Basics of Video Editing Technology

BFM7121 Basic Editing

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Progressive scanning

Progressive scan means drawing the odd and even scan lines in order without interlacing.

1
2
3
4
5
6
7
8
9
10
...

One complete frame, 25 frames per second (in PAL)

Interlaced scanning

One frame on interlaced scan video is created from 2 fields (odd and even field)

Upper field

1
3
5
7
9
11
13
...

Odd scan lines

Lower field

2
4
6
8
10
12
...

Even scan lines

Each field is displayed for 1/50th of second (in PAL) producing 25 frames per second

International televisioon standards

- **PAL (phase alternate line)** - The European standard for color television transmission, has 625 scanlines, scanned at a rate of 25 frames per second
- Operate at 50 Hz

- **SECAM (Sequential Colour a Memoire)** – a TV standard developed by the French and used in France, Russia and other countries (625 scanlines, 25 frames per second)

- **NTSC (National Television standards Commitee)** – The U.S. Standard for color TV transmission, has 525 scanlines, scanned at a rate of 30 frames per second (to be exact 29.97 frames per second)
- Operate at 60 Hz

International digital television standards

- **DVB (Digital Video Broadcasting)** – Digital television standard used in Europe
  - DVB-S (satellite TV)
  - DVB-C (cable TV)
  - DVB-T (terrestrial TV)
- **ATSC (Advanced Television Systems Committee) -** Digital television standard used in USA

Moviola editing table

http://www.manueliglesias.com/images_taller_montaje/moviola.jpg

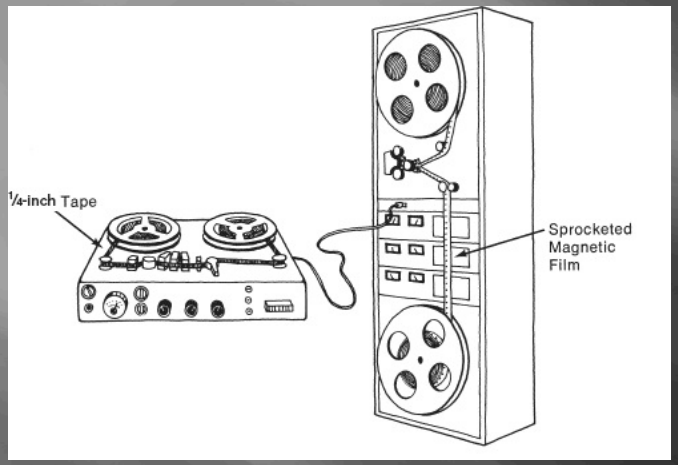
Steenbeck 35mm editing table

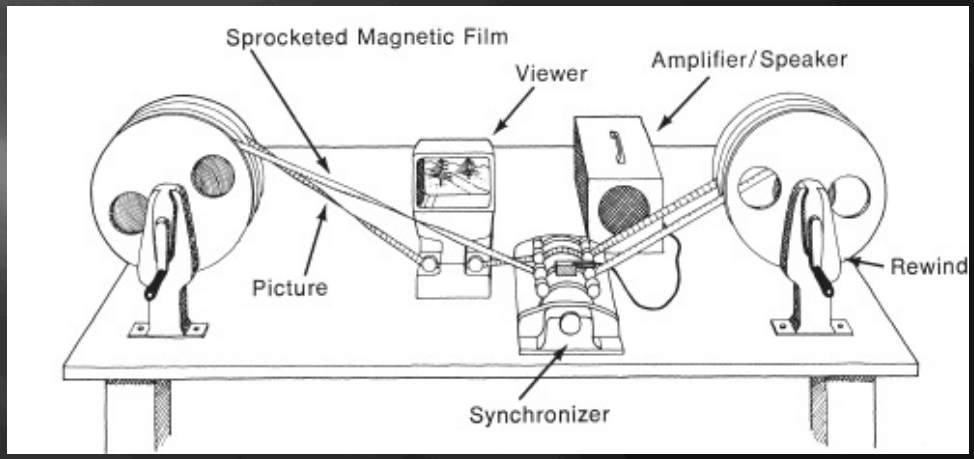
http://www.koelner-filmhaus.de/05_06-technik-schnitt.htm

Film editing

http://www.cinemax.jp/products/film_edit.html

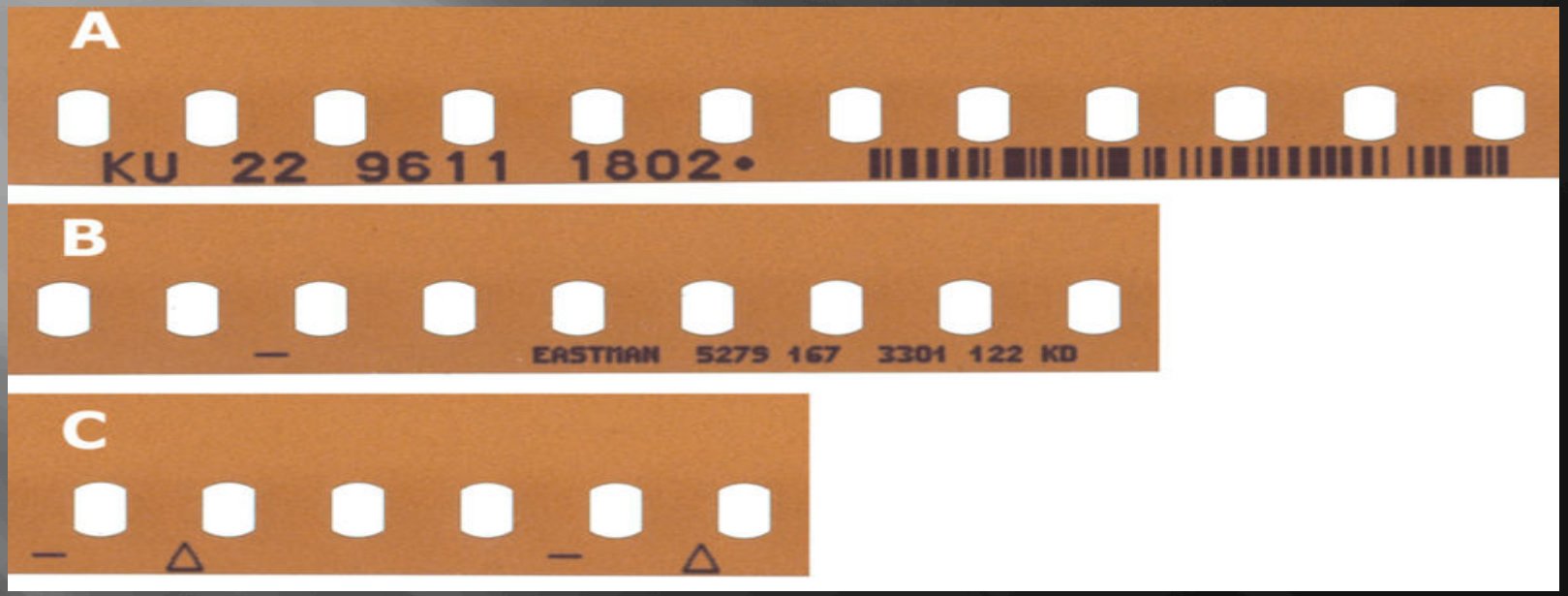
Film editing





Ascher, Steven & Pincus Edward. The Filmmaker's Handbook. A Comprehensive Guide for the Digital Age. 4th ed. Plume 2013.

Film edge numbers - keycode



http://en.wikipedia.org/wiki/Keykode

History of video editing

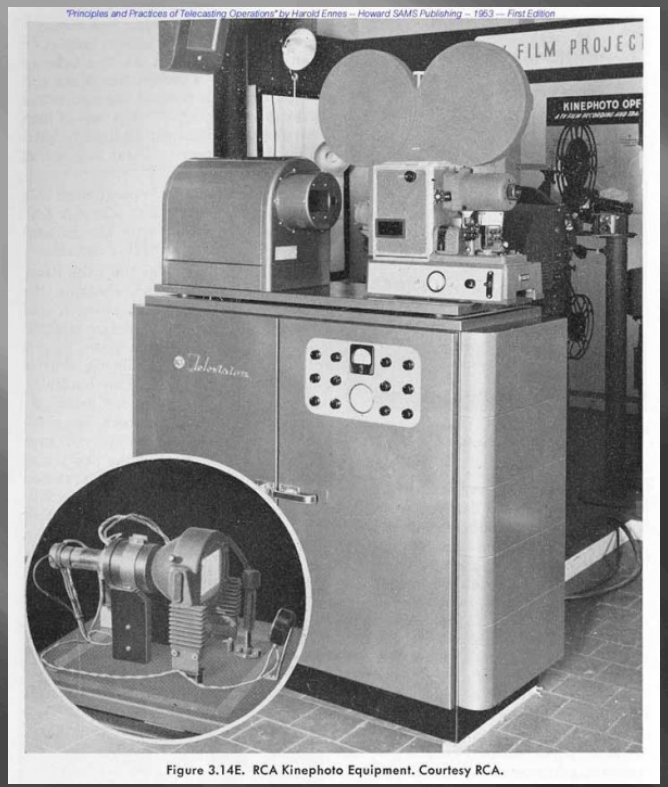


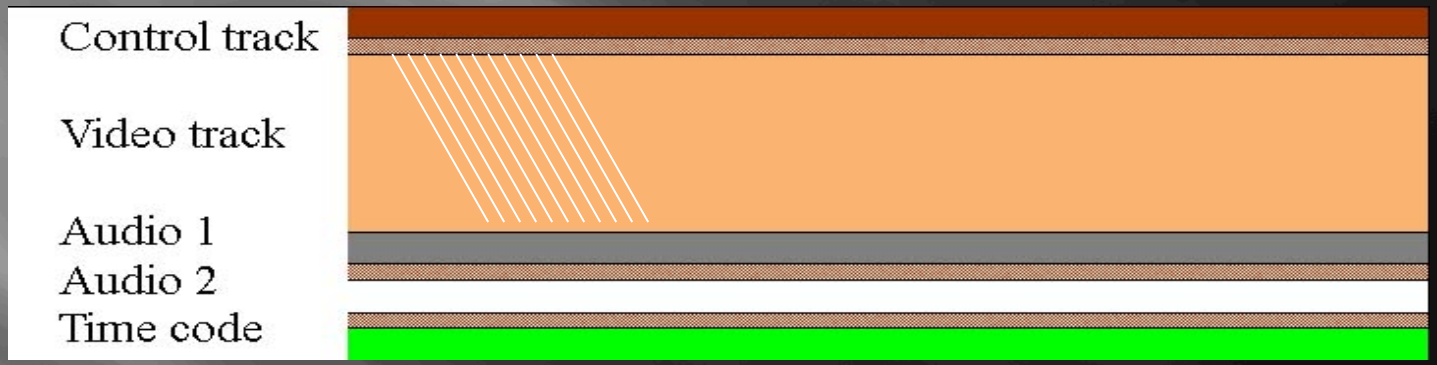
Figure 3.14E. RCA Kinephoto Equipment. Courtesy RCA.

- Kinescope – a recording of a television program made by filming the picture from a video monitor.
- Film stock was very expensive. Another solution was needed.

First videotape recorder

- 1956 AMPEX Ampex VR-1000 2-inch videotape recorder

Structure of videotape

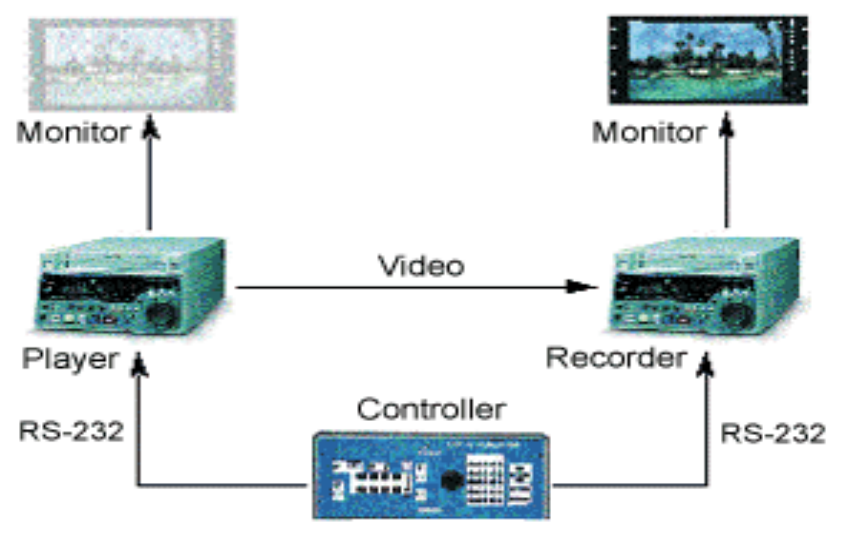


History of video editing

- The videotape recording process was first demonstrated in 1953, and the first machines went into service in 1956
- 1956 AMPEX 2-inch videotape recorder

- In late 1950-s SLICE and SPLICE editing
- Beginning of 1960-s Electronic editing devices were developed
- 1967 Time-Code based Editing

Linear editing system



Editing controller

Structure diagram of dual-post editing linear system with two VTRs and one controller

http://eng.625-net.ru/content/2004_08/prodsys7.htm

Control track and timecode

- **Control track** – an electronic signal recorded on videotape at each head revolution and each field that tells the next machine how to play back that particular video signal. Similar in concept to the sprocket holes in film
- **TIME-CODE** - Electronic indexing method used for editing and timing video programs. Timecode is a label that uniquely identifies each frame of video expressed as **hh:mm:ss:ff**
- SMPTE (Society of Motion Picture and Television Engineers) time code - Binary time code denoting hours, minutes, seconds and frames.
- Be careful with the timecode breaks!

