Victor Steinberg

Video Standards

Signals, Formats and Interfaces

Part 7

Image Geometry & Aspect Ratio

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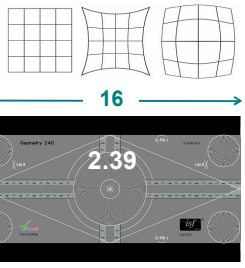
Video Image Geometry



Video camera, pointed to the square object, typically capture something ***similar*** to the original square.

In this presentation the **image geometry** is explained mostly via the **artificial test patterns** examples.

In TV the term Aspect Ratio (**AR**) is used rather loosely.

It describes how the picture fits into a screen of a particular proportion.

By definition Aspect Ratio of the rectangle is its width to height ratio.

Note that **Active Image Frame** rectangle is not the same as **Full Frame** rectangle.

There are several common **notations conventions:**

AR can be expressed as **W:H**, e.g. 16:9, or as **one number**, e.g. 1.777.., or **rounded**, e.g. 1.78, or **W/H : 1** (*it's funny, isn't it?),* e.g. 1.78:1

The simplest and the most popular variant: a **rounded number** *with implicit colon and unity*, e.g. AR = 1.78.

Two major parameters defining the displayed image geometry, and two mostly informative parameters:

1. **Display Aspect Ratio** (**DAR**), aka **Content Aspect Ratio**, aka **Picture Aspect Ratio**. Examples of full frame images DAR values are:
   1.33 (4:3) for the legacy 35 mm Academy format and legacy SDTV, **1.78** (16:9) for HDTV and UHDTV, **2.35** for the CinemaScope movie.
2. **Pixel Aspect Ratio** (**PAR**), derived from the **Active Frame** (**AF**) dimensions and DAR;
   E.g. for digitized full frame NTSC image AF = 714x486 and DAR = 4:3, PAR = (4/3)/(714/486) = 0.9076; for HD & UHD full frame PAR value is **1** (square pixel)
3. *Storage Aspect Ratio (SAR) - a confusing term (SAR is not AR!), function of digital full frame W and H, e.g. for 720x480 SAR = 720/480 = 1.5*
4. *Screen Aspect Ratio (aka Display Area Aspect Ratio), e.g. for the Display Area 597.6 mm x 336.15 mm Screen AR = 1.7777.. (16:9)*

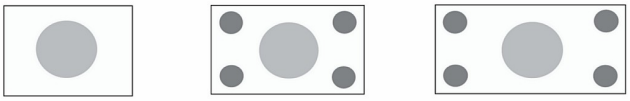
Content Aspect Ratio

It is important not to confuse the **Screen Aspect Ratio** with the **Content Aspect Ratio** aka **Picture Aspect Ratio**.
In the HD and UHD systems the screen aspect ratio is 16:9, in the legacy SD TV it was 4:3.
In cinematography and digital cinematography (DC) there is much greater variation - between 1.33 in early films to 2.35 in CinemaScope and even up to 2.77 in 70 mm films or widescreen 3D format.

Mapping an entire wide picture onto the full area of a narrower screen results in the "**Anamorphic Format**" which causes the picture to be geometrically deformed into a taller thinner image.
The use of anamorphic format provides **full vertical screen occupation** via **existing** equipment and conventional displays in a studio environment.
In the **CDN** (Content Delivery Networks) anamorphic format means smaller number of pixels (smaller digital frame width), so it provides for bandwidth saving.
Anamorphic AR could be 16:9 squeezed into 4:3 or 2.39 into 16:9, etc.

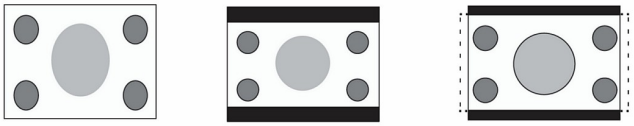
Original Picture Aspect Ratio

Legacy SD - 4:3 | HD, UHD -16:9 | Digital Cinema, e.g. 2.39:1



Transmitted / Stored Picture Format

Anamorphic, e.g. 16:9 in 4:3 | Letterbox-A, e.g. 16:9 in 4:3 | Letterbox-B, e.g. 14:9 in 4:3



Note that the aspect ratio is quite independent of the scanning parameters and so it is possible to have video signals with exactly the same scanning parameters but different aspect ratios.

Image Geometry Conversion Variants

In order to view undistorted 16:9 video on 4:3 screens, or 2.35 on 16:9 screen the "**LetterBox**" principle has been used, adding **black side bars below** and/or **above** the **Active Frame**.
Inversely, to view undistorted 4:3 video on 16:9 screens the "**PillarBox**" principle has been used, adding **black side bars** on the **left** and **right** sides of the **Active Frame**.

