pixels) in a sequential order rather than an alternate order. Figure depicts a sketch of an image using the progressive scan method.

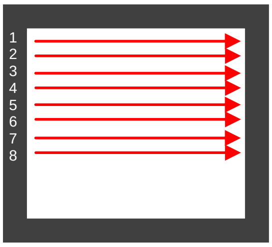


Figure 2: Progressive scan

In other words, in progressive scan, the image lines (or pixel rows) are scanned in numerical order (1,2,3) down the screen from top to bottom, instead of in an alternate order (lines or rows 1,3,5, etc... followed by lines or rows 2,4,6). Due to the projection rate of the data on the screen, the minimum refresh rate required in progressive scan in order to avoid flickering is 60Hz, which is double than the rate required in interlace scan.

# Benefits and drawbacks of interlacing vs. progressive

One of the most important factors in analog display systems is signal bandwidth. The greater the bandwidth, the more expensive and complex is the storage systems. For a given line count and refresh rate, analog interlaced video reduces the signal bandwidth by a factor of two.

Given a fixed bandwidth, interlace can provide a video signal with twice the display refresh rate for a given line count (versus progressive scan video at similar frame rate). The higher refresh rate improves the portrayal of motion, because objects in motion are captured and their position is updated on the display more often, and when objects are more stationary the human vision combines information from multiple similar half-frames resulting in the same perceived resolution as progressive full frames. This technique is only useful though, if the source material is available in higher refresh rates.

In laser based scanning systems, it is common to use resonating mirror to scan the horizontal direction. As the resolution of the projected image determines the resonance frequency of the mirror, for a constant resolution, a progressive scan requires twice the resonance frequency comparing to interlace scan, and enough power should be supplied to that axis in order to obtain large angles. Moreover, the relationship between the mechanical stiffness of the continuum axis and its resonance frequency is given by the formula $\omega = \sqrt{k/I}$: where $\omega$ is the resonance frequency [rad/sec], k is the mechanical stiffness [N/m] and I is the axis' mass moments of inertia $[Kg \cdot m^2]$. Therefore, in order to increase the frequency by a factor of 2, the mechanical stiffness needs to be increased by a factor of 4, which is not a trivial task. In addition, activation of a miniature axis at its resonance frequency is a complex task that involves sophisticated actuation schemes. Therefore, it is easier to vibrate an axis that has lower resonance frequency, which is the case in interlace scan versus the alternative.

On the other hand, one of the advantages of the progressive scan technique is that it is more compatible for digital data protocols and very popular due to use of LCD and Plasma screens.

# Maradin's Scanning Method

In Maradin, we have chosen to use interlaced scanning technique as of the following reasons:

- Lower bandwidth. The lower refresh rate required for interlace scan, which is half of that required for the progressive scan, makes the design of Maradin's mirror scalable for future products. The possibility to obtain a HD resolution in the next generation of Maradin's mirror is practical, and will not require a significant change in the dimensions of the mirror.
- Image quality. Maradin’s unique scanning regime, based on interlace scanning, supports the highest image quality, and image uniformity.
- The effort to update the video processing for interlace scanning is minimal and equivalent to modifications for other scanning regimes.

The following diagram (Figure 3) illustrates the interlaced scanning method used in Maradin's mirror. We note that in each field, any two successive rows are transmitted backwards. We follow the first blue line and the first red line (row no. 1 and no. 2, respectively) which are transmitted from left to right, and their continuing signals (row no. 3 and no. 4, respectively) that are transmitted from right to left.

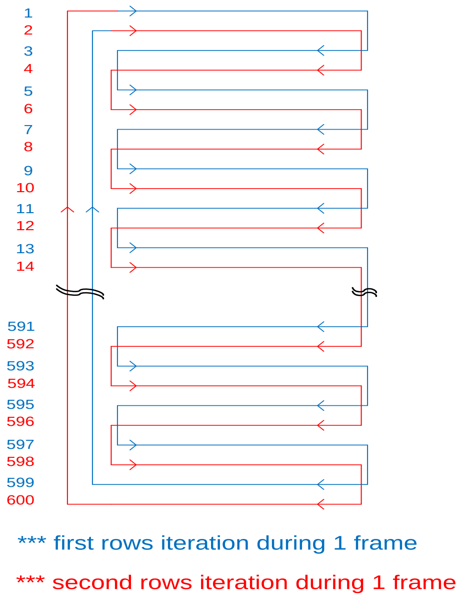


Figure 3: Straight row interlaced raster scanning. The blue line represents the odd field, and the red line represents the even field.