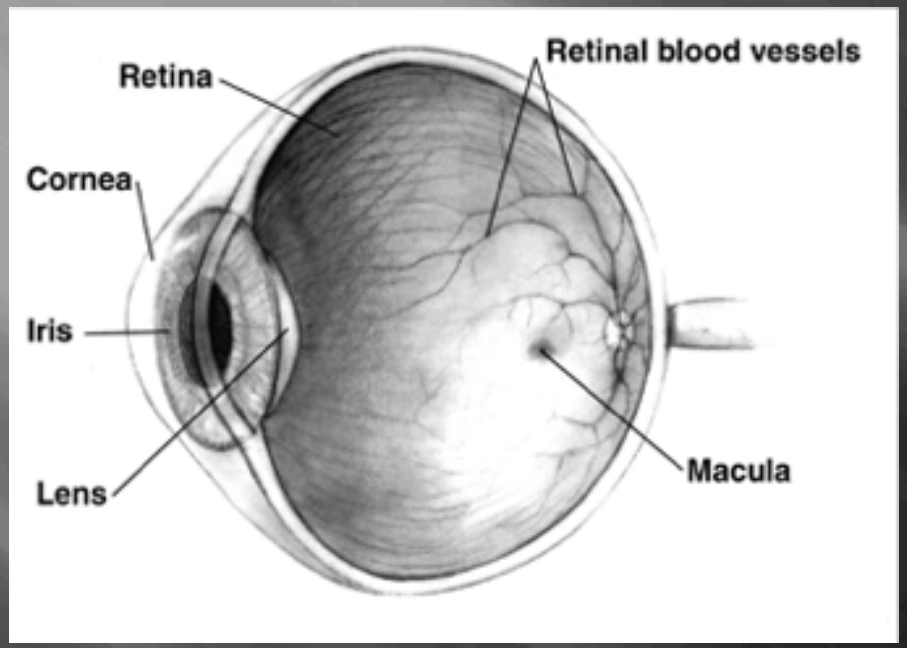
Use of timecode

- **PRESETS** - it is possible to set the start of the timecode in the camera, and in VTR's
- Every tape or memory card could start with new hour of timecode (first tape starts 01:00:00:00, second tape 02:00:00:00 etc.)

- In finished master tape the program starts at timecode **10:00:00:00**

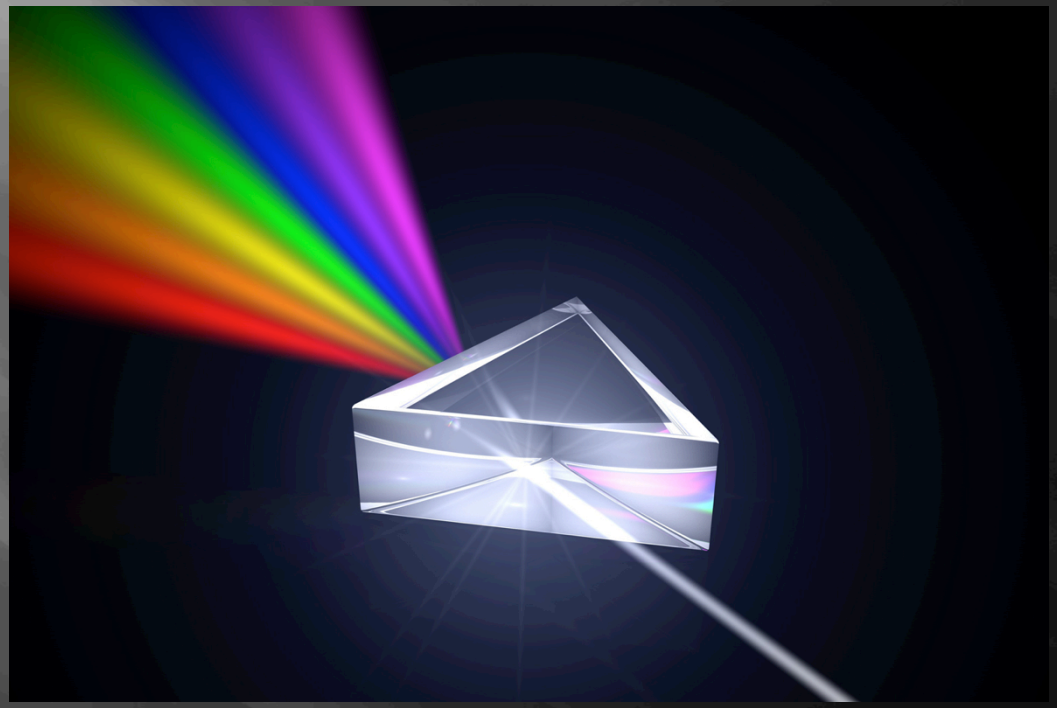
- **REC RUN** – timecode "runs" only when recording (usual practice)
- **FREE RUN** – timecode "runs" constantly (usually used "time of the day") – useful for multicamera setups or dual system audio recording

Human eye



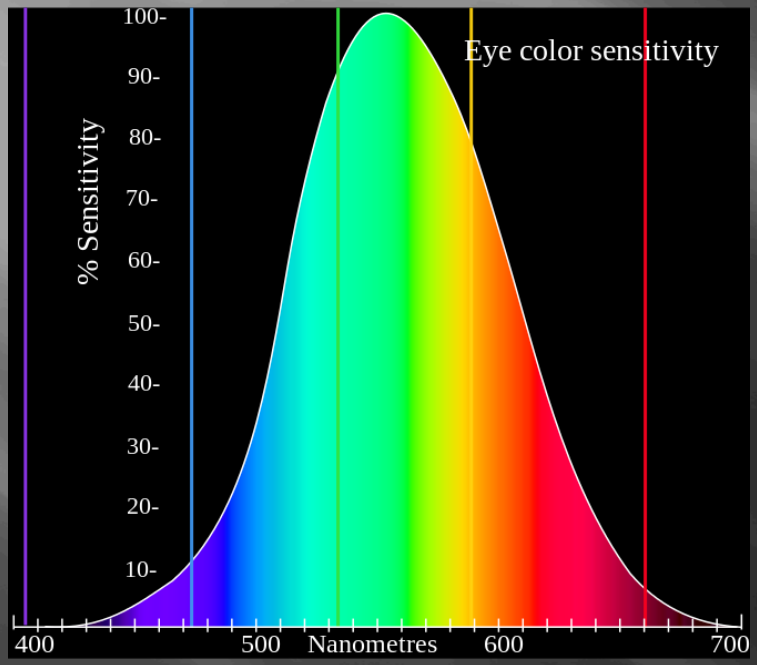
- There are about **120 million rod cells** (react for brightness) and **6 million cone cells** (react for color) in human retina.
- Human eye is more sensitive for brightness than for the color.
- In low light condition human eye sees in black and white.

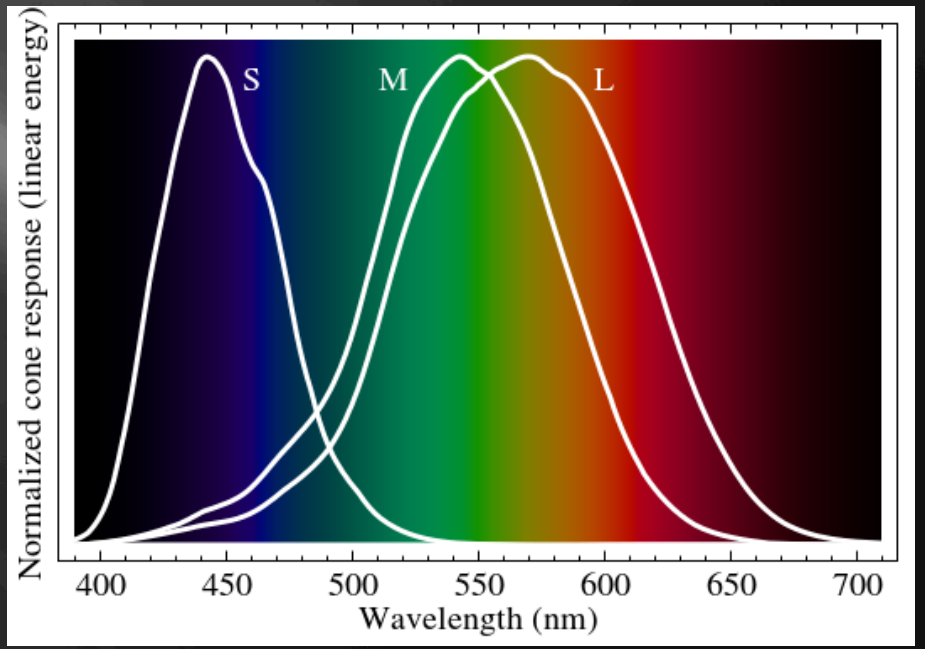
Breaking up white light in the prism



http://www.risk.net/IMG/847/94847/light-split-into-spectrum-by-prism.jpg

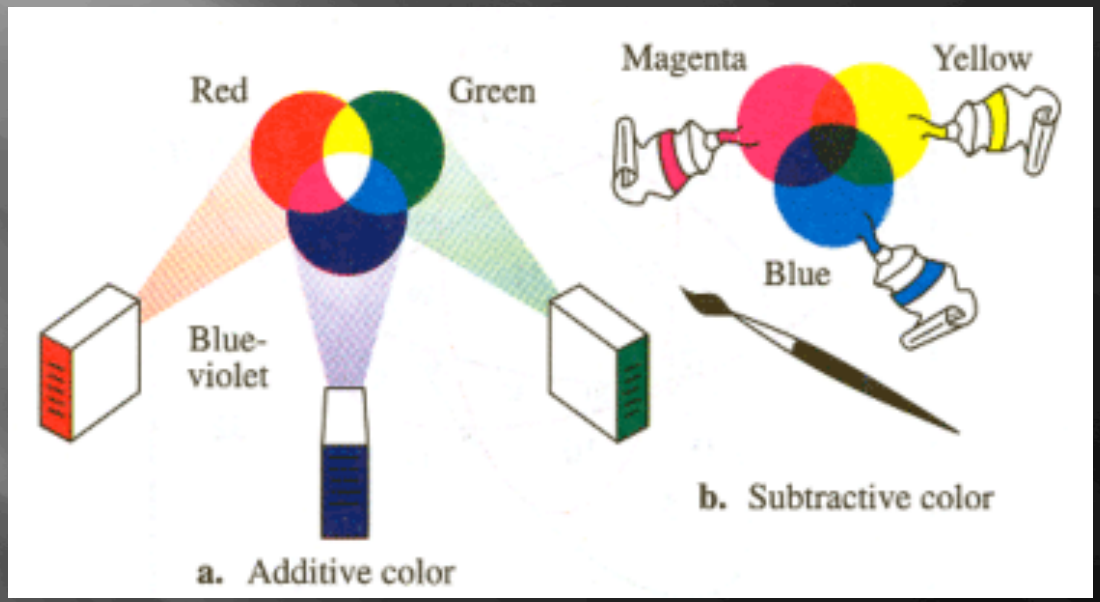
Human eye's relative color sensitivity based on the wavelength of the light





http://en.wikipedia.org/wiki/Color_vision

Additive and subtractive color model

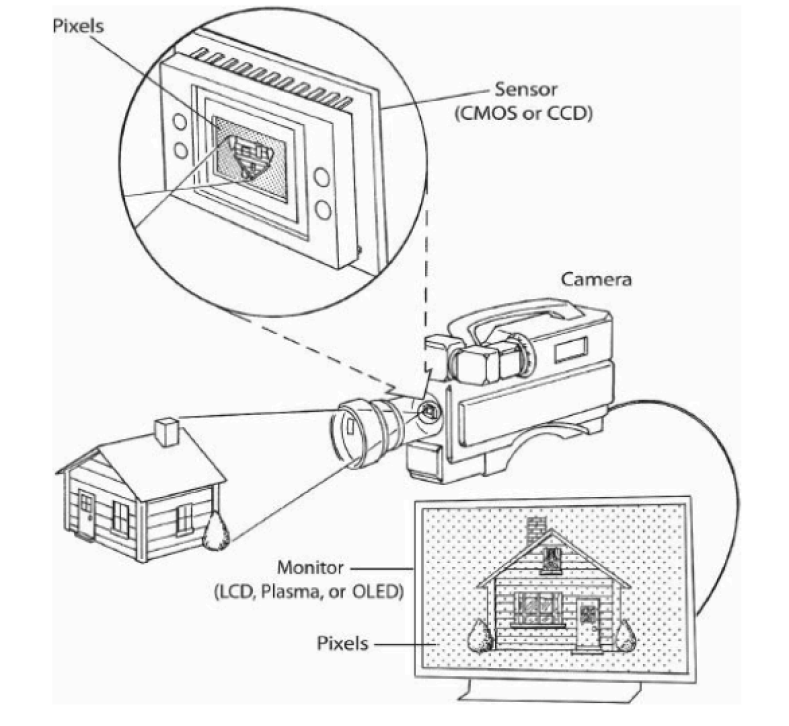


http://academics.wellesley.edu/Neuroscience/Neuro320/Coursecontent/colorbasics.html

Additive and subtractive color model

- Color Mixture
  - http://www.michaelbach.de/ot/col_mix/index.html
- Color Matching Game
  - http://www.michaelbach.de/ot/col-match/index.html

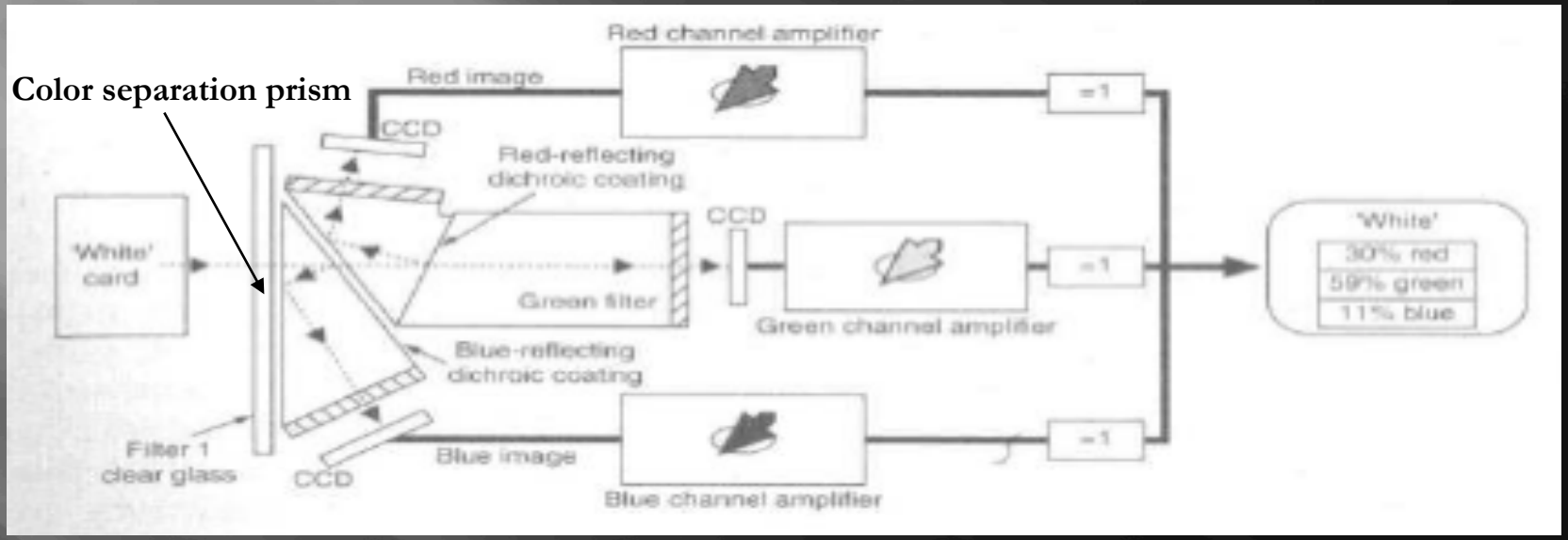
Video camera and monitor



- The image is turned upside down in the lens, registered as pixels in the camera light sensitive sensor (CCD or CMOS)
- Video signal is transformed back into pixels in the monitor screen that recreates the captured image.

