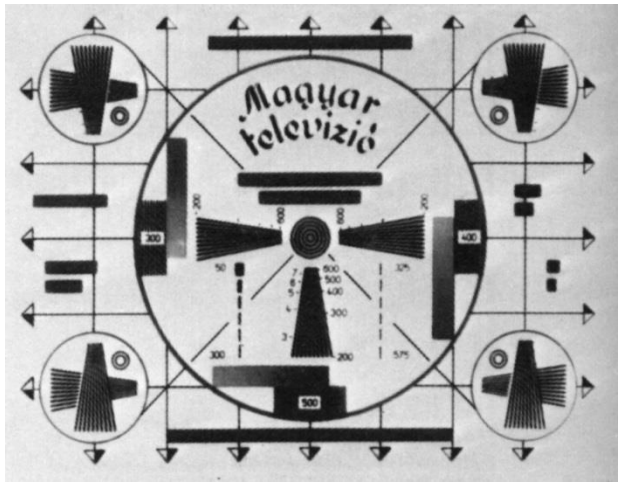

Infocommunication
Video broadcasting

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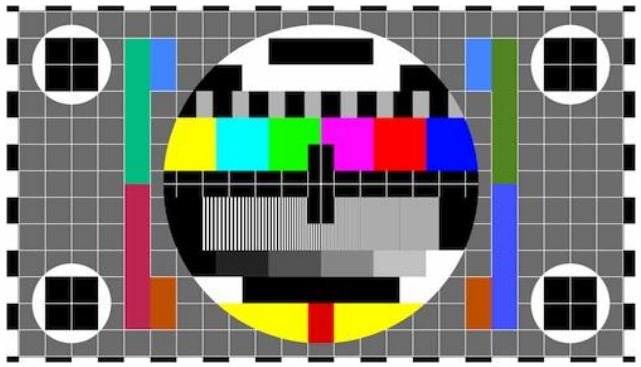

Digital Video Broadcasting

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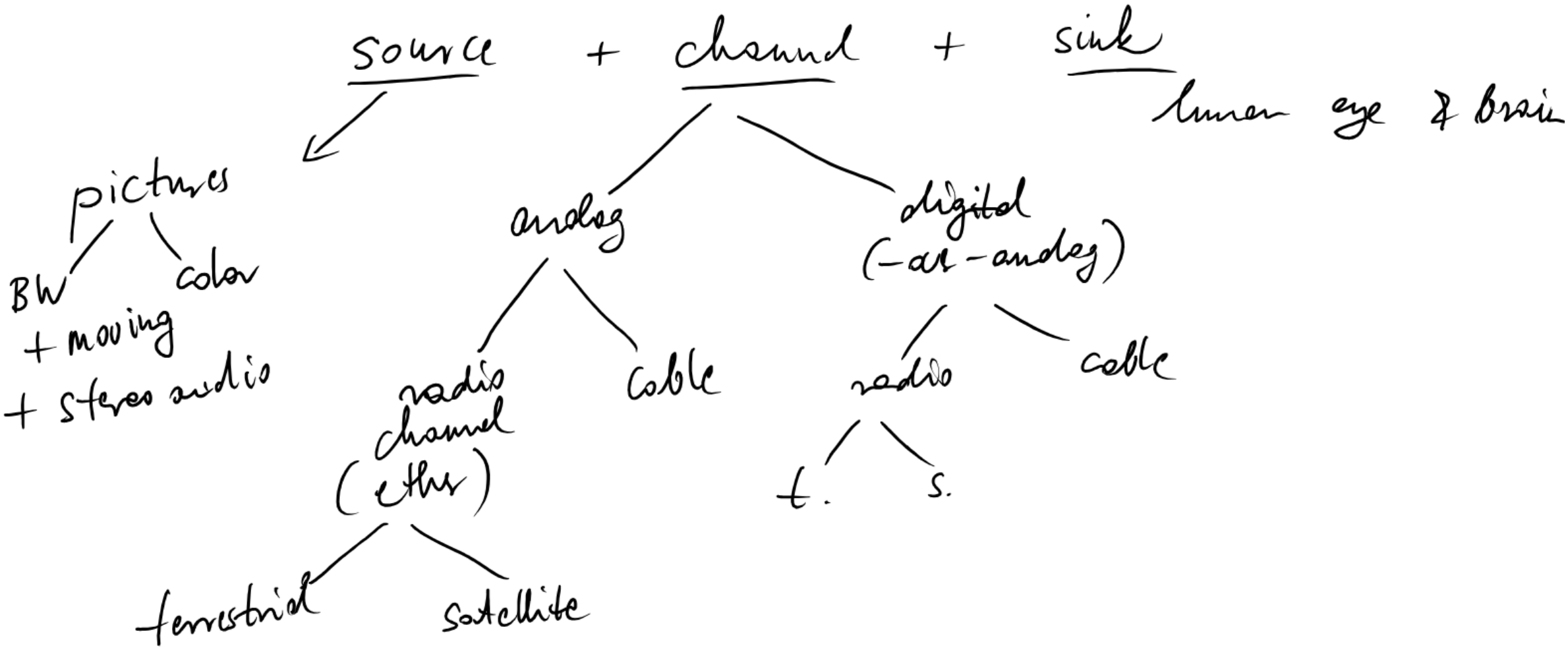
ANALOG TV

