Victor Steinberg

Video Standards

Signals, Formats and Interfaces

Part 5

Frames, Fields, Lines, Pixels

www.videoq.com

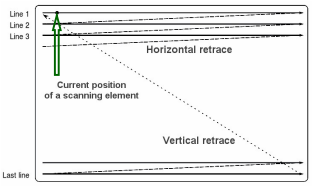
Brief History of TV Standards

For better understanding of the bizarre numbers you might see in the latest TV standards note that many of them relate to the **legacy systems**.
There are social and commercial rationales for the TV systems **backward compatibility** and **forward compatibility**, meaning that:
a) **Old TV sets** can display video images originated in **new standard**, or such images can be easily converted to the **old standard**,
b) **New TV sets** can display video images created in **old standard**, or such images can be easily converted to the **new standard**.

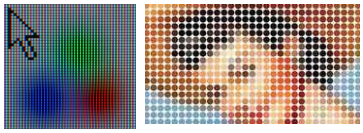
In 1941, the United States implemented the first NTSC standard: 525 **interlaced lines,** 60 **fields** per second**, monochrome** television.
The world's first 625-line television standard was designed in the Soviet Union in 1944 and became a national standard in 1946.
The first broadcast in 625 interlaced lines, 50 fields per second (25 **frames** per second), monochrome standard occurred in Moscow in 1948.
The concept of 625 lines per frame was subsequently implemented in the international standard adopted by **CCIR** and by many countries worldwide.

The electro-mechanical **scanning process** was in fact quite similar to the modern TV. Both **speed** and **phase** of the display were **synchronized** with the transmitter.

In the electronic TV the beam retrace takes time; the unwanted return traces are hidden during the **Blanking Intervals**, as opposite to the **Active Intervals** containing the video image.



Digital TV added to **Frame**, **Field** and **Line** new terms: **Pixel** and **Pixel Rate** (aka **Sampling Frequency**). Analog **Sync Signal** was replaced by **Time Reference Codes**.
In the digital file based systems Blanking Intervals have been abolished, but they still present in the **Serial Digital Interface** connections.

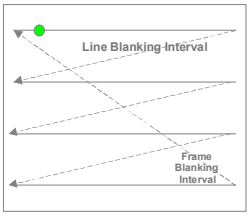


Scanning Standard

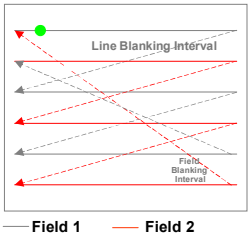
The Scanning Standard determines how the picture is sampled in **space** and in **time,** i.e. the **number of pixels** per line, the **number of lines** in the picture and the **number of picture frames per second** (fps) and it includes items such as **interlace**.
Only the conversion of video signals between **different frame rates** - for instance 50 fps to/from 59.94 fps conversion - can be truly called a "Standards Conversion". Conversion of frame size in pixels, preserving the frame rate, is commonly called “Scaling”.

There are **three different formats** depending upon how the image has been scanned and distributed:

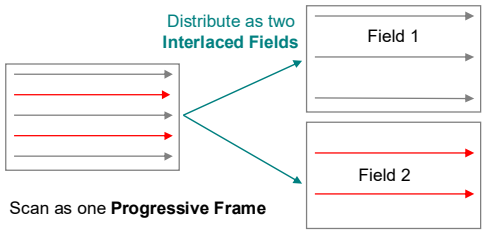
- **Progressive** - all video frame lines read or displayed one after another
- **Interlace** - all **odd-numbered lines** = **Field 1**, then comes **Field 2** consisting of **even-numbered lines**, two fields comprise one **Frame**; depending on the line numbering conventions, visible (active) image may start at Field 1 (Top Filed First = **TFF**) or at Filed 2 (Bottom Field First = **BFF**)
- **Progressive Segmented Frame** (psf, PsF, sF, SF) - scanned as one progressive frame, distributed as two Interlaced fields



Progressive Scan



Interlace Scan (TFF)

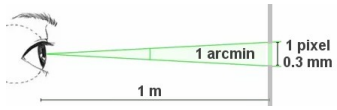


Progressive Segmented Frame

Scanning Standard & Optimal Viewing Distance

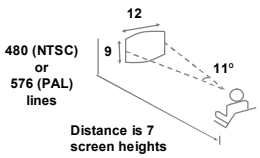
Fundamental TV Research was done at the Japan Broadcasting Corporation (NHK).