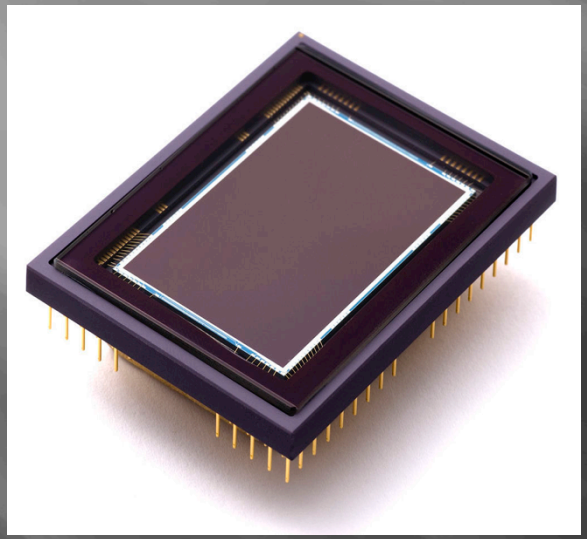
Ascher, Steven & Pincus Edward. The Filmmaker's Handbook. A Comprehensive Guide for the Digital Age. 4th ed. Plume 2013.

Splitting the color image into three components inside the 3 CCD camera (RGB)



$$Y = 0.299\,R + 0.587\,G + 0.114\,B$$ (in PAL)

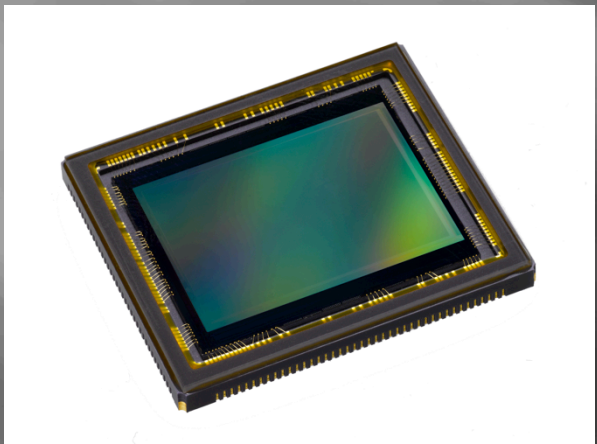
CCD - Charge-Coupled Device



- An array of light sensitive elements. Light is converted to an electrical charge in a linear fashion – proportional to the brightness impinging on each cell. The cells are coupled to a scanning system which, after analog to digital conversion, presents the image as a series of binary digits.

http://img.directindustry.com/images_di/photo-g/ccd-image-sensor-25439-4429821.jpg

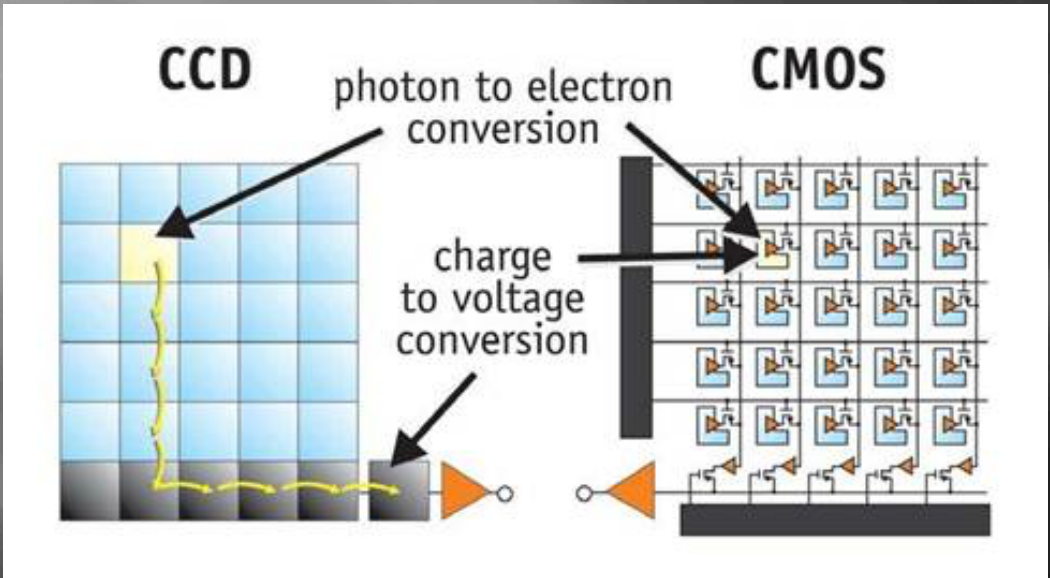
CMOS - Complementary Metal-Oxide Semiconductor



- The chips are cheaper than the alternative CCDs, they consume less power, can be more sensitive (faster), have less image lag and can include image-processing functions on the sensor chip.

https://martinmoorephotography.files.wordpress.com/2012/01/k-r-cmos-sensor.jpg

CCD vs CMOS

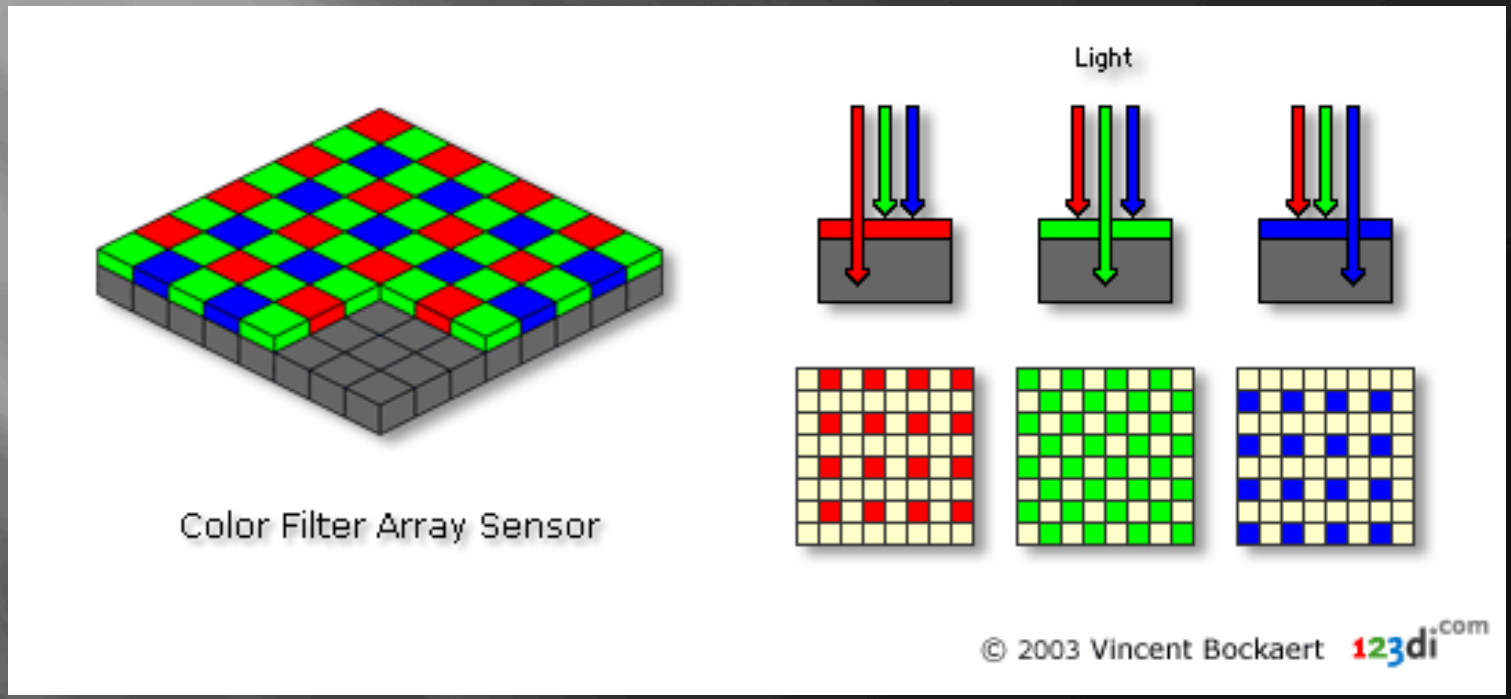


http://meroli.web.cern.ch/meroli/lecture_cmos_vs_ccd_pixel_sensor.html

- CCDs move photogenerated charge from pixel to pixel and convert it to voltage at an output node.
- CMOS imagers convert charge to voltage inside each pixel.

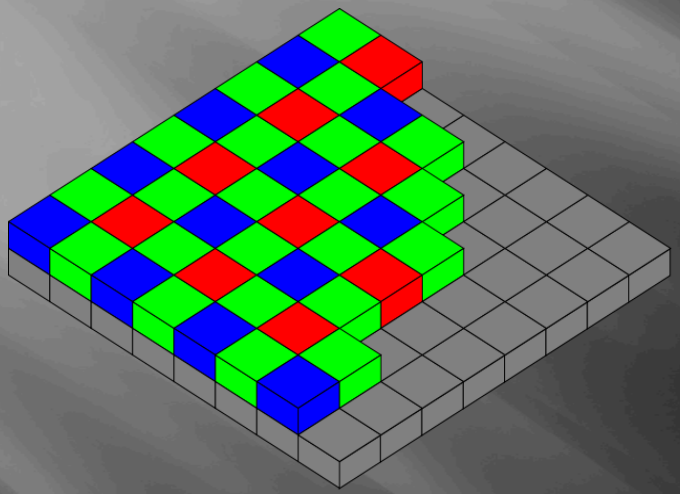
- Read more:
- http://meroli.web.cern.ch/meroli/lecture_cmos_vs_ccd_pixel_sensor.html
- http://www.dalsa.com/corp/markets/CCD_vs_CMOS.aspx

Bayer pattern array



http://www.dpreview.com/glossary/camera-system/sensors

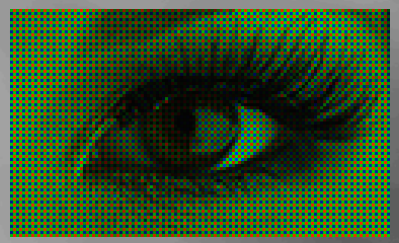
Bayer pattern array

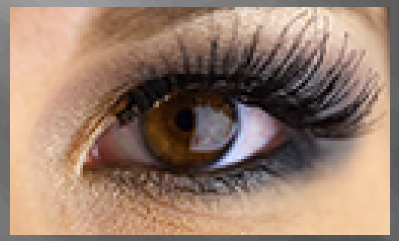


http://en.wikipedia.org/wiki/Bayer_filter

- Similar to human eye (eye is most sensitive in the green spectrum) the Bayer filter has 2 times more green than red & blue pixels.
  - Developed in 1976 by dr. Bryce E. Bayeri (company Eastman Kodak).
- Read more:
  - http://www.cambridgeincolour.com/tutorials/camera-sensors.htm
  - http://www.red.com/learn/red-101/bayer-sensor-strategy

RAW video

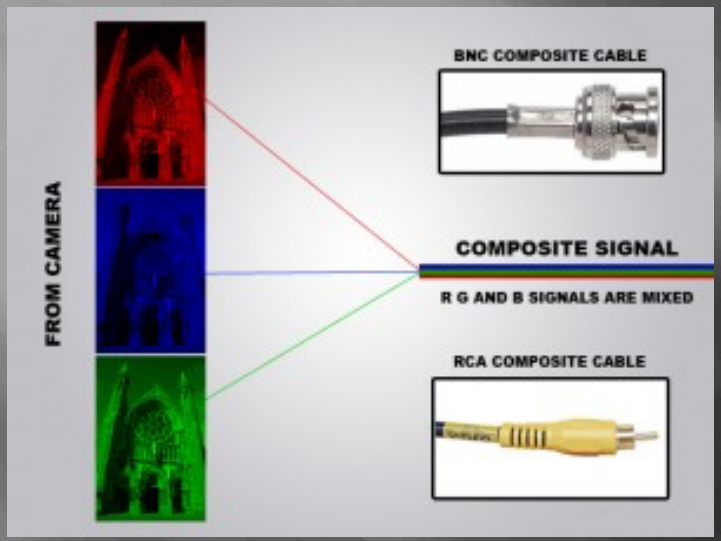




- Cameras that record in RAW format preserve all the data coming from the camera sensor. This allows greater flexibility in post processing and image manipulation in the post production.
- To see the RAW image is needed:
  - demosaic or debayer – calculating RGB values for each pixel (processor intensive)
  - fixing of white balance
  - fixing of color space (rec 709 for example)

http://www.red.com/learn/red-101/bayer-sensor-strategy

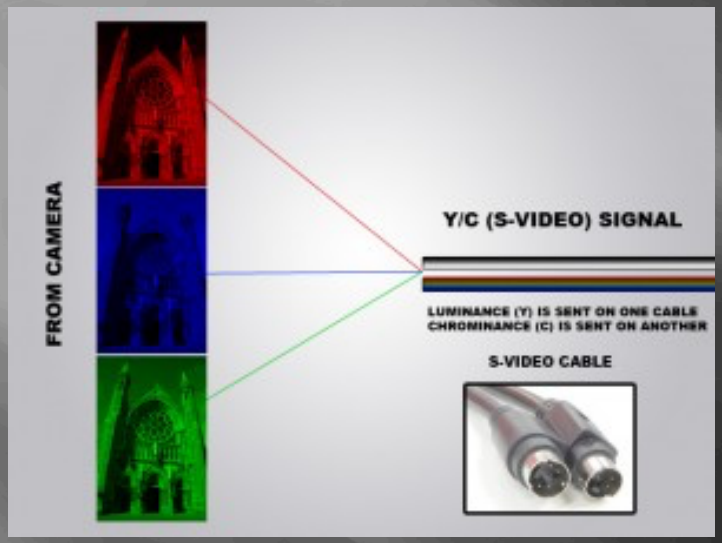
Composite video signaal



- **Composite video signal** is an analogue signal that combines luminance and chrominance along with the timing reference sync and color burst information
- One cable needed (BNC or RCA)

http://www.productionapprentice.com/tutorials/general/component-composite-and-digital/