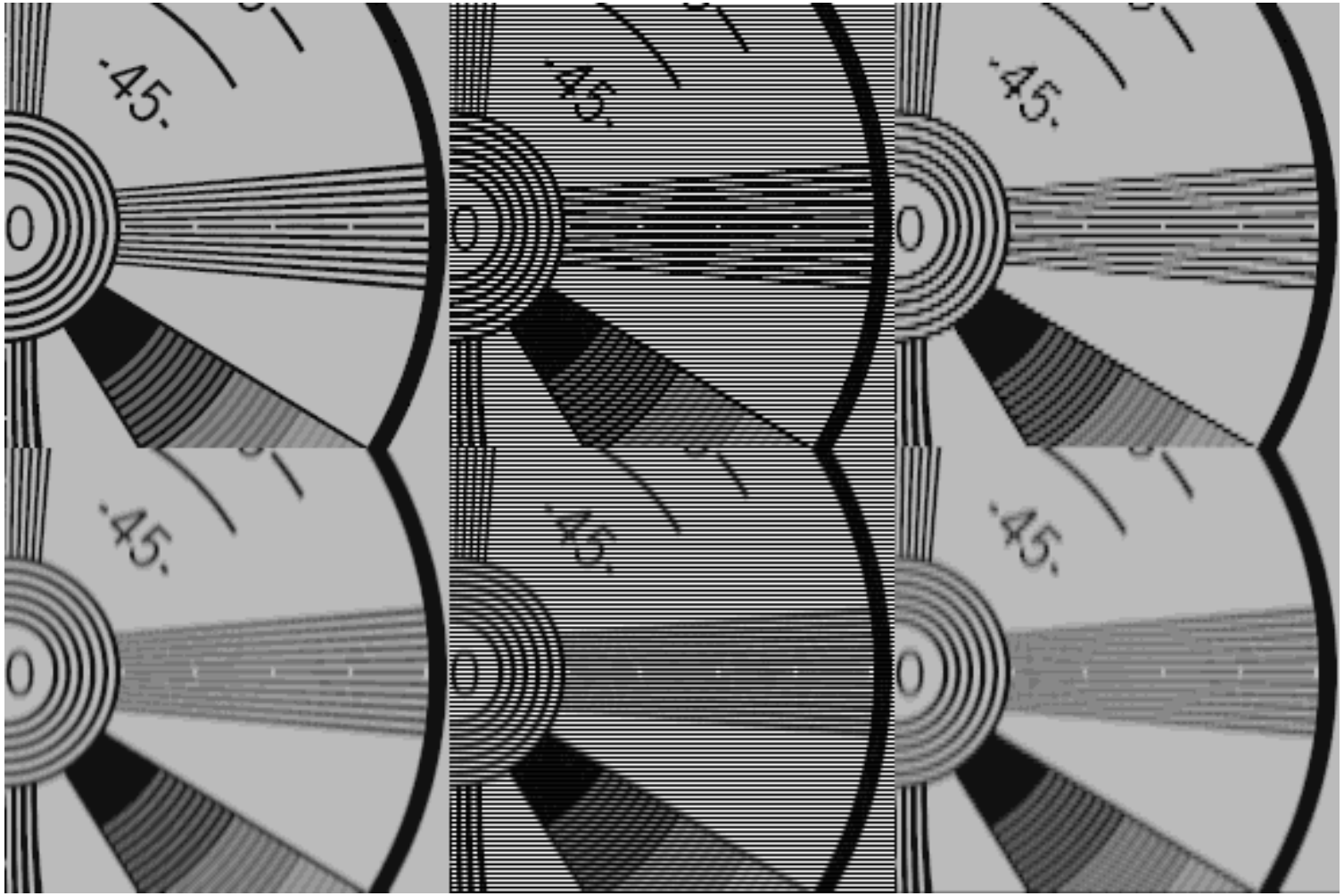
Video Broadcasting



Limits of human eye

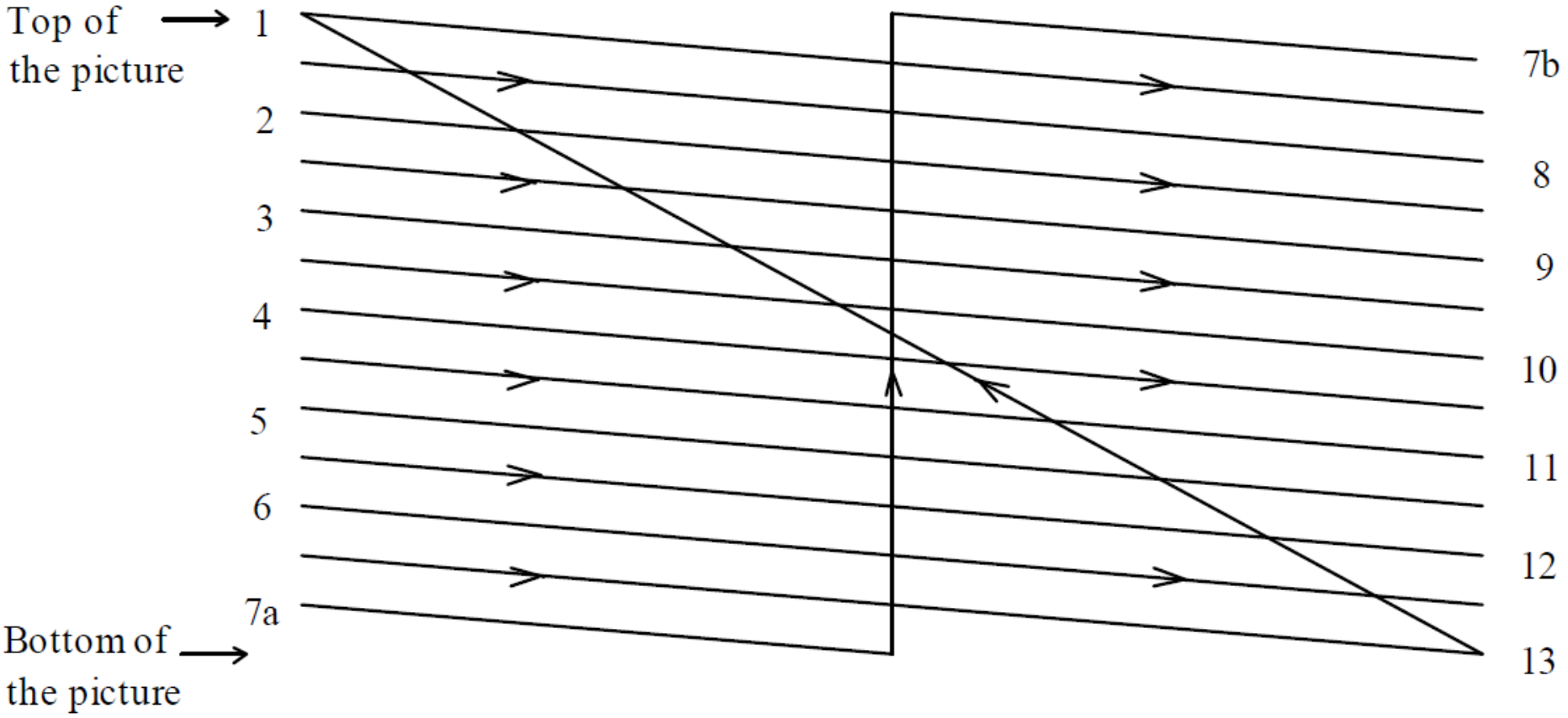
- picture resolution:
  - brightness: 2' ($\frac{2}{60}°$)
  - color: 10' ($\frac{10}{60}°$)
- color resolution:
  - ~100 tones
  - hue ~ color dependent
- motion: 15–20 fps [brain]
- flickering: 45–55 Hz → fusion freq. of eye
- angle: vertical at 20°, aspect ratio: 4:3, 16:9,

Flickering



Source: https://en.wikipedia.org/wiki/Interlaced_video

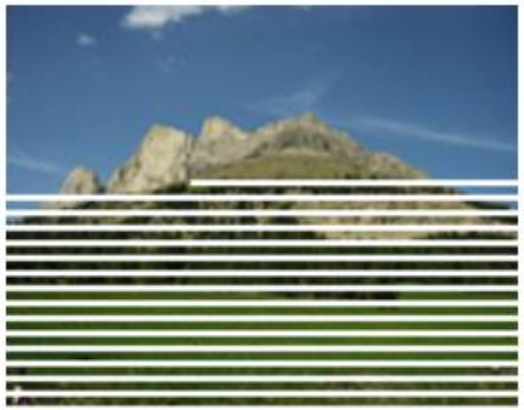
Line interlacing



Source: PP

Example for interlacing

Upper field (top) - all odd lines (1,3,5,7, etc.) are drawn first.



