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Video Standards

Signals, Formats and Interfaces

Part 1

Introduction & Overview

www.videoq.com

Introduction to Video Standards

- The term "**video**" in Latin means "I see". Strictly speaking, any signal carrying viewable information could be called a "Video Signal". The signal from a fax machine is one example, another member of this noble family of video signals could be the radar screen signal. Here, however, we are strictly concerned only with video signals in the broadcast, entertainment and social networks environments.
- And now the convergence of computer and video technologies has created **multimedia**, and this too demands a harmonization of **terminologies** as much as **technologies**.
- **A standard** can be defined as a set of rules or characteristics defining a particular system or product. Some standards are mandatory, but most, including the TV standards, are voluntary.
- There are a number of organizations responsible for **standardization** at global, regional and national levels.

Standards Bodies

United Nations

ITU

The International Telecommunication Union (**ITU**) is a specialized agency of the United Nations (**UN**)

ITU-R Radiocommunication Sector of ITU

BT Series Broadcasting service (television)

Recommendation ITU-R BT.656-5 (12/2007)

Interface for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601

Global Institutions

ISO International Organization for Standardization

cie International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

Regional Institutions

EBU TECH

At the regional level there are several broadcast unions (ABU, EBU, etc) also issuing documents dealing with standardization. The European Broadcasting Union (**EBU**) issues EBU Technical Recommendations

Industry Alliances, Associations and Societies

HDMI HIGH-DEFINITION MULTIMEDIA INTERFACE

The **HDMI Forum**, the nonprofit body that oversees the HDMI specification

SMPTE

The Society of Motion Picture and Television Engineers (**SMPTE**) is an international professional association

ARIB Association of Radio Industries and Businesses

The Association of Radio Industries and Businesses (**ARIB**) is a standardization organization in Japan

National Institutions

ANSI American National Standards Institute — **USA**

DIN — **Germany**

GOST-R — **Russia**

All these bodies try to co-operate rather than compete with each other.
For example, the famous **Recommendation ITU-R BT.601** is equivalent to **SMPTE ST 125** and **EBU Tech. 3246**.

Frame Size Progress

SDTV:
Standard Definition TV
In color since 1953 (NTSC2)

Sub-HDTV:
Variant of High Definition TV
1280×720 pixels

HDTV:
High Definition TV
1920×1080 pixels
currently dominating video format

UHDTV:
Ultra High Definition TV
3840×2160 pixels or more
"4K" is just a convenient name

In 20 years the pixels count increased from 720x480 = 345,600 to 3840×2160 = 8,467,200, i.e. 25 times!

Video Technologies Timeline

1997

Production & post-production:

Mixture of **SD, HD, file** & **tape** formats:
- Analog Component (Betacam SP)
- Digital Component (Digital Betacam, HDCAM, DVCPRO)
- Digital Composite (D2, D3)

Distribution:

Mixture of:
- Analog Composite SDTV (NTSC/PAL/SECAM)
- Digital SDTV (MPEG2 TS)
- Digital HDTV (MPEG2 TS)

2007

Production & post-production:

Digital component file formats, disk storage, variety of wrappers & compression codecs

First (experimental) variants of:
- UHDTV
- HDR (High Dynamic Range)

Distribution:

Mixture of **MPEG2** and **AVC** (H264) for:
- Digital SDTV
- Digital HDTV

YouTube and **Netflix** become massively popular for streaming **online video**

2017

Production & post-production:

Digital component file formats, variety of wrappers & compression codecs, transmission of uncompressed video over network infrastructure

Majority of titles produced in **SDR HDTV**, growing production of **SDR UHDTV** and **HDR UHDTV** titles

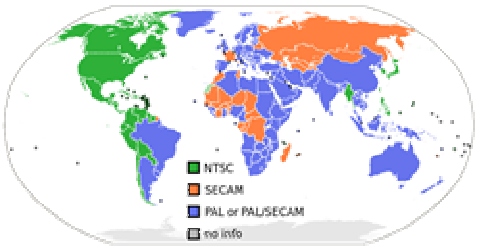
Distribution:

Mixture of **AVC** (H264) and **HEVC** (H265) codecs for **multi-format** distribution, variety of **frame sizes** and **frame rates**

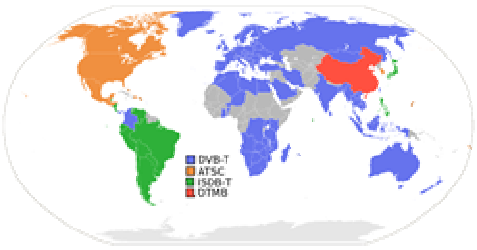
Massive streaming of online video

World Broadcast Maps

Analog Television Systems

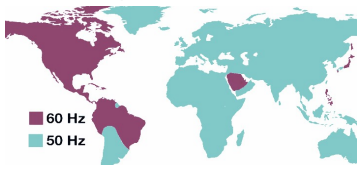


Digital Television Systems



At the dawn of black-and-white television it was reasonable to link the field repetition rate (in case of 2:1 interlacing, frame rate is equal to half field rate) with the frequency of the AC power line. This prevented slow scroll of the horizontal hum bar on the TV picture.