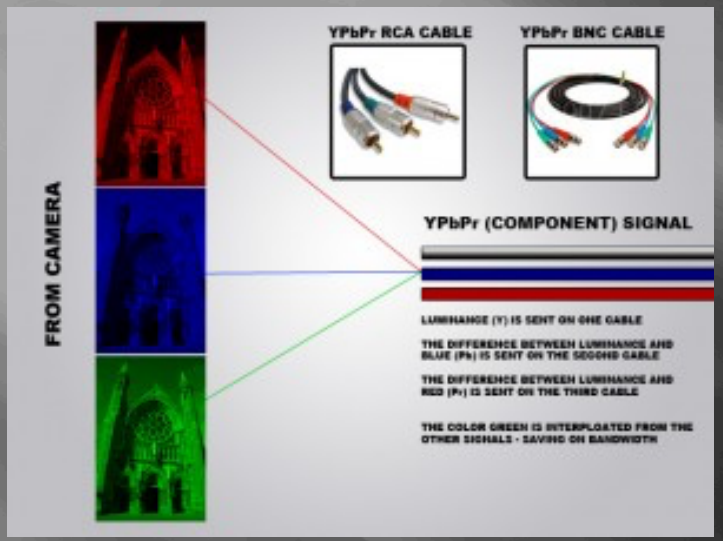
Y/C or S-video signal



- **Y/C or S-video signal** consists on two seperate parts:
  - luminance – black and white information
  - chrominace – color information
- Needs one 4-pin cable (S-Video)

http://www.productionapprentice.com/tutorials/general/component-composite-and-digital/

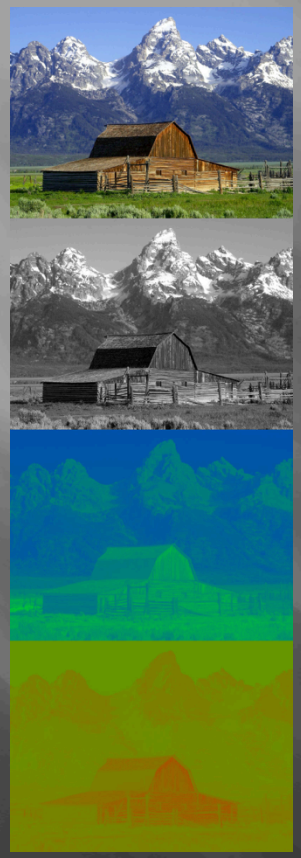
Component video signal



- **Component video signal** uses three separate cables:
  - Luminance
    - Y
  - color difference signals
    - R-Y
    - B-Y
- Needs three cables (BNC or RCA)

http://www.productionapprentice.com/tutorials/general/component-composite-and-digital/

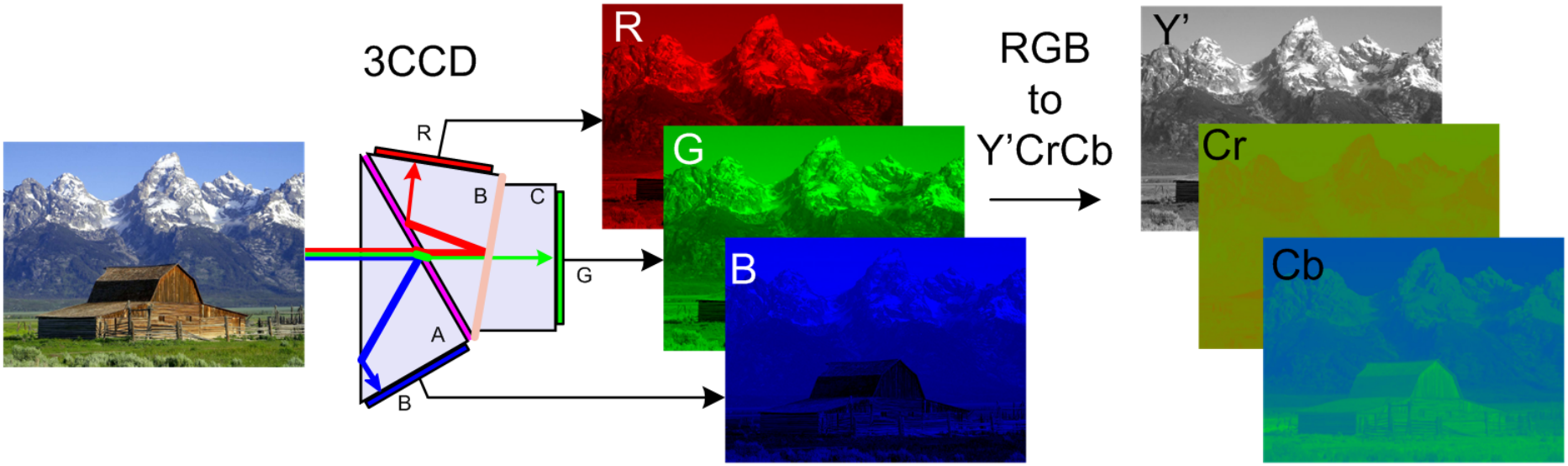
Component video signal



- Different sysmbols used for component video:
  - **Y, R-Y, B-Y**
  - **YUV**
  - **Y, Pb, Pr** – analog component video
  - **Y, Cb, Cr** – digital component video