Lower field (bottom) - now all even lines (2,4,6,8, etc.) are drawn.

As looking at the TV one recognizes a picture like the one above.

Source: http://www.paradiso-design.net/videostandards_en.html

Number of lines on TV

3 x 3 x 3 x 3 x 5 = 405 (United Kingdom)

3 x 5 x 5 x 7 = 525 USA, Japan, …

5 x 5 x 5 x 5 = 625 EU, Australia, Africa, Asia, …

3 x 3 x 7 x 13 = 819 (France)

Source: http://alpha.tmit.bme.hu/vitma301/gyak09_foliak.pdf

Signal Conversion

picture: 1 brightness + 3 colors

luminance: $Y = 0.3 \cdot R + 0.59 \cdot G + 0.11 \cdot B$

$$0 = 0.3 \cdot (R - Y) + 0.59 \cdot (G - Y) + 0.11 \cdot (B - Y)$$

first TV: BW, grayscale → Y $\quad Y(x,y) \rightarrow Y(t)$ tracing

late TV: compatible w. BW

$\underbrace{R-Y}_{C_R}$ / $\underbrace{G-Y}_{C_G}$ / $\underbrace{B-Y}_{C_B}$ color difference signal

chrominance

→ keep only C_R and C_B

Color difference signals

$$Y = 0.3 \cdot R + 0.59 \cdot G + 0.11 \cdot B$$

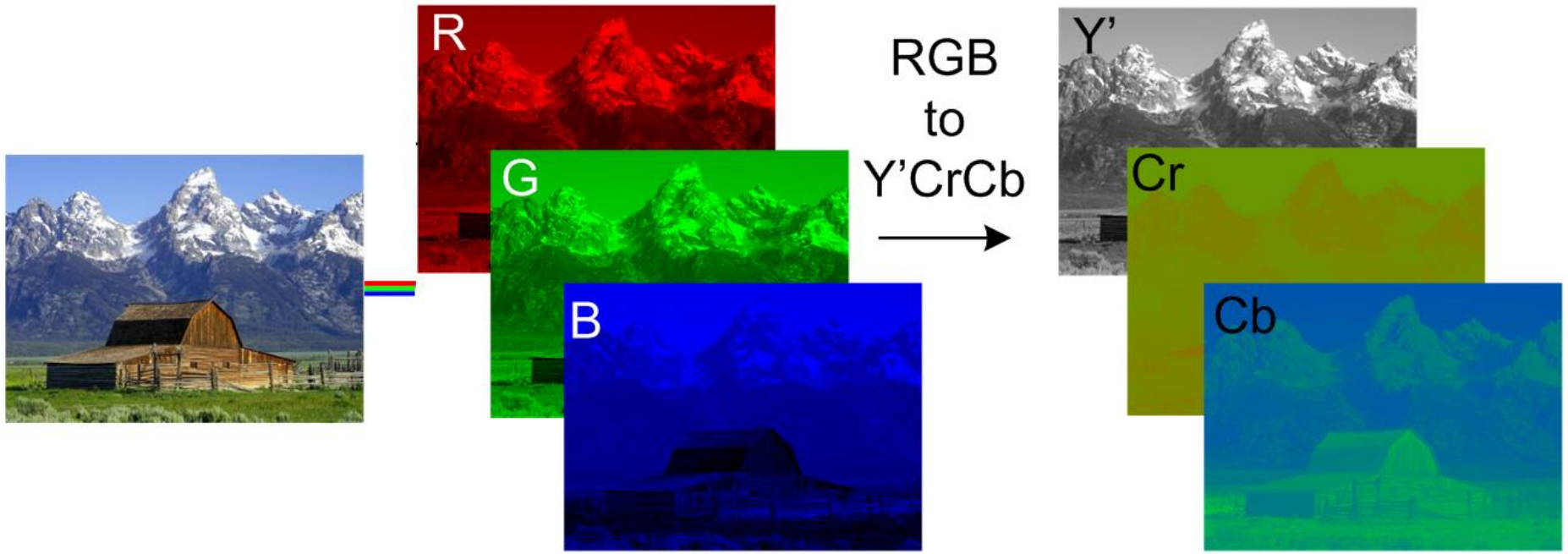
$$-(R - Y) = \frac{0.59}{0.3} \cdot (G - Y) + \frac{0.11}{0.3} \cdot (B - Y)$$

$$-(G - Y) = \frac{0.3}{0.59} \cdot (R - Y) + \frac{0.11}{0.59} \cdot (B - Y)$$

$$-(B - Y) = \frac{0.3}{0.11} \cdot (R - Y) + \frac{0.59}{0.11} \cdot (G - Y)$$

Source: http://alpha.tmit.bme.hu/vitma301/gyak09_foliak.pdf

C_R and C_B



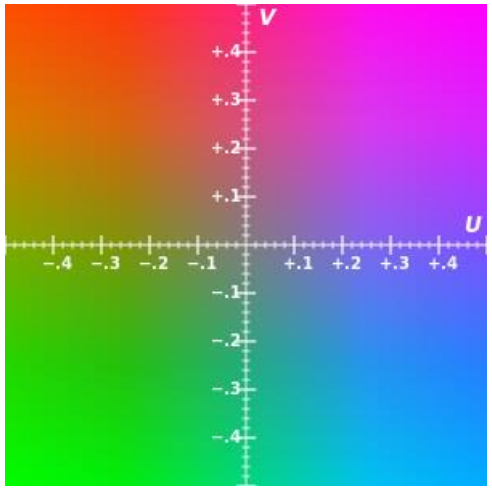
Source: https://en.wikipedia.org/wiki/YCbCr