*In the old variants of Web TV you probably saw the "**PostStamp**" images with quite annoying black bars on all 4 sides of the Active Frame.*
For example, the 4:3 video was first inserted into 16:9 frame (PillarBox bars added), and then the resulting 16:9 picture was inserted into 4:3 frame (LetterBox bars added).

4:3

16:9

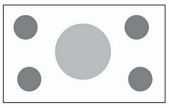
There are several popular **AR down-conversion modes**:

If a panoramic view is more important that **loss of fine details**, then **letterboxing** is the best choice.

Letterbox has the operational advantage that it does not require any "picture content sensitive" adjustment and intensive operator participation.

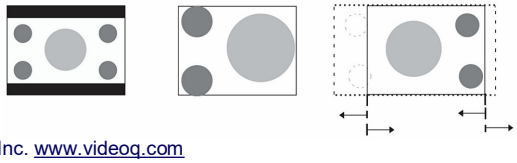
If loss of fine details is unacceptable, there is a choice between **Zoom** and **PanScan** modes.

HDTV source 16:9



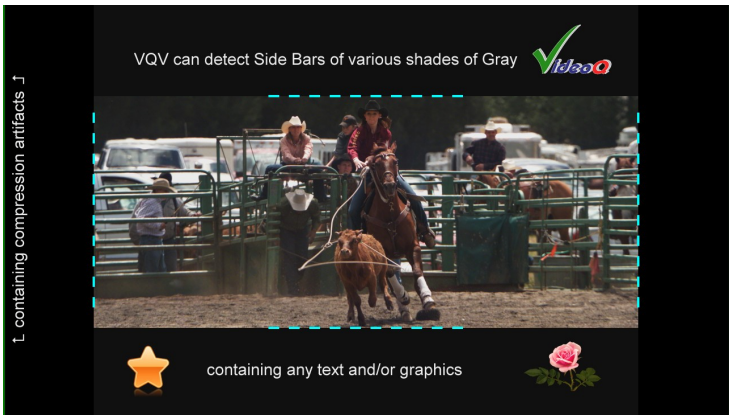
Down-converted SDTV 4:3

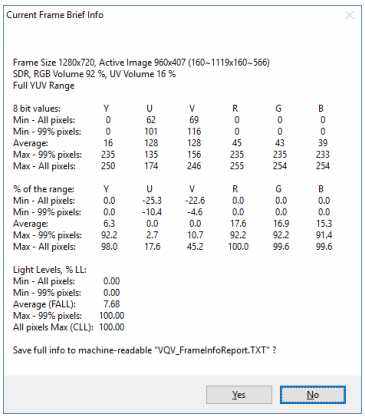
Letterbox mode | Zoom (Window) mode | Panscan mode



Active Frame Size & Side Bars Detection

In the ideal world, the source AR (Content Aspect Ratio set upstream) and Side Bars details are specified in the **embedded metadata**.
If so, the AUTO controller takes care about all image geometry conversion parameters.
But in real world the metadata may be wrong or missing. For example the Side Bars type and size may vary along the clip timeline; some scenes are Full Frame Height, but some other scenes are Letterboxes of various heights, Pillarbox, or even converted to ”PostStamps”.
In such case the “Side Bars Detector” (QA/QC software tool) may help.

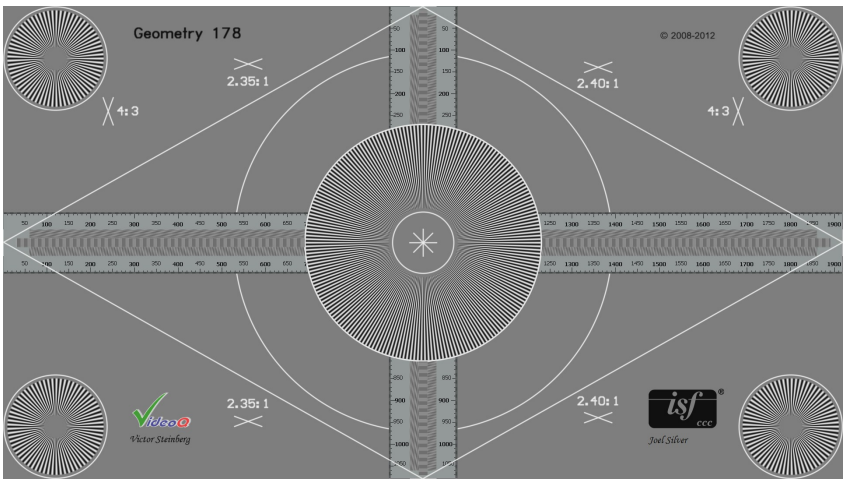




Testing Image Geometry

This static test pattern allows to check and measure with 1 pixel accuracy all relevant video image parameters:

- Overscan
- Underscan
- Letterbox
- Pillarbox
- Quality of scaling or proof of no scaling
- Video projector Pan & Zoom settings
- Video projector optical distortions, visible on two big circles, diamond lines, and 4 Radial Plates in the corners
- Video projector tilt compensation, “Keystone” (trapezoid) image



Active Format Description (AFD)

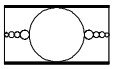
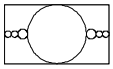
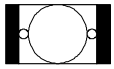
Active Format Description (AFD) is a **standard set of codes** that can be sent in the **transport stream** or via the **SDI interface.** AFD code carries information about the **Picture Aspect Ratio** and **Active Frame** parameters.