AC Power Lines Frequencies & TV Frame Rates, Hz

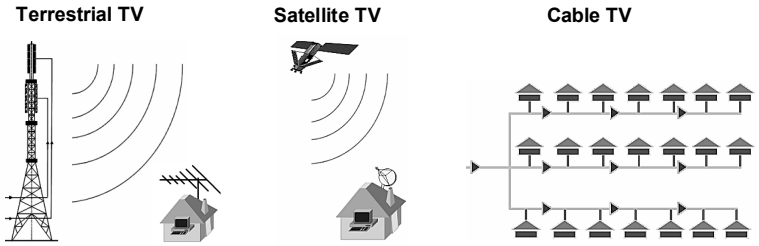


When the color TV era began, with its crystal referenced rates and much better filtering of DC supply rails, the link became more or less irrelevant.
The only justifiable reason for preserving it was to reduce the visibility of unpleasant **low frequency *beating between AC powered lighting pulsation and video camera frame/field rates***.

Historically, the most significant boundary in the TV world is the one between ***different frame rates***:
so we are still split between **50 Hz** and **60 Hz** countries (although strictly speaking the latter figure is **59.94 Hz**).

Content Delivery Options

So called **"Big Three"**:

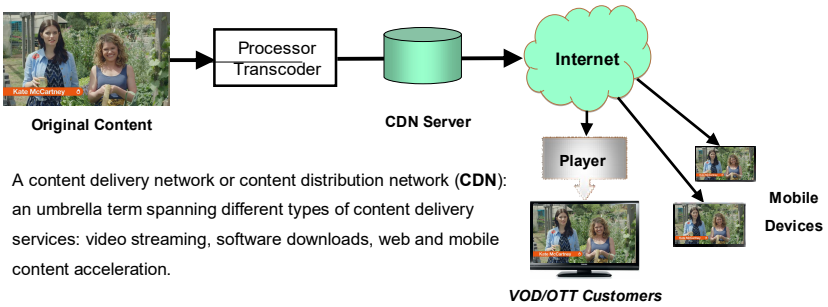


New challenger:

Multi-screen

Multi-format

Network-based TV



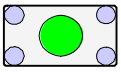
A content delivery network or content distribution network (**CDN**): an umbrella term spanning different types of content delivery services: video streaming, software downloads, web and mobile content acceleration.

Video Standard Elements

- The **Levels Mapping Scheme** determine how camera should interpret a scene light values and how receiver should interpret video signal values, i.e. rules of conversion within and/or between the signal and light domains. For example, in the digital domain it is necessary to define the relationship between the **reference light levels** and the **digital codes** they signify.

- The **Color Information Representation** determines how color information is carried.

- The **Aspect Ratio** describes how the picture fits into a screen of a particular **proportion**.

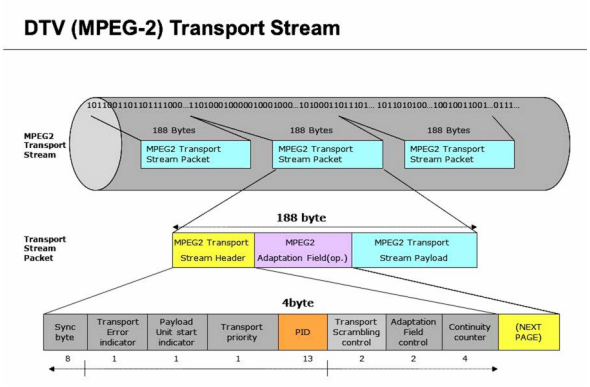


- The **Scanning Standard** determines how the picture is sampled in space and in time (i.e. the number of lines in the picture, number of pixels per line, and the number of pictures per second) and it may include other items such as interlace.

Video Formats

Video Format is an agreed way of packaging the picture information for transmission or recording. There are many choices and dimensions:

- Digital or Analogue
- File or Stream
- RGB or YUV
- Planar or Interleaved
- Serial or Parallel
- Compressed or Uncompressed
- Wrapped (in a container) or “Raw Data”
- Elementary Stream or Transport Stream



The specification and designation of a format are often poorly defined.