PAL, NTSC, SECAM color difference signals

- PAL:
  - Y + ***QAM***{u,±v}

$$u = \frac{(B - Y)}{2.03}$$

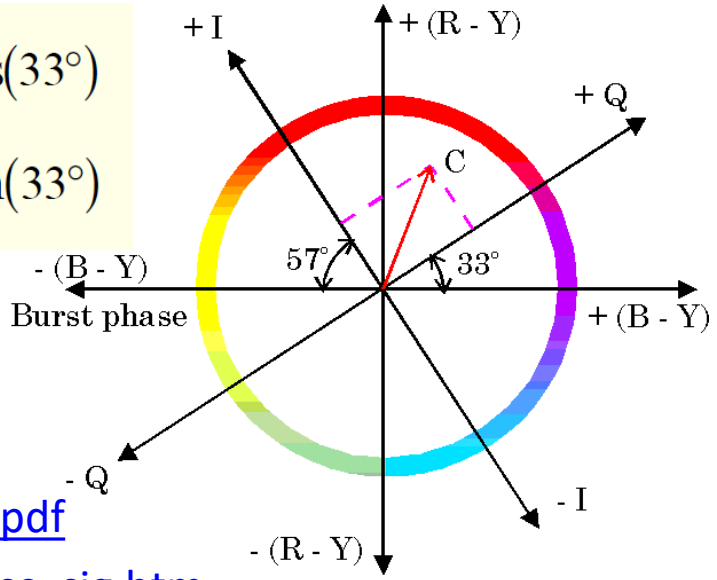
$$v = \frac{(R - Y)}{1.14}$$



- NTSC:
  - Y + ***QAM***{I,Q}

$$I = -u \cdot \sin(33°) + v \cdot \cos(33°)$$

$$Q = +u \cdot \cos(33°) + v \cdot \sin(33°)$$

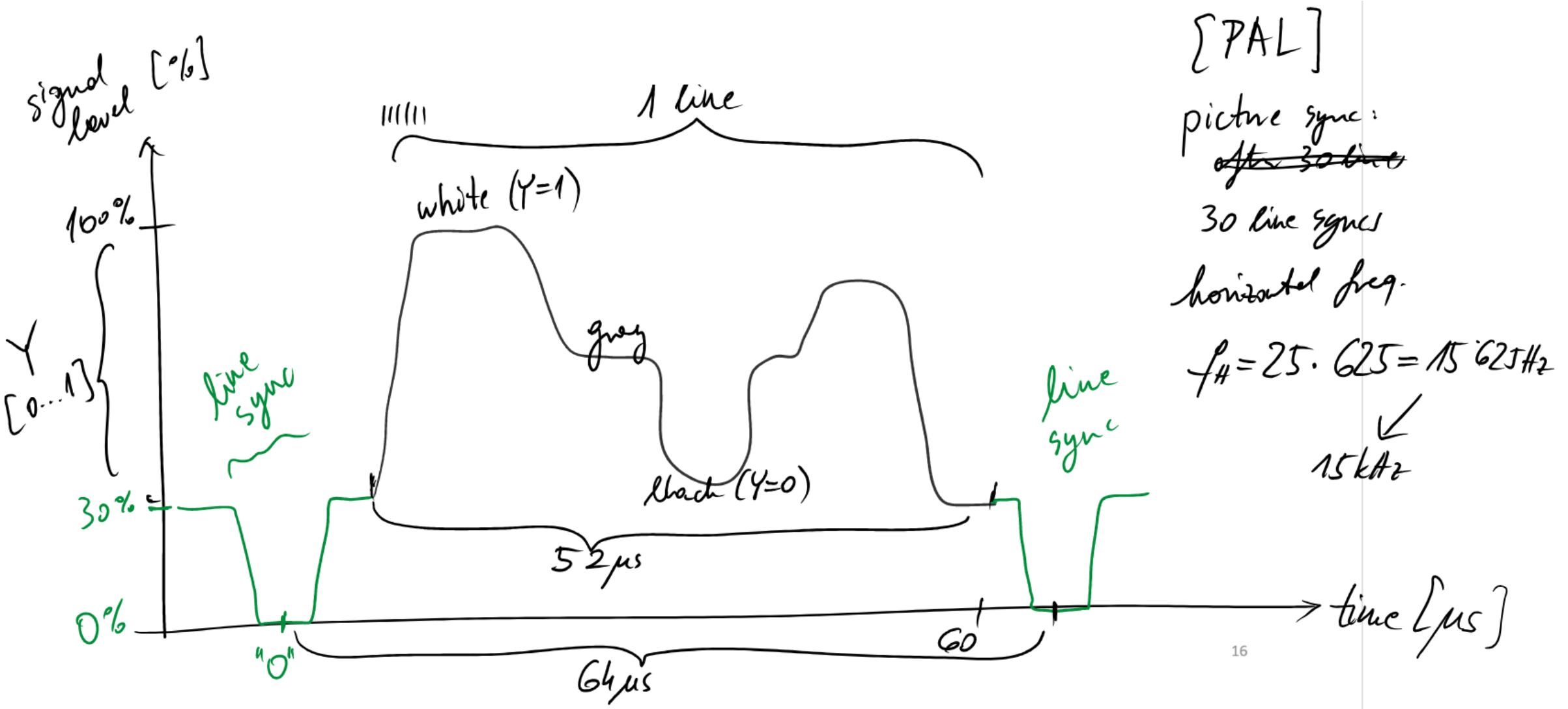


- SECAM:
  - Y + ***FM1***{u} \ ***FM2***{v}

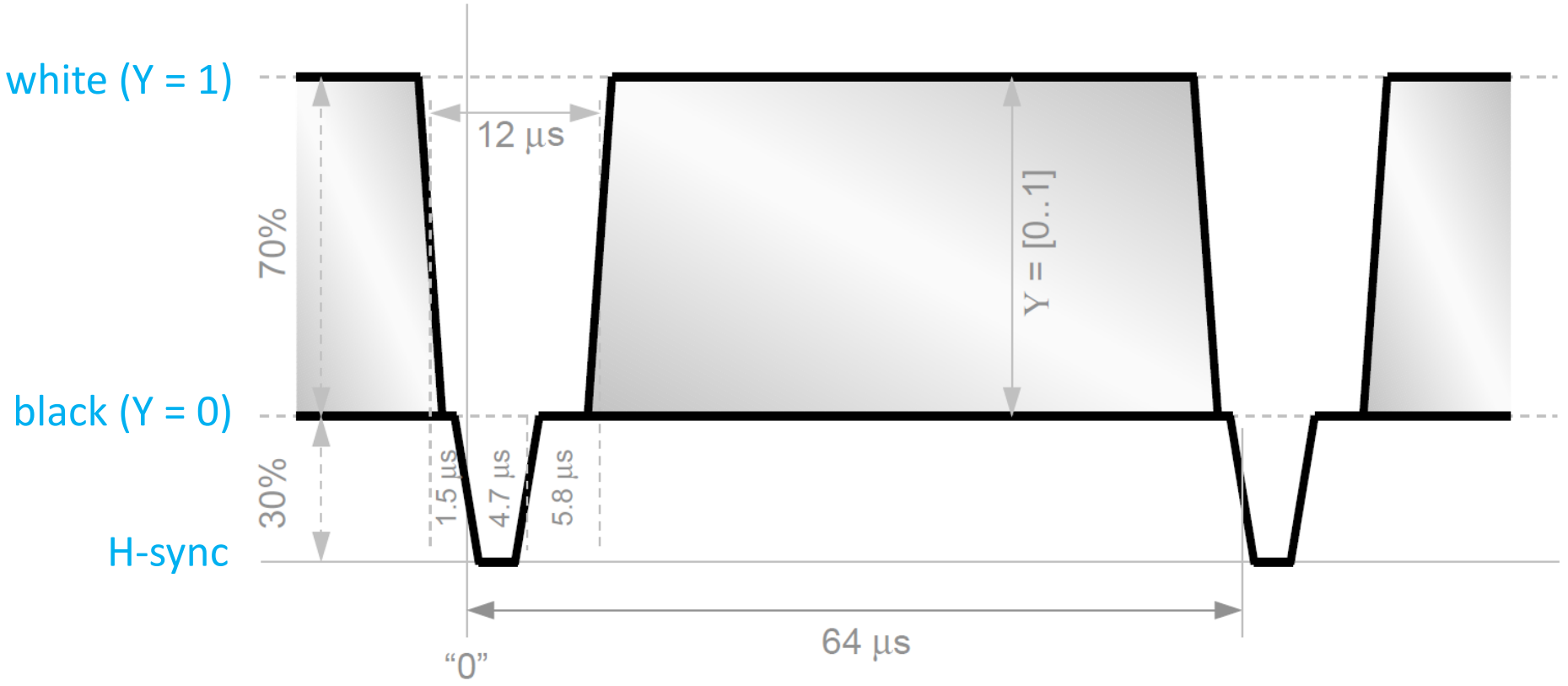
Source: http://alpha.tmit.bme.hu/vitma301/gyak09_foliak.pdf