The **AFD codes** were originally developed within the **Digital TV Group** in the UK and submitted to **DVB** as an extension, then adopted by **ATSC** (with some changes) and included in the **SMPTE** standard 2016-1-2007, "Format for Active Format Description and Bar Data".

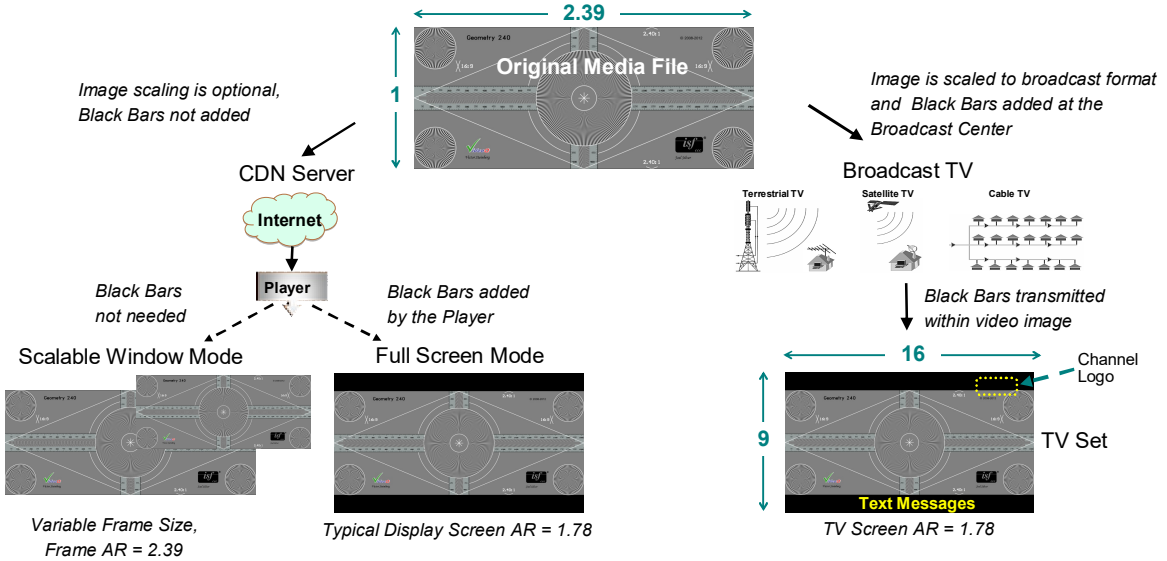
Complete list of codes can be found in **ETSI** TS 101 154 V1.7.1 Annex B, **ATSC** A/53 Part 4 and **SMPTE** 2016-1-2007.

It should be said that AFD is a **signaling** method, **informing** the display device about the **content originator preferred display mode**, but not **enabling** some particular image processing mode.

Few examples of AFD codes for 16:9 coded frame

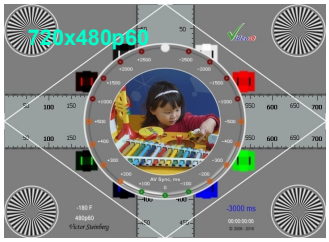
Active Format		Description
AFD = **0100** Box >16:9 (centre)		Image with **aspect ratio greater than 16:9** as a **vertically centered letterbox** in a 16:9 coded frame
AFD = **1000** Full frame		Image is **full frame**, with an aspect ratio that is **the same as** the 16:9 coded horizontally centered frame
AFD = **1001** 4:3 (centre)		Image with a **4:3 aspect ratio** as a **horizontally centered pillarbox** image in a 16:9 coded frame.

Black Bars & Delivery Options

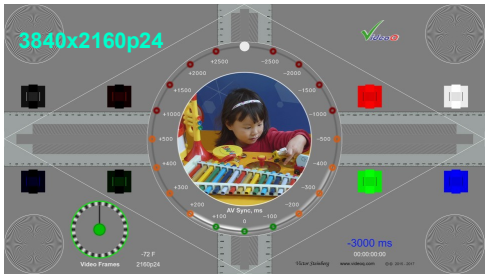


Testing Image Geometry

The MPCAVS (Multi-Purpose Chart with AV Sync components) dynamic test pattern is available in a variety of frame sizes and frame rates:



This universal test can be used to check and measure among other parameters the video image **geometry parameters** and **AR conversion**.



About This Presentation

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