Video standards and formats are often confused, not all formats are fully described in the official documents.

Video Interfaces

Video Interfaces are often named by the signal format, e.g. “Analog Component YPrPb” or just “RGB”.

However, **HDMI** = **H**igh-**D**efinition **M**ultimedia **I**nterface is named by its application.

There are many variants and flavors of widespread **SDI** = **S**erial **D**igital **I**nterface, e.g. UHD signal can be carried by Quad-3G-SDI interface or by single 12G-SDI interface.

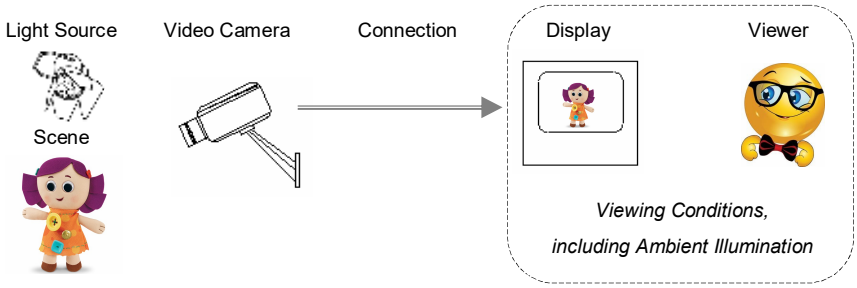
The digital interfaces are much more sophisticated than analog; the description covers more than one layer – in accordance with the Open Systems Interconnection model (OSI model).

In practice, the **Physical Layer** (Layer 1, the lowest) should be checked first.

It defines the shapes and properties of the electrical connectors, the layout of pins, voltages, electrical and/or optical fiber cable specifications, signal timing and similar low-level parameters related to transmission and reception of raw bit streams over a physical medium.

Next 6 layers (Data Link Layer, Network Layer, Transport Layer, etc.) define packets, frames, protocols, dialogs, etc.

Incredibly Simple TV System Diagram



It is over-simplified, bit it's still true.

Problems appear when serious experts promote the idea of **"exact reproduction"** by the display screen of the original scene **colors** and light levels **dynamic range**.

But the truth is that the purpose of the TV system is to create for the typical viewer (so-called "average observer") only more or less trustworthy ***illusion*** of seeing something ***similar*** to the original scene.

To achieve maximal **viewing comfort**, the system should **adjust/modify** video signal and scene image parameters, thus providing the "content semantic value", i.e. the viewer is happy to see familiar/recognizable object/person even if the light output of the display differs from the original by several orders of magnitude !

SDR & HDR: Long-term Peaceful Coexistence ?

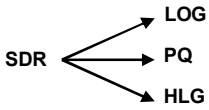
Currently there are 4 types of video data formats in use,
based on different DR (Dynamic Range) models:

- Ubiquitous widespread **SDR** (Standard Dynamic Range) format
- **HDR-LOG** (High Dynamic Range – Log Camera Video)
- **HDR-PQ** (High Dynamic Range – Perceptual Quantizer: **Dolby Vision**, **HDR10**, **HDR10+**)
- **HDR-HLG** (High Dynamic Range – Hybrid Log Gamma)

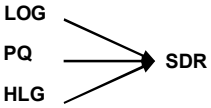
Dynamic Range Conversion – Necessity & Options

- Mixed SDR/HDR environment requires SW and HW engines for auto-enhancement, up-, down- and cross- conversion within and/or between all four above-mentioned formats.
- This functionality is also related to the optimal choice of ***mezzanine*** DR format and architecture of vision mixers/switchers operating in such SDR/HDR environment.

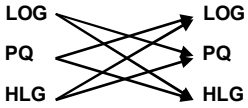
DR Up-conversion



DR Down-conversion



DR Cross-conversion



Example of HDR10 Test Pattern

10 Two-tones Patches
aimed at testing
Display Clipping Levels

7 White SPLUGE
Conical Grayscales
aimed at testing
Display Clipping Levels

Black PLUGE rectangles and
Black SPLUGE Conical Grayscale
on **Reference Black** background
aimed at testing
Display Min Brightness

Valid Range 10 bit Linear Ramp
with critical levels markers
aimed at testing
Display Tone-mapping Uniformity ("Banding")

Precise **FALL & CLL** readout
aimed at calibration & testing of
Content Levels Analyzers

Special **HDR Grayscale**
aimed at testing
Display Light Output Profile
and **Clipping Level**

Special **HDR Color Bars**
aimed at testing
Display Light Output Profile

About This Presentation

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"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

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