Source: http://cnyack.homestead.com/files/modulation/ntsc_sig.htm

Baseband time function of analog TV

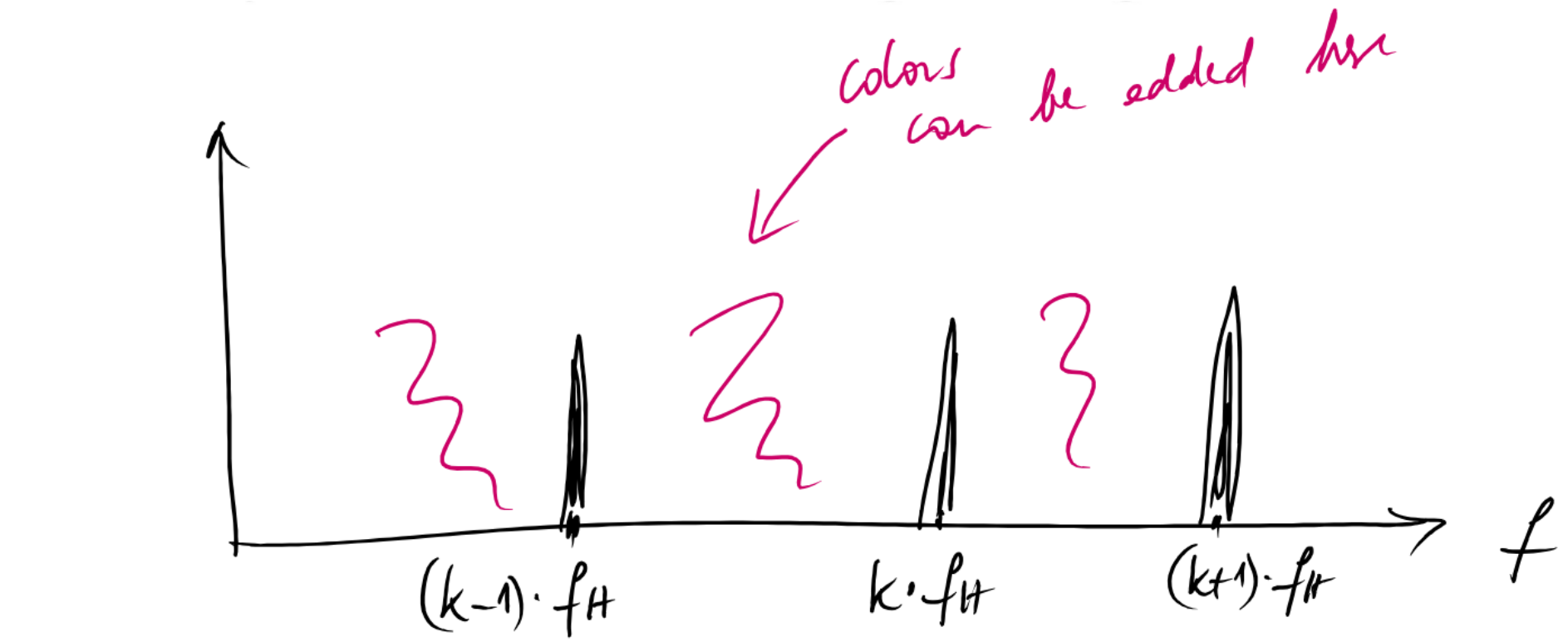


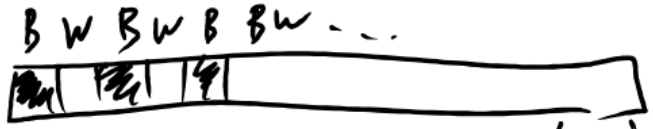
Baseband time function of analog TV