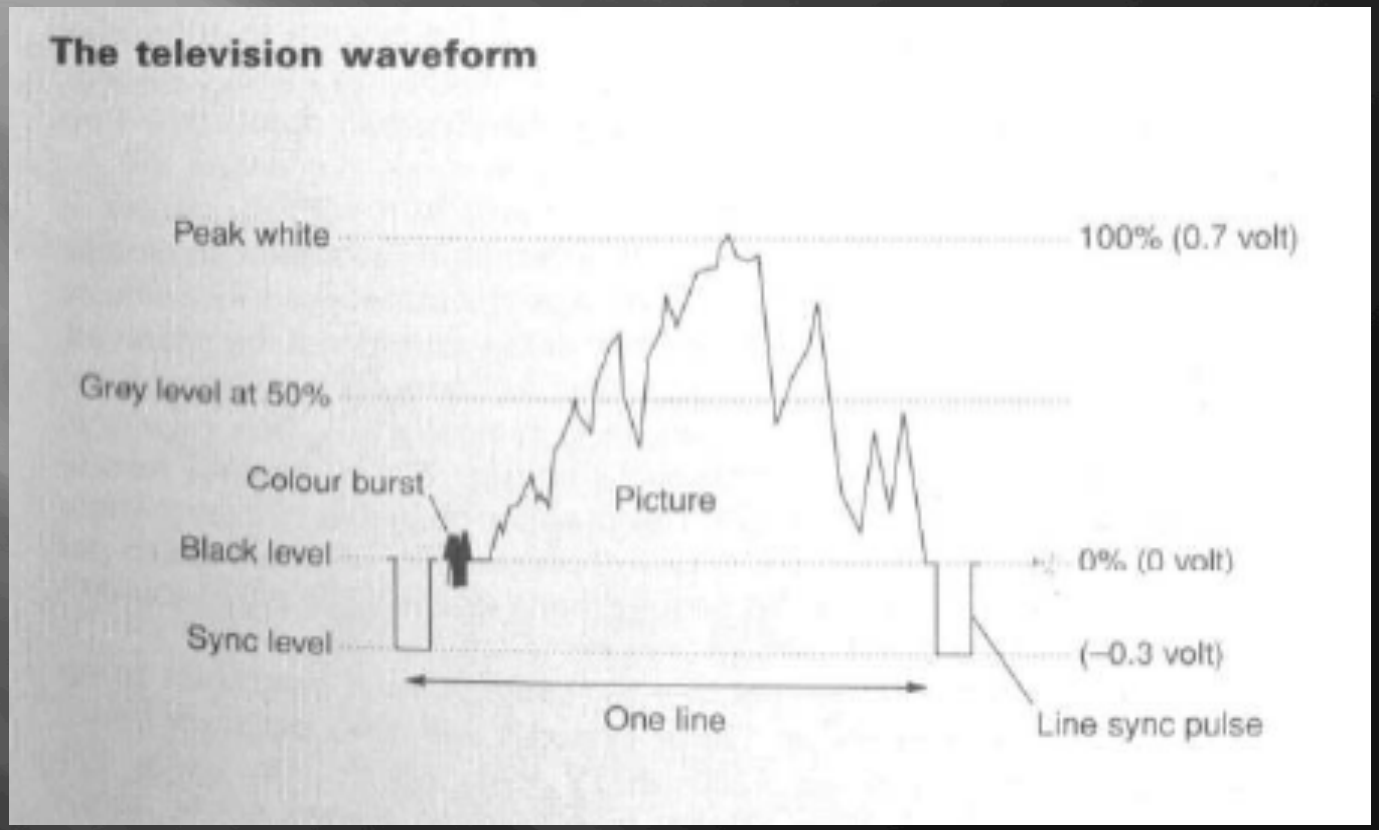
http://en.wikipedia.org/wiki/YCbCr

Component video

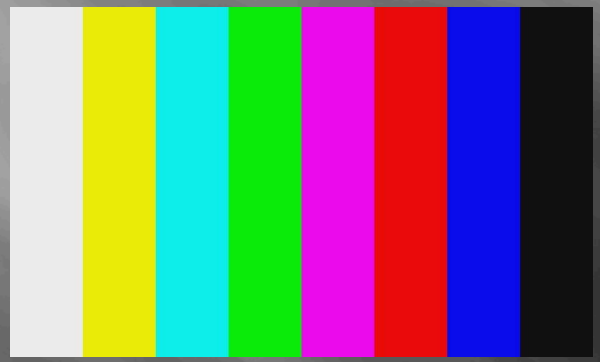


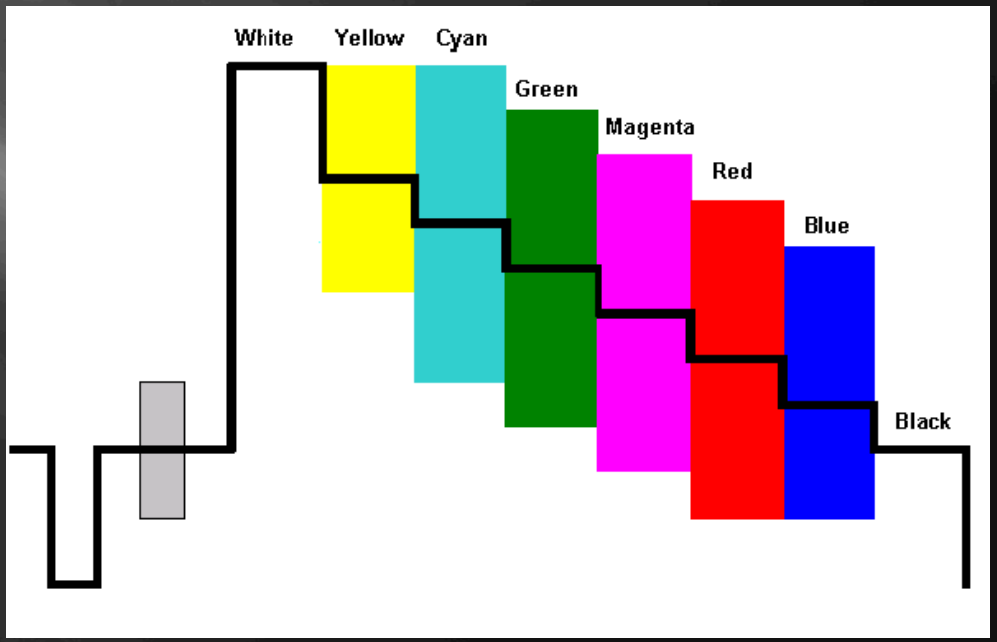
http://en.wikipedia.org/wiki/YCbCr

Analog videosignal waveform



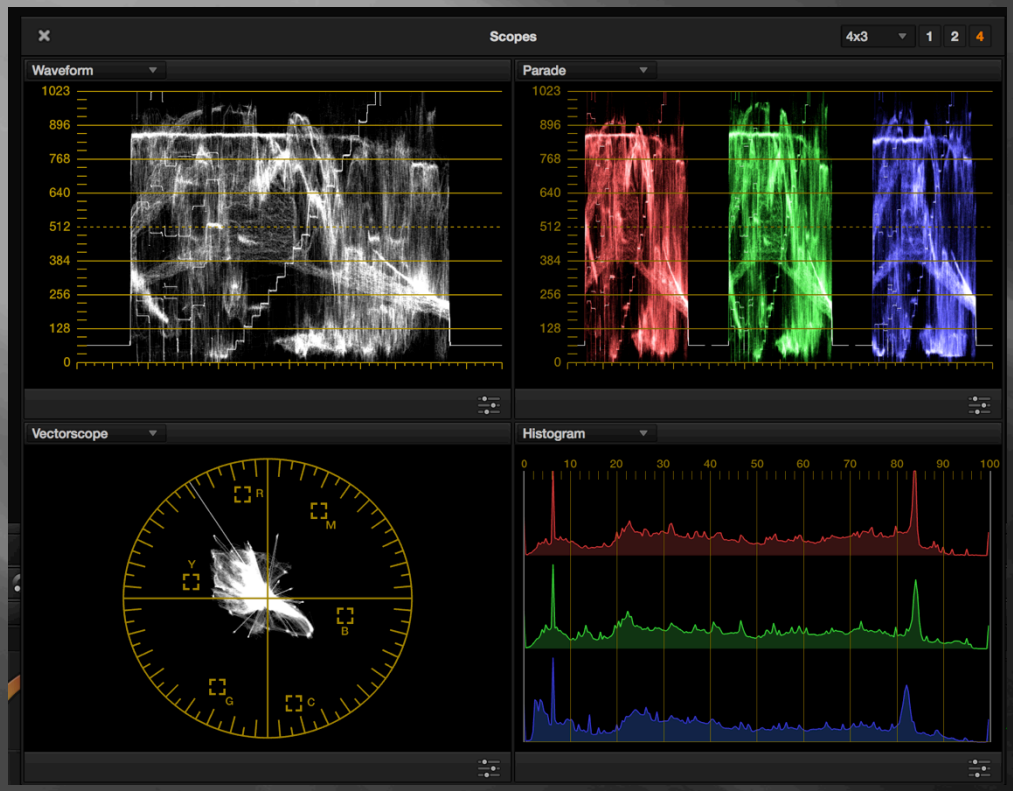
Waveform monitor – test table





http://educypedia.karadimov.info/electronics/televisioncolor.htm

Videoscopes



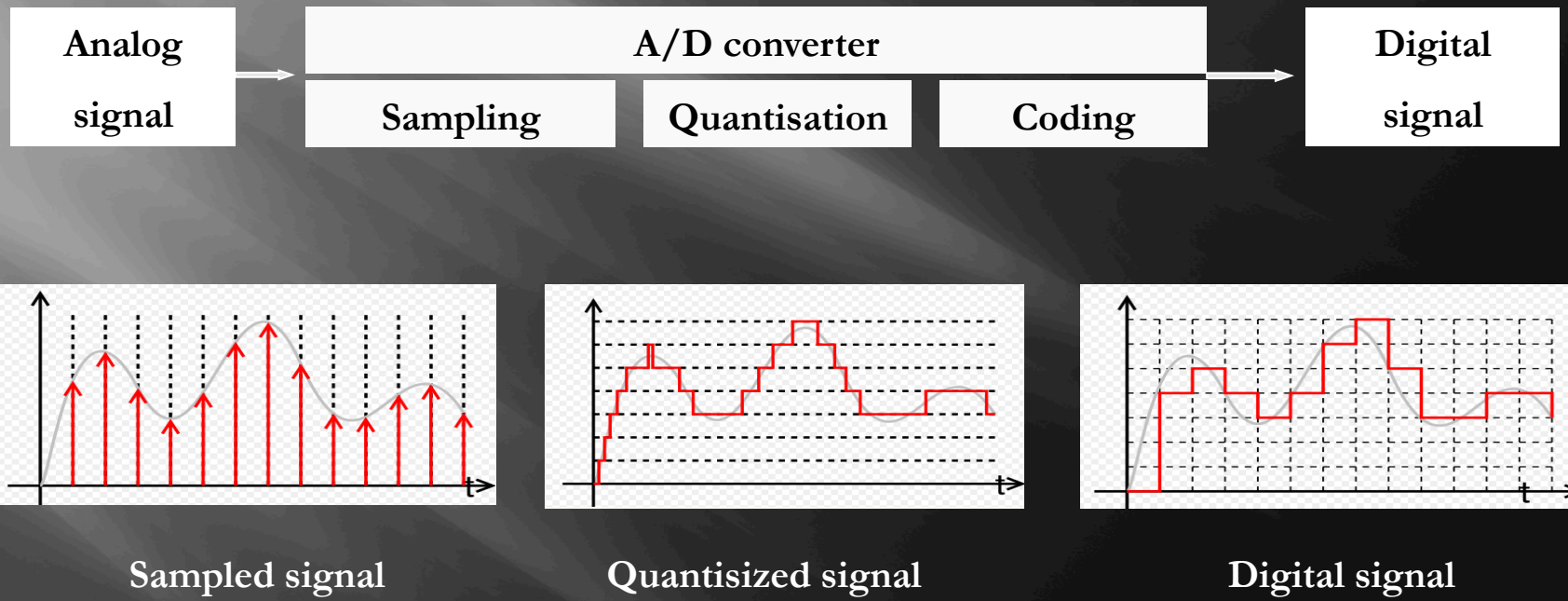
- Videoscopes in Davinci Resolve-s:
  - Waveform
  - Parade
  - Vectorscope
  - Histogram

Analog vs digital signal

- **Analog** – a continuously varying electronic signal. Audio and video analog signals deteriorate with each copy or generation (loss of quality of the signal).

- **Digital -** electronic system which functions by converting the analog signal into a series of discrete binary bits (ones and zeros). The quality of the digital signal does not deteriorate with each copy or generation.

Analog to digital conversion



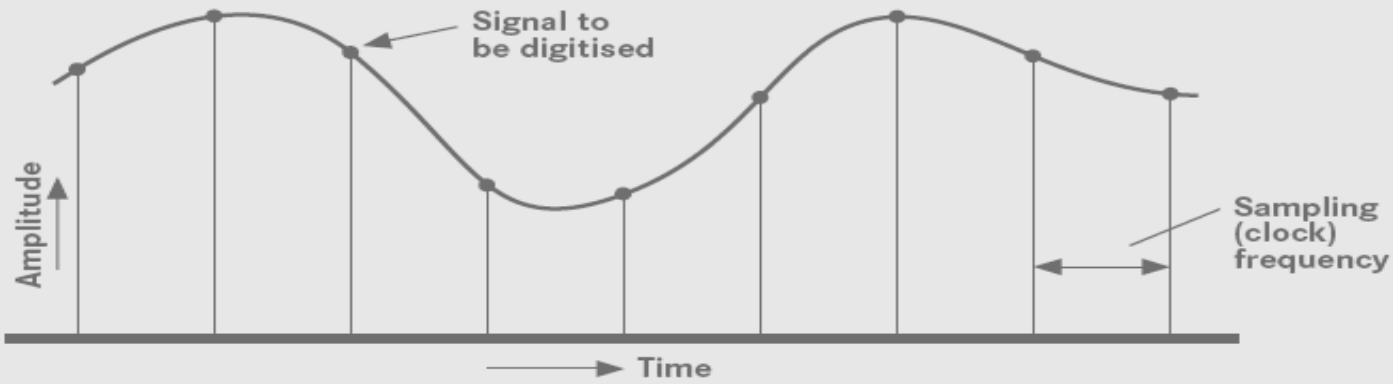
Sampled signal

Quantisized signal

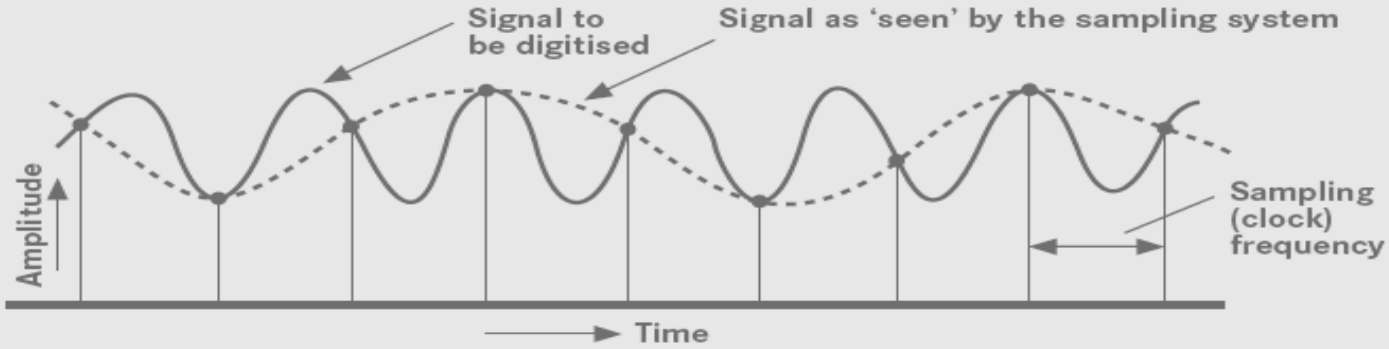
Digital signal

Sampling

- **Sampling –** measuring the analog signal values at specific time intervals (taking samples).
- Sampling rate must be at least 2 times greater than the analog signal's highest frequency component (**Nyquist criteria)**.
- For example CD disk sampling rate **44,1 KHz** is a bit higher than two times 20 KHz (the highest frequence human can hear)
- If sampling rate is too low then there will be **aliasing** sampling artifacts.
- To avoid aliasing defects **low pass filter or anti-alias filter** is used that removes the not needed high frequencies from the signal.

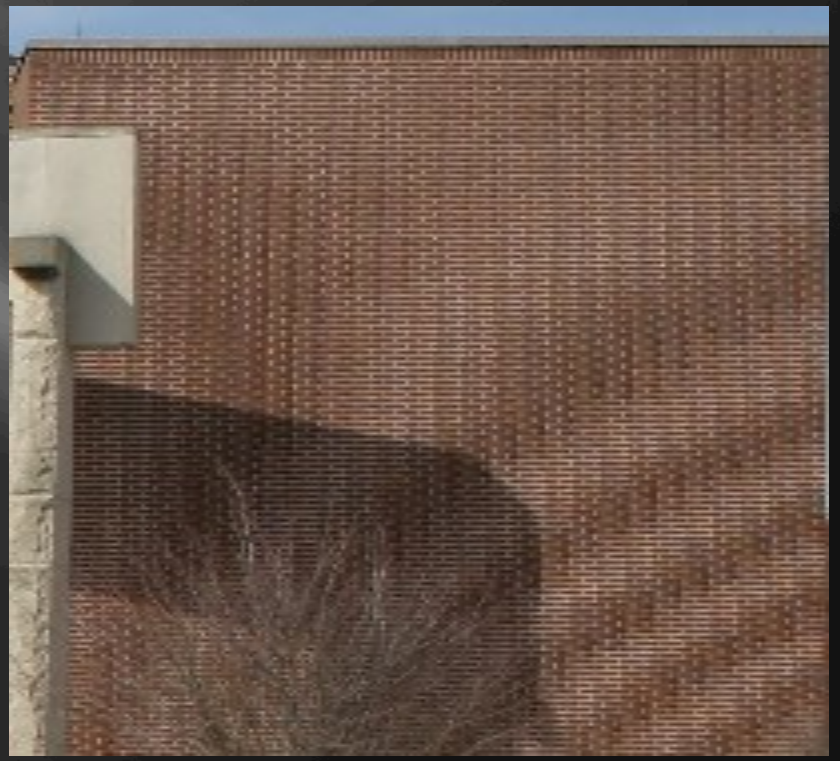


Correct: Sampling (clock) frequency is high enough to resolve the signal



Wrong: The signal frequency is too high for the sampling (clock) frequency, resulting in the wrong signal being seen by the sampling system

Moire pattern



http://en.wikipedia.org/wiki/Aliasing

http://en.wikipedia.org/wiki/Aliasing

http://www.red.com/learn/red-101/resolution-aliasing-motion-capture

Quantization

- **Quantization –** giving numerical value to the sampled signal
- The larger is the scale the more detailed changes in the amplitude of the signal can be described (the smallest is the quantization error)
- **Quantization error –** the difference between the original analog signal and its digital representation.

Quantization

- **Bit depth** – how many binary bits are used for describing a sampled signal

  8 bit = 2^8 = 256 discrete levels
  10 bit= 2^{10} = 1024 discrete levels
  12 bit= 2^{12} = 4096 discrete levels
  16 bit= 2^{16} = 65536 discrete levels
  20 bit = 2^{20} = 1048576 discrete levels
  24 bit = 2^{24} = 16777216 discrete levels

- The higher the bit depth the higher the quality of video or audio but also the amount of data will get larger.

Binary code

- **Bit** - (short for *binary digit*) is the smallest unit of digital data. A bit has a single binary value, either 0 or 1.

- **Byte** - a unit of computer information that is equal to eight bits

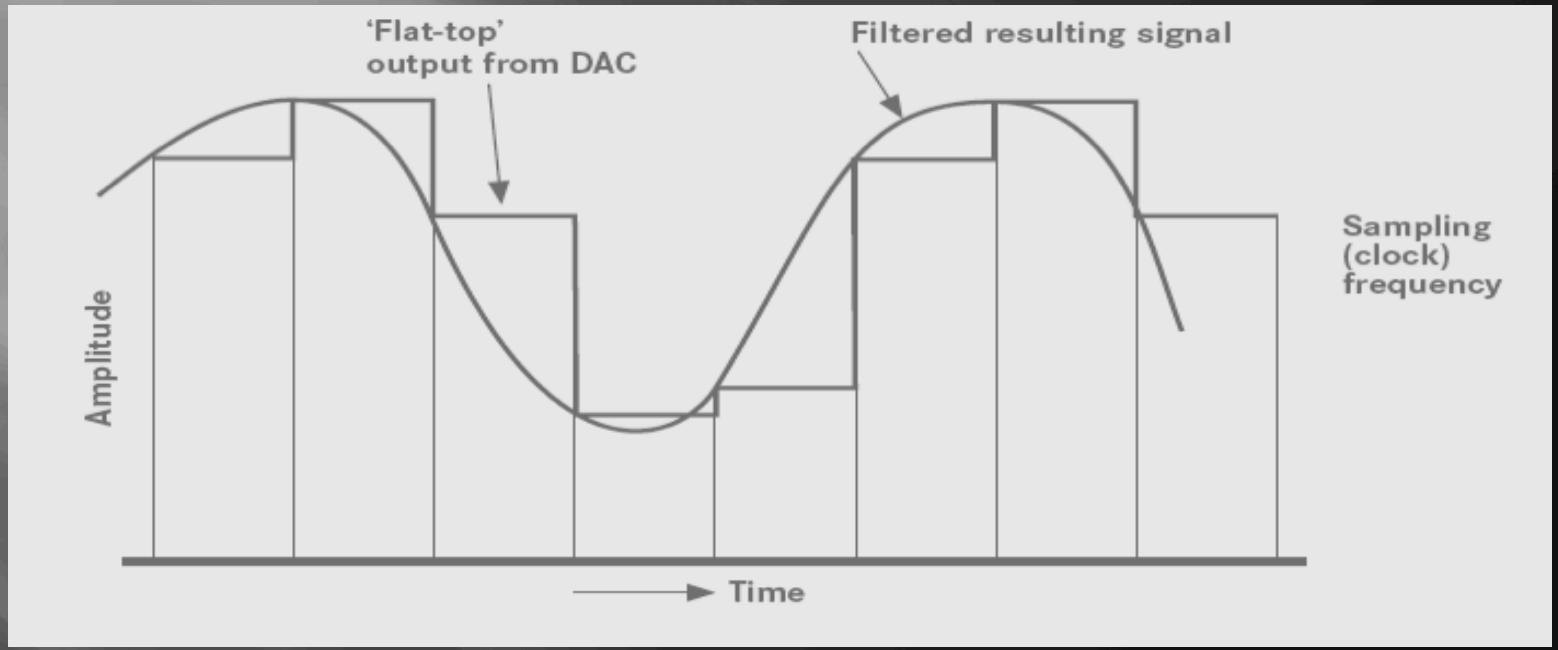
  1 byte (B) = 8 bit (b)

  Large amounts of data are described in kilobyte (kB), megabyte (MB), gigabyte (GB), terabyte (TB), petabyte (PB) etc.