Showed viewers position themselves so the smallest detail subtends an **angle of one minute**, (the **limit for normal vision**).
Closer than this and you can see scan lines/pixels, further away and the picture’s too small.

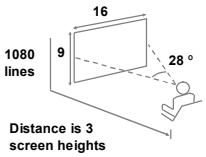


Taking this result as a starting point, it was easy to calculate the **optimal viewing distance** for any **scanning standard**:

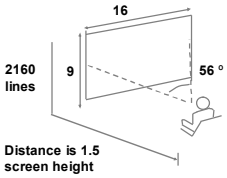
SD



HD



UHD



*BTW: If your **UHD screen height** is **0.8 m**, then your optimal viewing distance is **1.2 m**, and … unfortunately, there is no room for coffee table, and …. if you sit on a sofa with your friends, the viewing distance is at least **2.5 m**, and from this distance your wonderful **UHD screen looks like regular HD!***

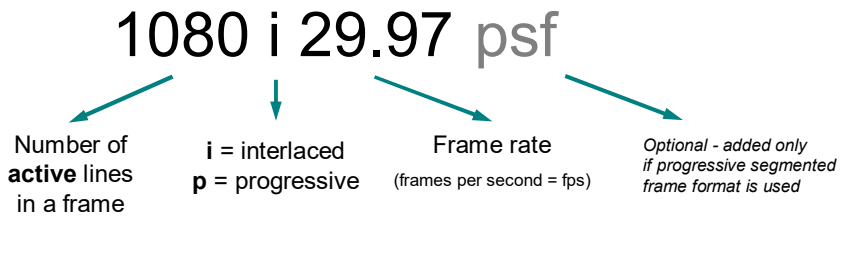
Scanning Format Names

Scanning format name includes the **number of active lines**, plus the **interlace format symbol**, plus the **frame rate**.

For example:

*Note that this naming convention deliberately excludes the horizontal size of video frame, e.g. in 480p29.97 format the number of samples (pixels) per line can be 720 **or** 640.*

*However, you can always use longer names like **720x480p29.97** or shortest **480** (assuming 720, p, and 29.97).*



This naming convention can be also used for **full number of frame lines**, which includes the lines of vertical blanking intervals.

For example, **625p50** and **1125i29.97** are absolutely correct names, if we talking about analog signals or digital SDI interfaces.

EBU recommended the naming convention as above, but alternative naming conventions are still widely used:

- For the interlaced formats the correct Frame Rate can be replaced by the misleading Field Rate, so instead of correct **1080i29.97** you may see *1080i59.94*,
- For the progressive segmented frame format abbreviated *"psf"* can be entered instead of **"i"**, e.g. *1080psf50*, or even worse, "psf" is omitted and correct **1080i25psf** becomes *1080i50*.

About This Presentation

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Based on the book

"Video Standards: Signals, Formats and Interfaces" by Victor Steinberg

Published by Snell & Wilcox

For further reading we recommend wikipedia.org

About VideoQ

Company History

- Founded in 2005
- Formed by an Engineering Awards winning team sharing between them decades of global video technology.
- VideoQ is a renowned player in calibration and benchmarking of video processors, transcoders and displays, providing tools and technologies instantly revealing artifacts, problems and deficiencies, thus raising the bar in productivity and video quality experience.
- VideoQ products and services cover all aspects of video processing and quality assurance - from visual picture quality estimation and quality control to fully automated processing, utilizing advanced VideoQ algorithms and robotic video quality analyzers, including latest UHD and HDR developments.

Operations

- Headquarters in Sunnyvale, CA, USA
- Software developers in Silicon Valley and worldwide
- Distributors and partners in several countries
- Sales & support offices in USA, UK