Source: http://alpha.tmit.bme.hu/vitma301/gyak08.pdf

Spectrum of analog TV signal



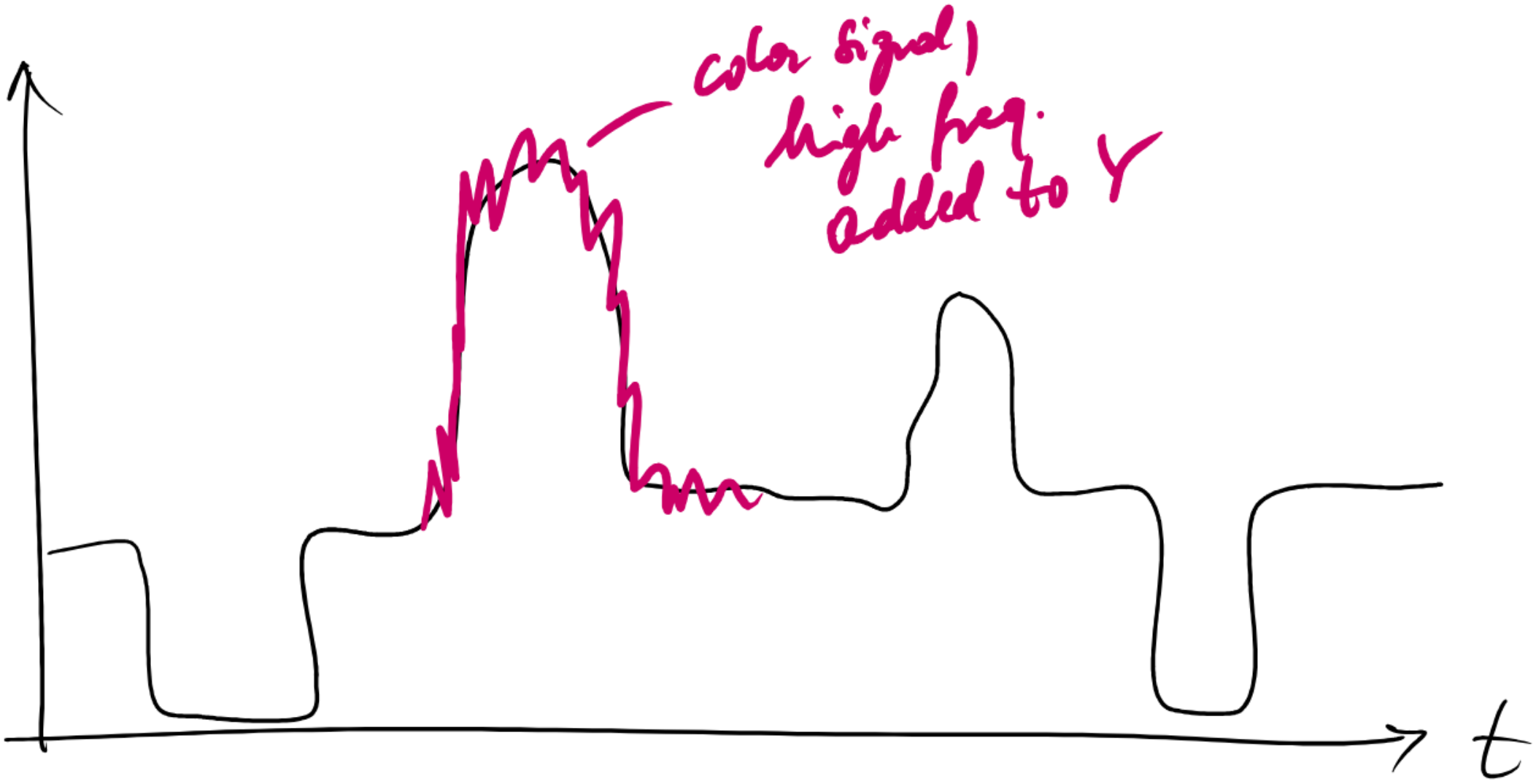


800 pixel horizontally

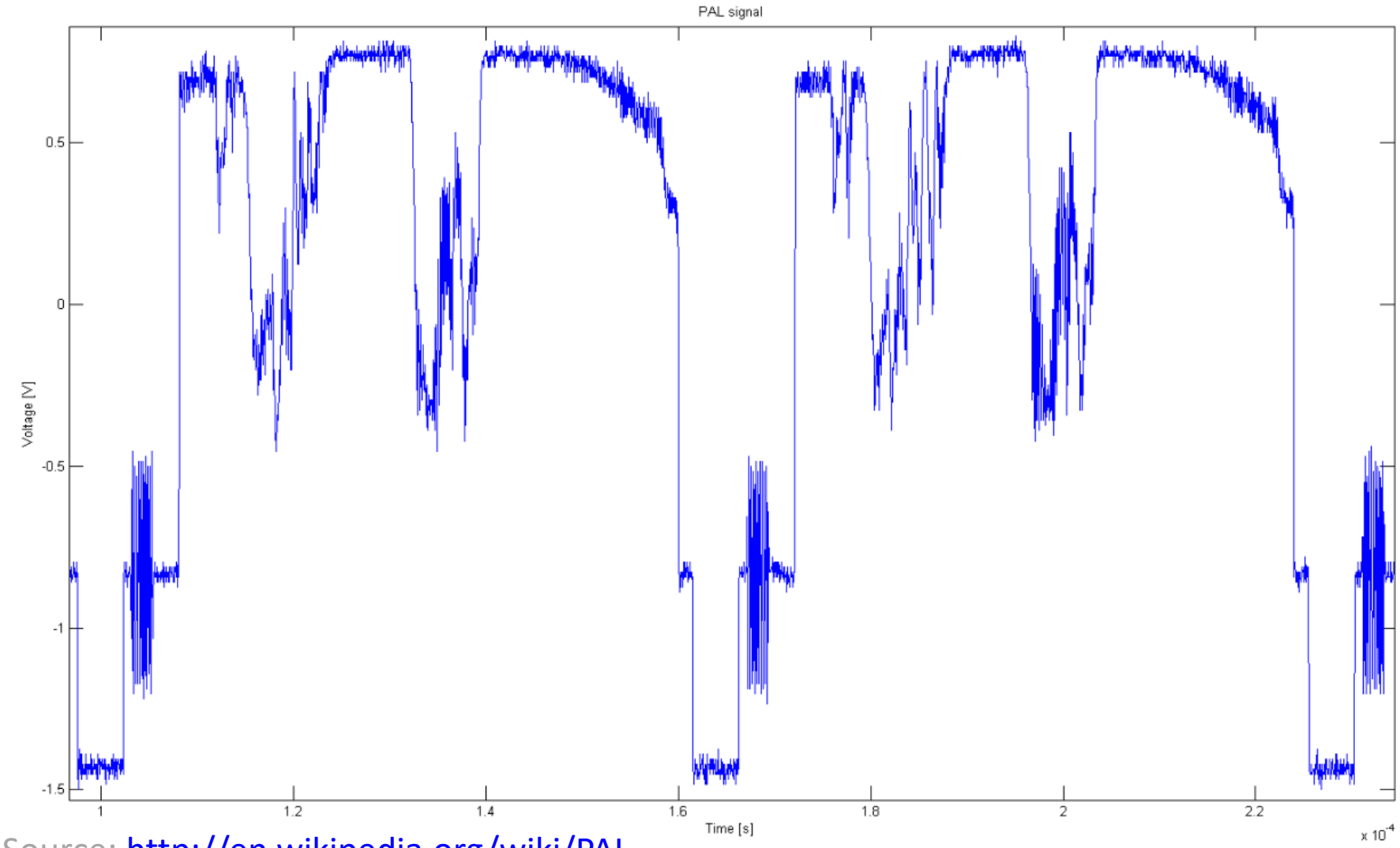
bandwidth of TV signal: $15 \cdot 625\,Hz \cdot \frac{800}{2} = 6.25\,MHz$