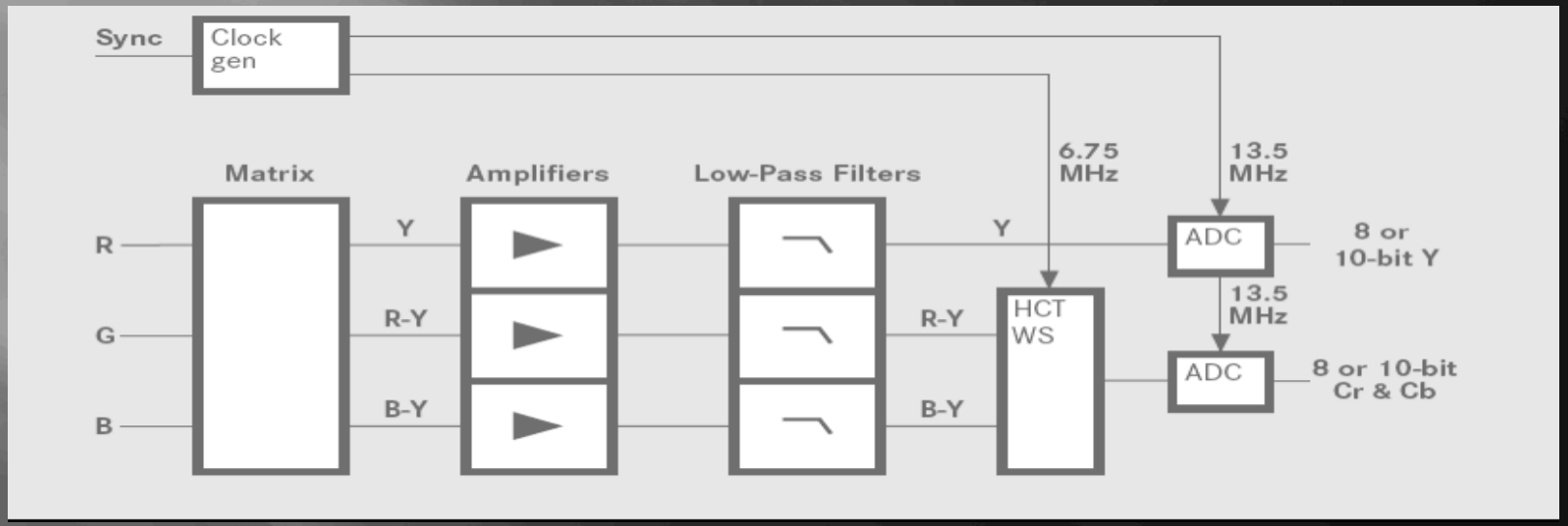
  - Kilobyte can mean 1000 (10^3) bytes or 1024 (2^{10}) bytes.

    - https://en.wikipedia.org/wiki/Byte

Digital – analog conversion



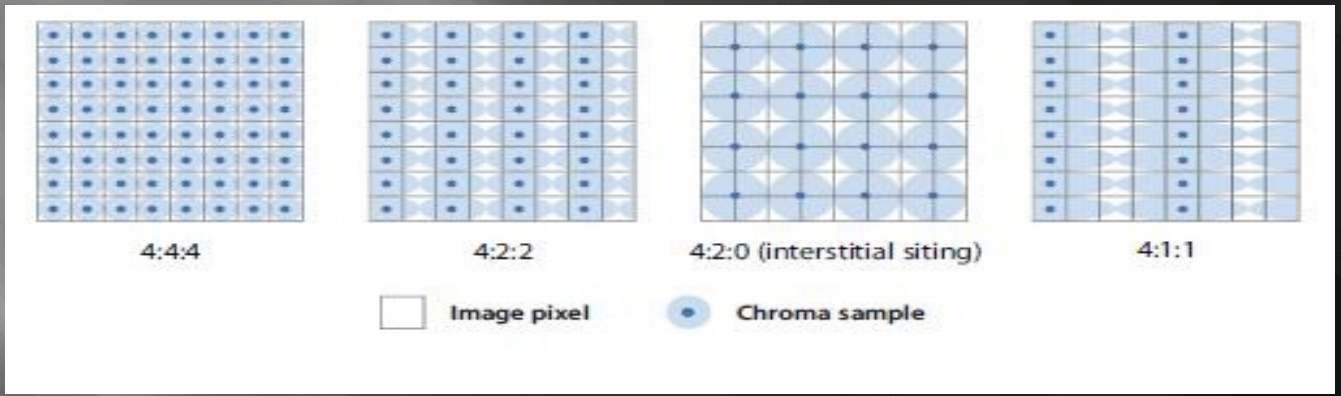
Standard definition video digital encoding



Chroma subsampling

- 4:4:4 — Every RGB or Y, Cb, Cr pixel is sampled equally. Maximum color information is preserved.
- 4:2:2 — Color difference channels (Cb, Cr) are sampled with ½ the sample rate. Half of color information is stored.
- 4:1:1 — Color difference channels (Cb, Cr) are sampled with ¼ the sample rate. Quarter of the color information is stored.
- 4:2:0 — Similar to 4:1:1. Quarter of the color information is stored.

Video chroma subsampling



Read more: http://www.red.com/learn/red-101/video-chroma-subsampling

Digital connections

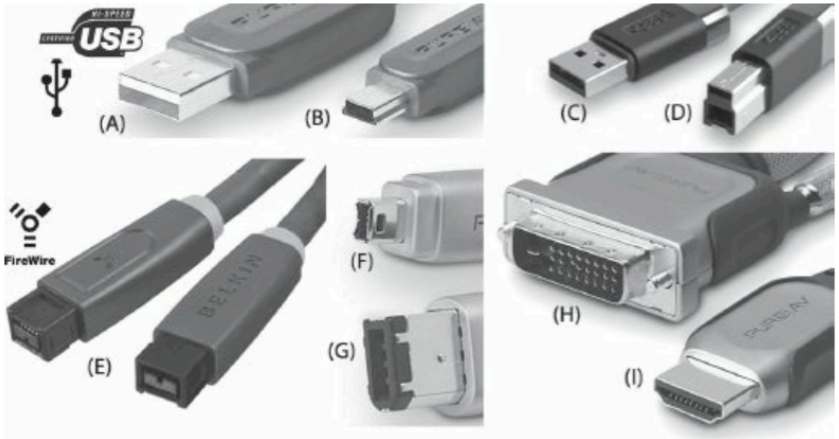


Fig. 5-29. Data and video connectors. (A) USB 2.0 male A connector. (B) USB 2.0 Mini B connector. (C) USB 3.0 male A connector (USB 3.0 is faster than 2.0 but this connector is backward compatible with 2.0 ports). (D) USB 3.0 male B connector. (E) FireWire 800 (IEEE 1394). (F) FireWire 400 four-pin connector. (G) FireWire 400 six-pin (the two extra pins supply power). (H) DVI connector. (I) HDMI connector. For other

Ascher, Steven & Pincus Edward. The Filmmaker's Handbook. A Comprehensive Guide for the Digital Age. 4th ed. Plume 2013.

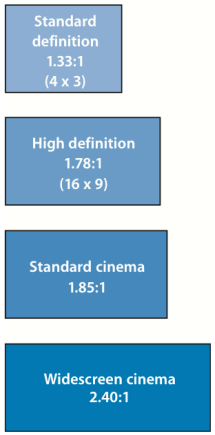
SDI – serial digital interface

- SDI – serial digital interface
  - Digital connection over BNC coaxial cable (video and audio)
- HD-SDI – used for HD video
- Dual-link HD-SDI
- 3G-SDI
- 6G-SDI
- 12G-SDI

Picture aspect ratio

Aspect Ratio of the Video Frame

The ratio of horizontal to vertical dimensions of a film or video frame is called the *aspect ratio*. Aspect ratio is independent of absolute image size or resolution.



Aspect ratio can be expressed as absolute dimensions (4 x 3), a ratio (4:3), a fraction (4/3), or as the decimal equivalent of a ratio (1.33:1, or simply 1.33).

- Video aspect ratios are often written as ratios, such as 4:3 for SD video or 16:9 for HD video.
- Film aspect ratios are often written as decimal equivalents, such as 1.33, 1.85, and 2.40. The higher the decimal number, the wider the image. An aspect ratio of 2.40 is wider than 1.85, and 1.85 is wider than 1.33.
- Digital video resolutions are usually written as absolute pixel dimensions, such as 720 x 480, 1280 x 720, 1920 x 1080, and so on.

Aspect ratio	Medium
1.33 (4:3)	Early 35 mm film and SD television
1.37	4-perforation 35 mm camera footage (prior to projection)—also known as "Academy" aspect ratio
1.66 (15:9)	Standard European film; masked in projector
1.78 (16:9)	HD television
1.85	Standard North American and UK film; masked in projector
2.40 (also referred to as *2.35* and *2.39*)	Widescreen (anamorphic) film projection

Read more:

http://www.widescreen.org/aspect_ratios.shtml

http://filmmakeriq.com/lessons/the-changing-shape-of-cinema-the-history-of-aspect-ratio/

Video compression

- **Compression** – mathematical reduction of visual information in order to save computer disk space and maintain the essence of the picture.

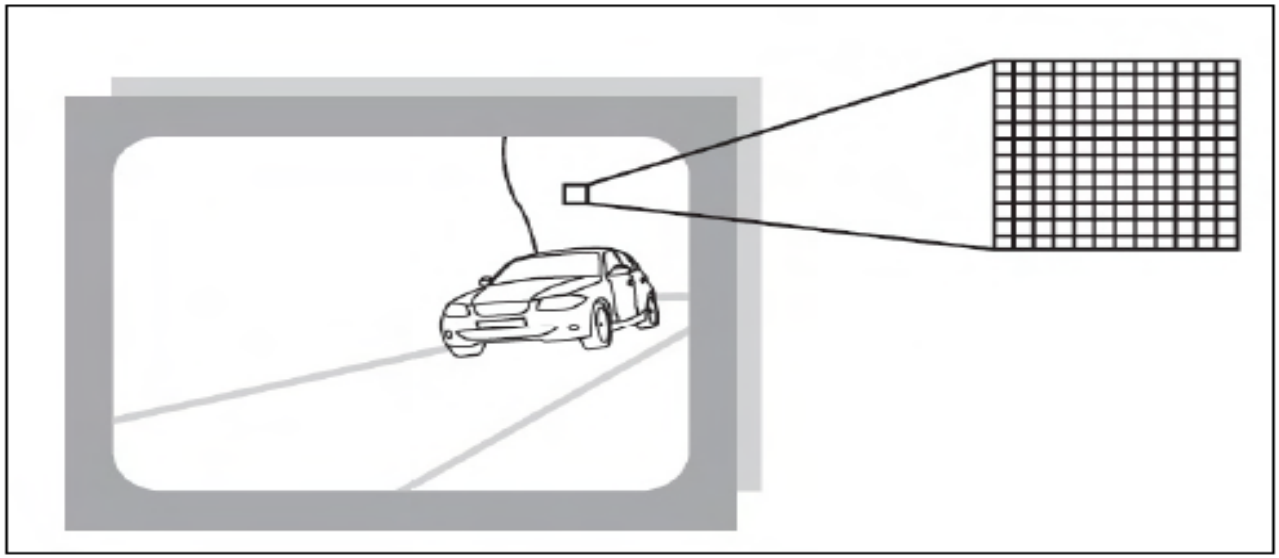
- **JPEG -** a standardized image compression mechanism. JPEG stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.
- **MJPEG** (Motion JPEG) **-** a video compression scheme in which each frame is separately compressing using the JPEG standard
- **MPEG -** A digital video standards developed by the Motion Pictures Expert Group

MPEG standards

- **Read more about MPEG standards:**

  Pank, Bob. The Digital Fact Book. 20th Aniverssary Ed. Converged Media. Pages 125 -130.

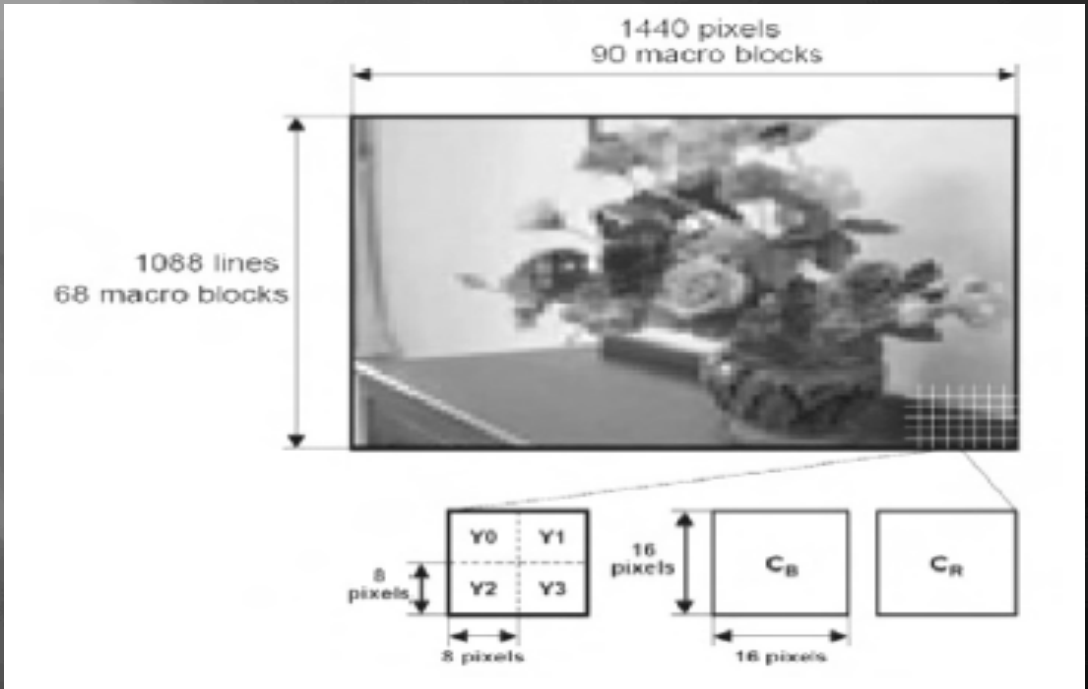
Intra-frame compression



Intraframe compression works because each pixel of blue sky is almost exactly the same as the one next to it. The system needs to record only the differences.

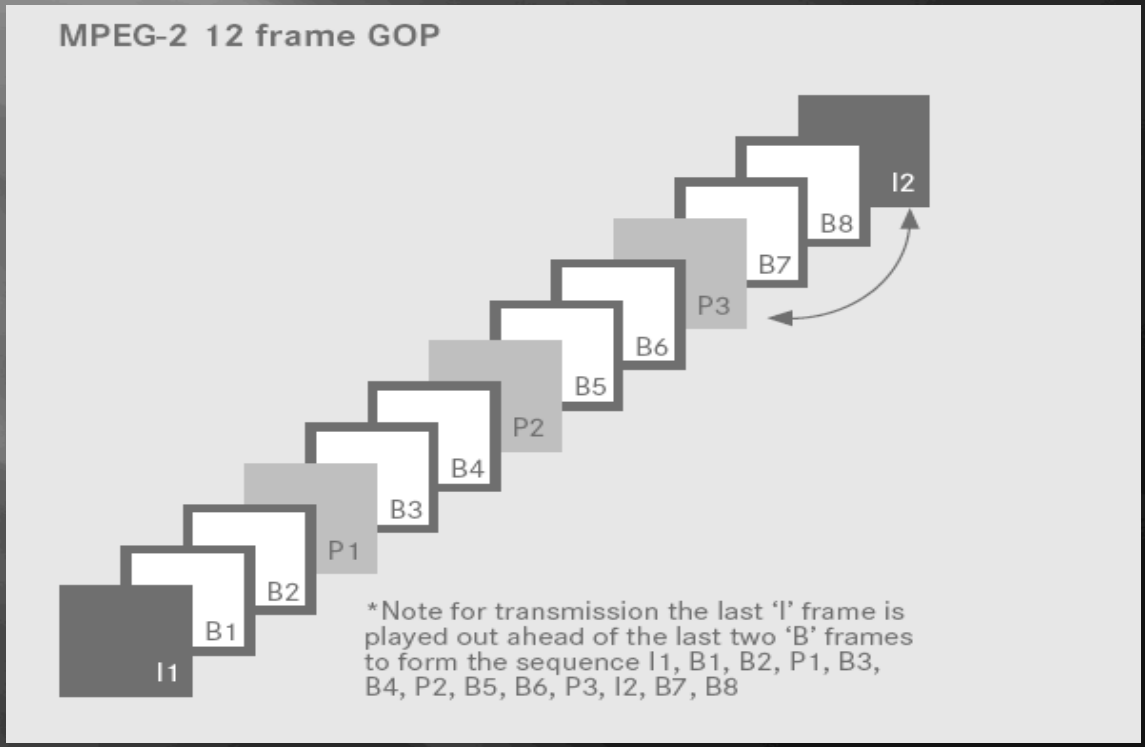
Puhovski, Nenad. High Definition. Report from Cilect Standing Commitee for New Technologies. Madrid, 2006

Intra-frame compression



Puhovski, Nenad. High Definition. Report from Cilect Standing Commitee for New Technologies. Madrid, 2006

Inter-frame compression
GOP - group of pictures

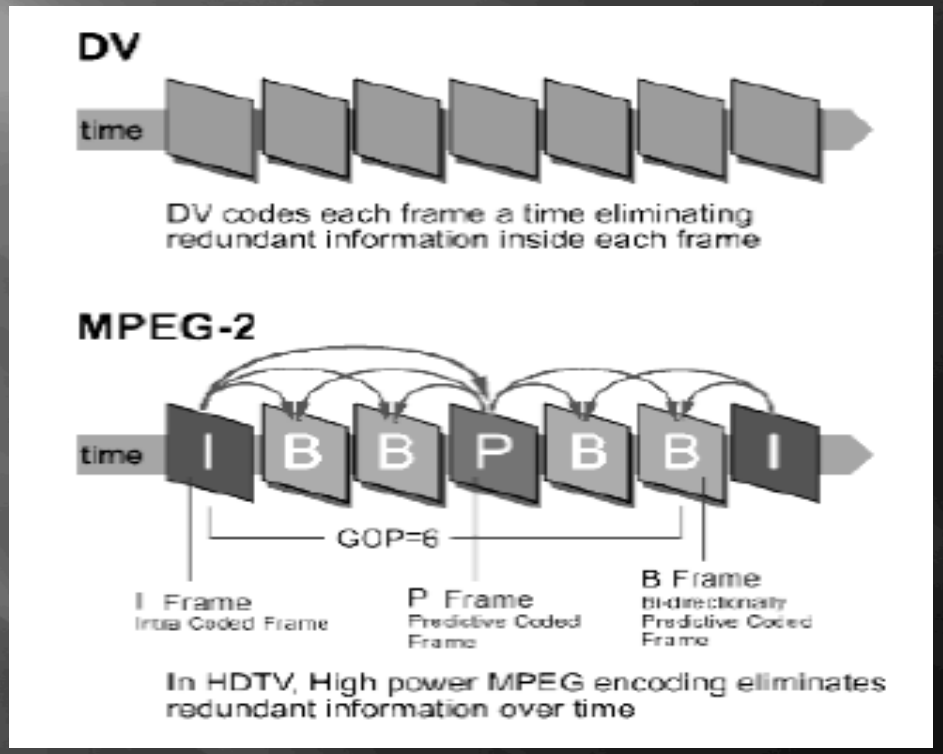


Inter-frame compression

- **I-frame** (intraframe) – complete frame
- **P-frame** (predictive) – prognosis forward
- **B-frame** (bi-directional) – dual side prognosis

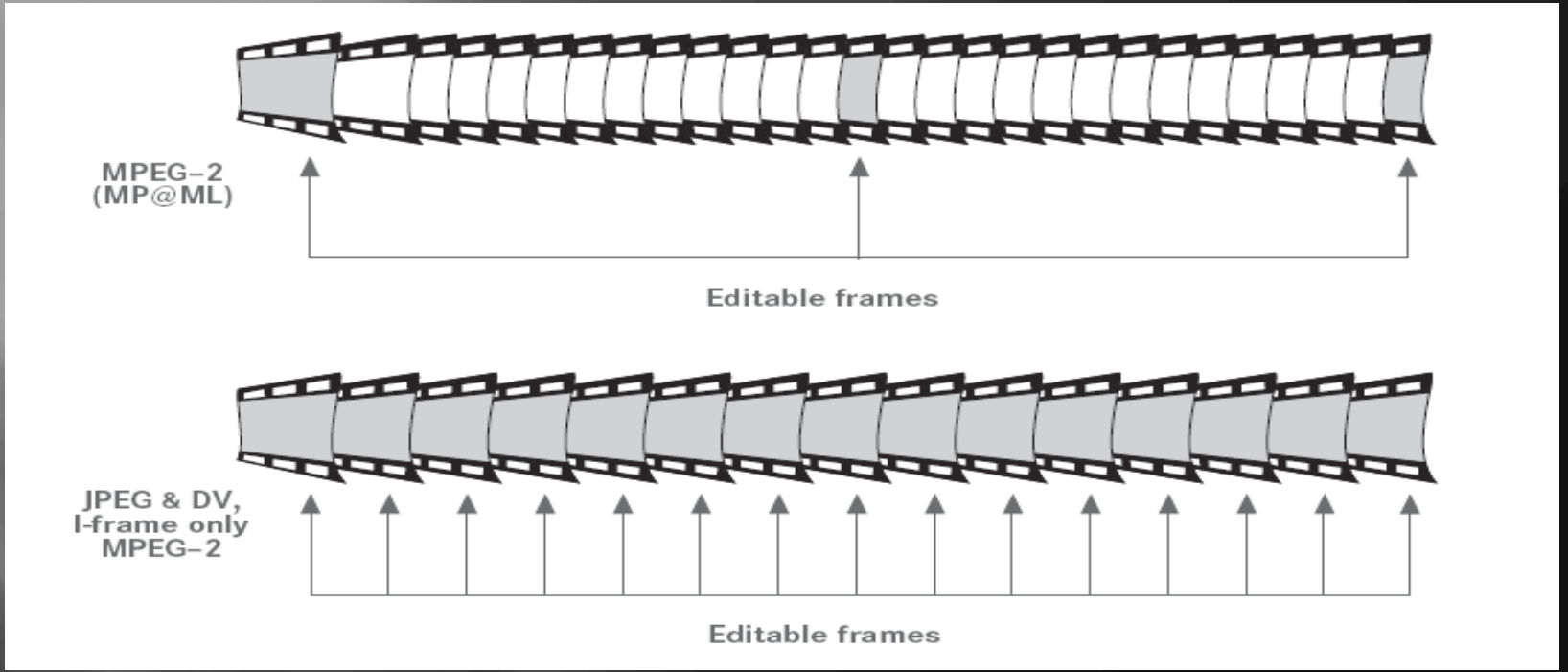
- "P" and "B" frames include only data about the changes. They can not be individually edited or viewed. The video data is recreated by the image processor based on the **GOP - Group of Pictures.**

Intra-frame vs. inter-frame compression



Puhovski, Nenad. High Definition. Report from Cilect Standing Commitee for New Technologies. Madrid, 2006

MPEG-2 vs. DV editing



Pank, Bob. The Digital Fact Book. 11th Ed, lk 49.

Codecs optimized for editing

- Apple ProRes
  - https://www.apple.com/final-cut-pro/docs/Apple_ProRes_White_Paper.pdf
- Avid DNxHR ja DNxHD
  - http://www.avid.com/US/industries/workflow/DNxHD-Codec
  - http://www.avid.com/static/resources/US/documents/DNxHD.pdf

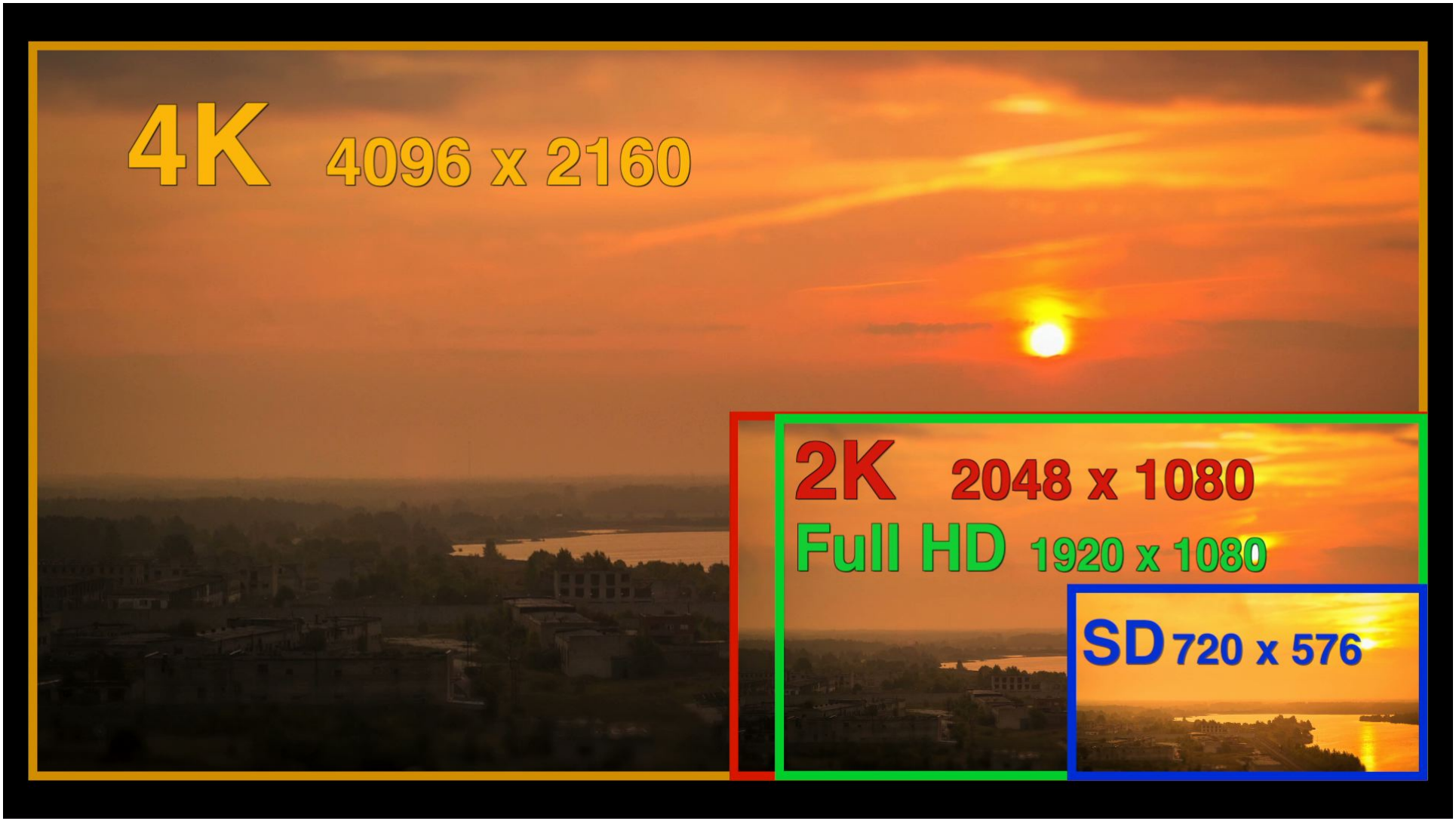
SD and HD video format comparison

- Standard definition PAL video
- **576i50** 720x576 pixels, interlaced, 50 fields in second
  - 4:3 or 16:9 aspect ratio
- High definition video (in Europe)