18

Time function of color signal

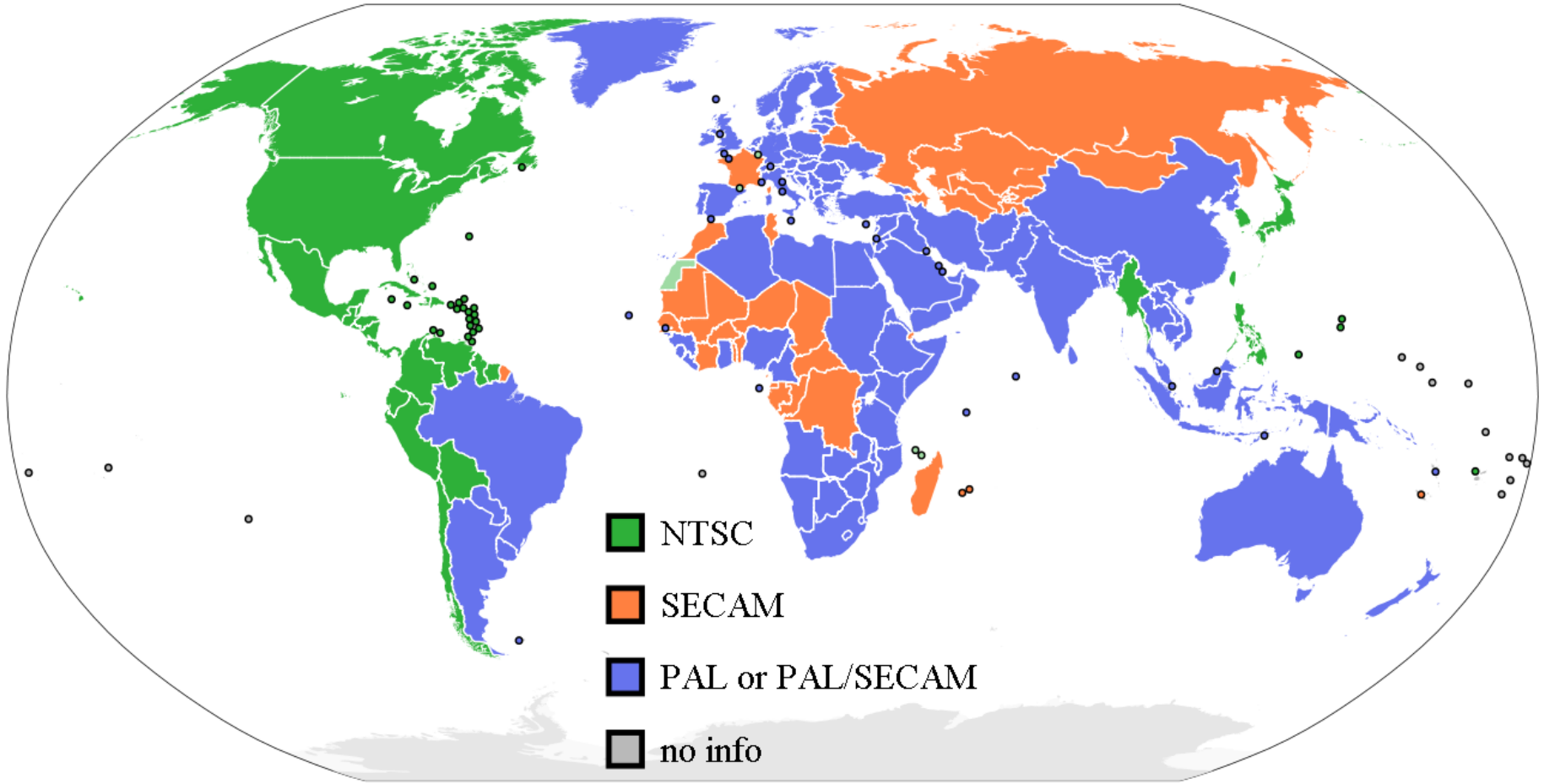


Oscillogram of composite PAL signal—two lines



Source: http://en.wikipedia.org/wiki/PAL

Analog TV systems by nation



Source: http://en.wikipedia.org/wiki/PAL

Satellite transmission (analog)

- Geostationary, ~36.000 km above ground
  [terrestrial antenna: 100-150 km - vs. 36k km => large diff!]
- Very small SNR, FM
- 6 MHz frequency deviation
- 8-10 audio channels
- Baseband BW: 7.25 MHz
- Carson-rule: B = 2 * (7.25 + 6) = 27 MHz raster
- Vertical / horizontal polarization

DIGITAL TV

Digital TV, DVB

- DVB = Digital Video Broadcasting
- Why?
  - Better quality?
  - More channels?
  - Better encryption?
  - Better error control?

- What is needed for DVB?
  - Source coding
  - Encryption coding
  - Error tolerant coding
  - Modulation

Source coding

- YUV / YIQ signal
- Resolution?
  - 1920x1080 (HD)
  - 1280x720 (SD)
  - 1440x1080 (Hungary)
  - 720x576 (Hungary)
- Progressive vs. interlaced

- Coding: MPEG group
  - In live videos, strong contours are rare
  - Enough to code & transmit the varying content

Modulation

- QAM + OFDM
- + good against ISI
- + Single Frequency Network
- + high spectral efficiency
- - sensitive to Doppler effect
- - large delay (5-6 sec)

DVB-C (Community)

- Cable provider:
  - change some analog channels to digital -> same 8 MHz raster
- 8 MHZ, QAM-64 (6 bit/symbol)
- Elementary function: 15% raised cosine
- ~ 6 Mbaud signal, ~38 Mbps channel
  - HD: ~ 6-8 Mbps
  - SD: ~ 2 Mbps
  - Several digital channels in one 8 MHz freq. band

DVB-S (Satellite)

- worse SNR than DVB-C
- QPSK modulation
- same 38 Mbps multiplex channel as in DVB-C
  - requires 37 MHz
  - (no problem, in GHz region)
- for sparsely populated areas

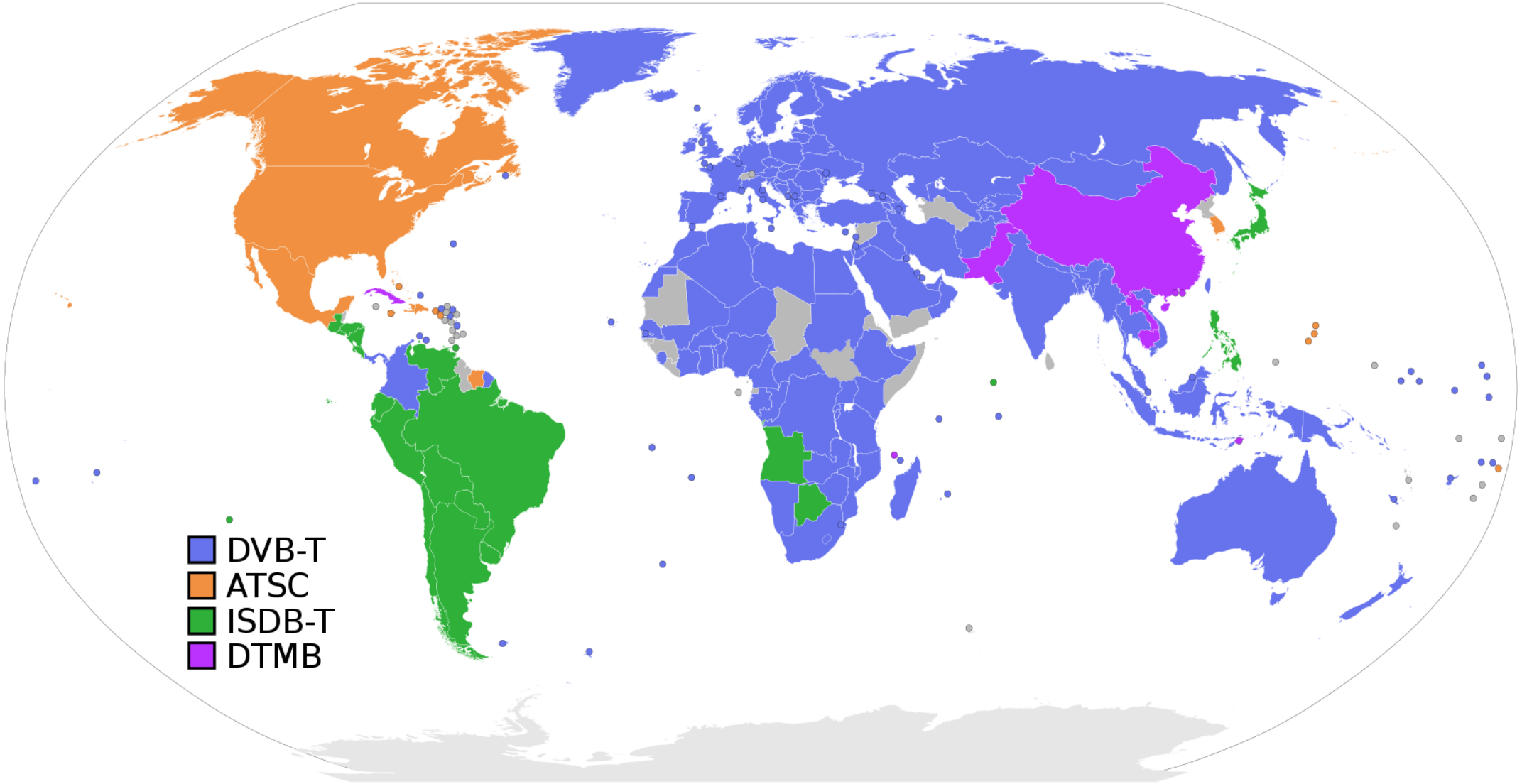
DVB-H (Handheld)