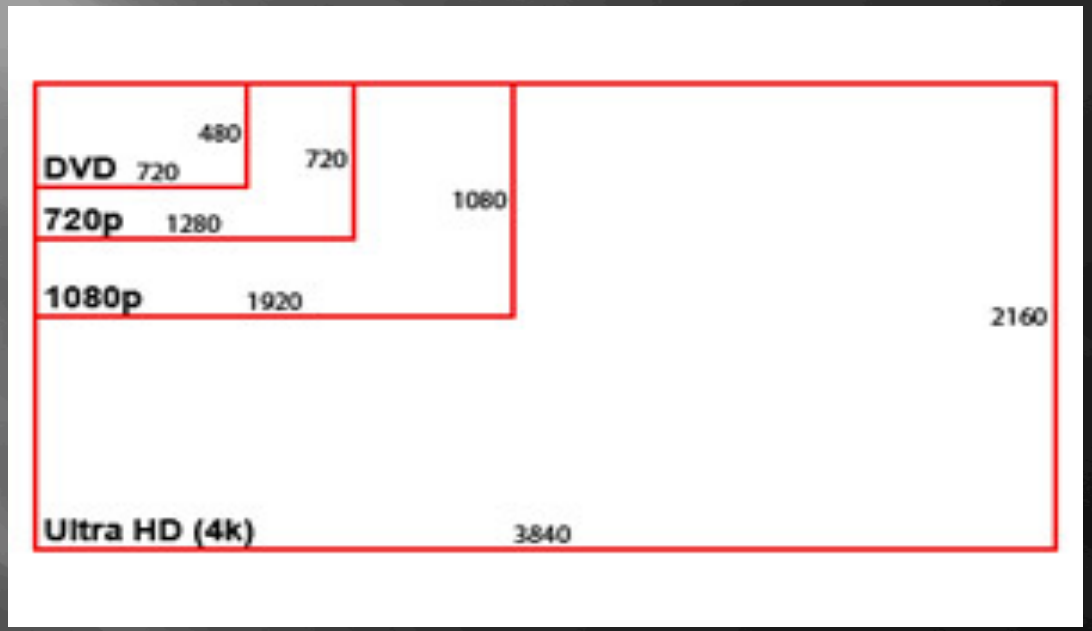
720p50 1280x720 pixels, progressive, 50 frames in second

1080i50 1920x1080 pixels, interlaced, 50 field in second
(or 25 frames in second)

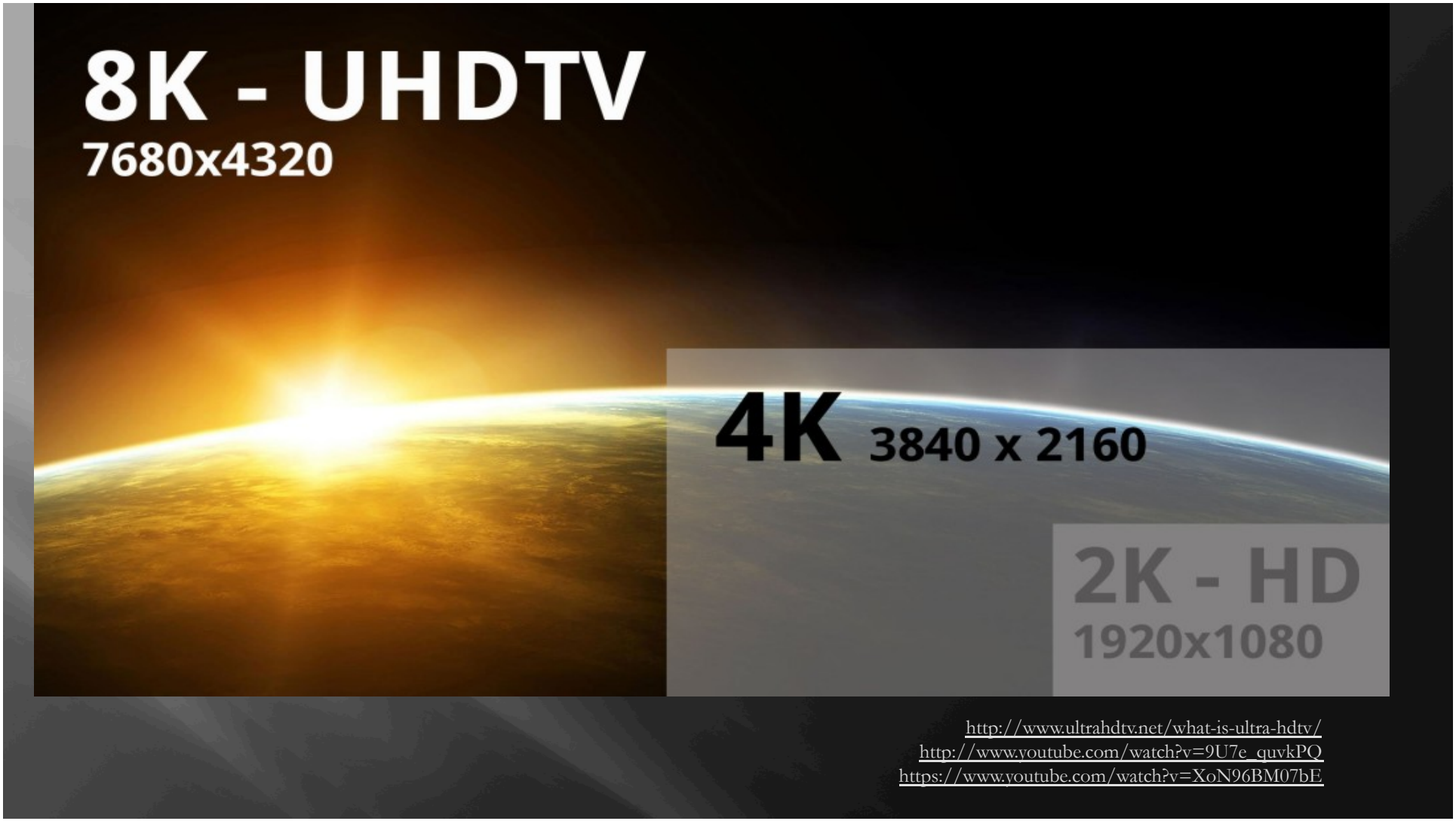
  - HD video format has only 16:9 aspect ratio


4K
4096 x 2160
2K
2048 x 1080
Full HD
1920 x 1080
SD
720 x 576

Format comparison



http://hometheaterreview.com/ultrahd-ultra-high-definition/



http://www.ultrahdtv.net/what-is-ultra-hdtv/
http://www.youtube.com/watch?v=9U7e_quvkPQ
https://www.youtube.com/watch?v=XoN96BM07bE

HDTV vs DCI digital cinema formats

- **16:9 HDTV** 1920 x 1080 (1.78:1)
- **16:9 UHDTV** 3840 x 2160 (1.78:1)

- *2K Full Container 2048 x 1080*
- **2K Flat** 1998 x 1080 (1.85:1)
- **2K Scope** 2048 x 858 (2.39:1)

- *4K Full Container 4096 x 2160*
- **4K Flat** 3996 x 2160 (1.85:1)
- **4K Scope** 4096 x 1716 (2.39:1)

DCI - Digital Cinema Initiatives

- **Picture:** JPEG2000 coding
- CIE XYZ color space
- 12 bit for each color channel (36 bits per pixel)
- Max bit rate 250 Mbit/sec
- **Sound:** 24 bit, sampling rate 48 kHz or 96 kHz,
- WAV uncompressed PCM

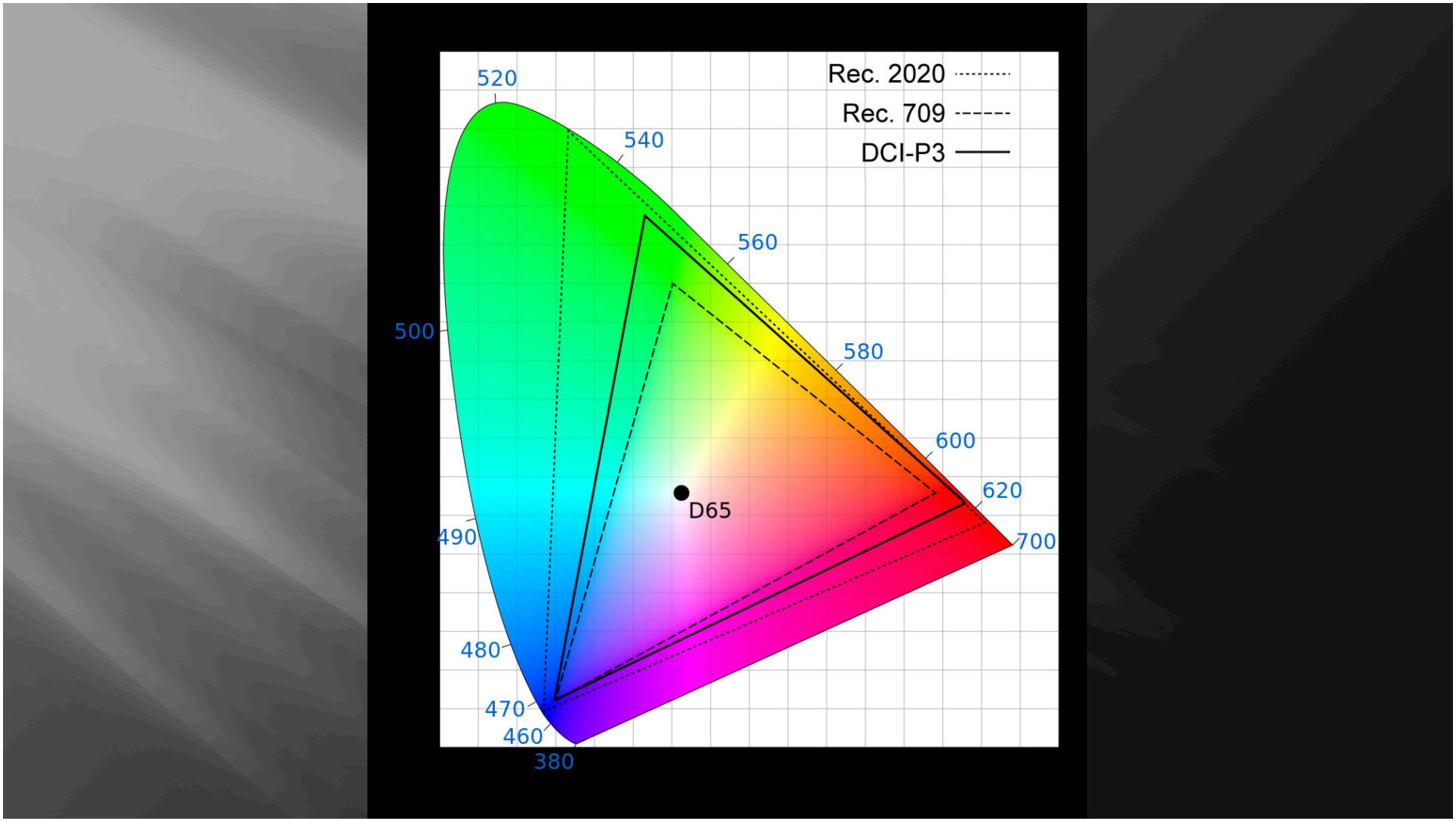
- http://www.dcimovies.com
- http://dcimovies.com/specification/DCI_DCSS_v12_with_errata_2012-1010.pdf
- http://www.jamesmilnersmyth.com/prepare-project-dcp-digital-cinema-package/

International standards

- ***ITU-R BT.601*** – Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios
- ***ITU-R BT.709*** – Parameter Values for the HDTV Standards for Production and International Programme Exchange
- **ITU-R BT.2020** – Parameter Values for ultra-high definition television systems for production and international programme exchange

- **ITU - International Telecommunications Union** is a specialized agency of the United Nations (UN) that is responsible for issues that concern information and communication technologies.

Read more: http://www.itu.int/rec/R-REC-bt


Rec. 2020
Rec. 709
DCI-P3
520
540
560
580
600
620
700
500
490
480
470
460
380
D65

Memory cards

CF (CompactFlash)

SD (Secure Digital)

SDHC (High Capacity)

SDXC (Xtra Capacity)

CFast 2.0

Sony Memory Stick Pro Duo

Sony SxS Pro

http://en.wikipedia.org/wiki/Comparison_of_memory_cards

Panasonic P2 and Micro-P2 format

P2 – "Professional Plugin"

http://www.panasonic.com/business/provideo/why-p2-hd-faqs.asp
http://pro-av.panasonic.net/en/sales_o/p2/microP2/

Camera systems used in BFM

- http://www.tlu.ee/en/production/User-Manuals

Watch yourself

THE HISTORY OF CUTTING – THE BIRTH OF CINEMA AND CONTINUITY EDITING
http://filmmakeriq.com/2014/01/the-history-of-cutting-the-birth-of-cinema-and-continuity-editing/

THE EVOLUTION OF MODERN NON-LINEAR EDITING: PART 1 – FROM TAPE TO DIGITAL
http://filmmakeriq.com/lessons/the-evolution-modern-non-linear-editing-part-1-from-tape-to-digital/

THE EVOLUTION OF MODERN NON-LINEAR EDITING: PART 2 – THE DIGITAL REVOLUTION
http://filmmakeriq.com/lessons/the-evolution-of-digital-non-linear-editing-part-2-the-digital-revolution/

Suggested readings

- Ascher, Steven & Pincus Edward. The Filmmaker's Handbook. A Comprehensive Guide for the Digital Age. 4th ed. Plume 2013.
- Ward, Peter. Digital Video Camerawork. Media Manual. Focal Press 2000
- Browne, Steven E. Video Editing. A Post-Production Primer. Focal Press, 1997.
- Pank, Bob. The Digital Fact Book. <http://www.quantel.com/resource.nsf/Files/
- Quantel_Digital_Factbook/$FILE/Quantel_Digital_Factbook.pdf>
- Pank, Bob. Digital Film Supplement. <http://www.quantel.com//resource.nsf/Files/Digital_Film/$FILE/Digital_Film.pdf>.
- Ward, Peter. Digital Video Camerawork. Media Manual. Focal Press, 2000.
- Puhovski, Nenad. High Definition. Report from Cilect Standing Commitee for New Technologies. Madrid, 2006 <http://161.58.124.223/documents/Hidefreport.pdf>.
- John Watkinson „The Art of Digital Video" Focal Press, 2000