- Mobile TV
- access to service while in moving vehicle
- display size: larger postal stamp
- tuner consumes much power
- not widespread (lack of business model)

DVB-T (Terrestrial)

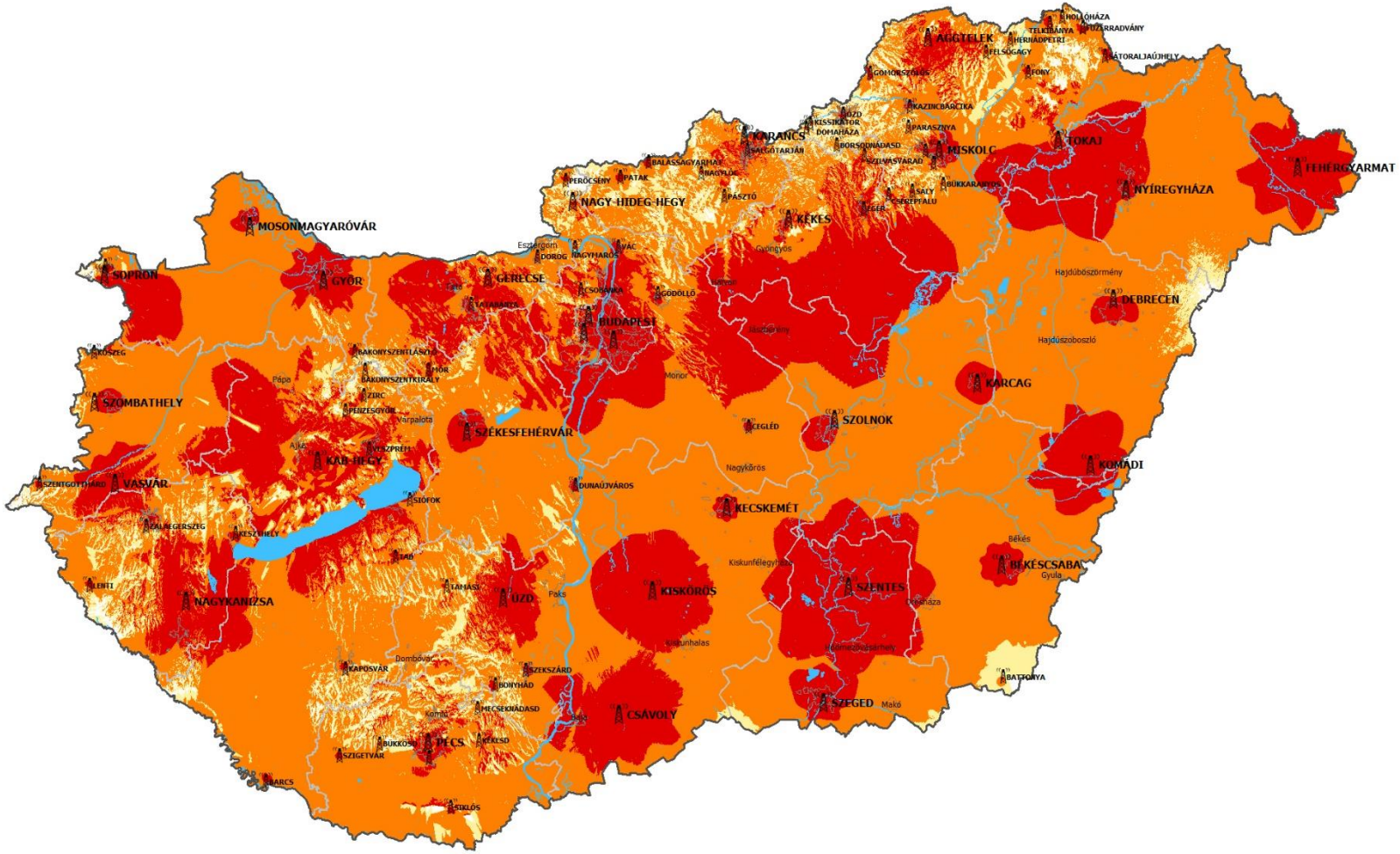
- problems:
  - multipath propagation, dispersion
  - ISI (vs. analog: ghost image)
- Forward error correction
- Cyclic error correction
  - Reed-Solomon code, RS(204, 188)
- OFDM with ~8000 subcarriers
  - QAM-16
- different from country to country
  - Hungary: MPEG-4, H.264 source coding

Digital TV systems by nation

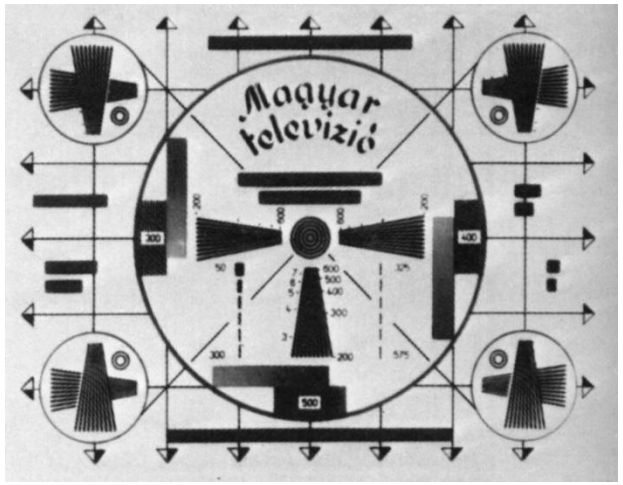


Source: http://en.wikipedia.org/wiki/Digital_terrestrial_television

DVB-T coverage in Hungary



Source: https://mindigtv.hu/premium/tv/technikai-informaciok-1/lefedettsegi-terkep-2/



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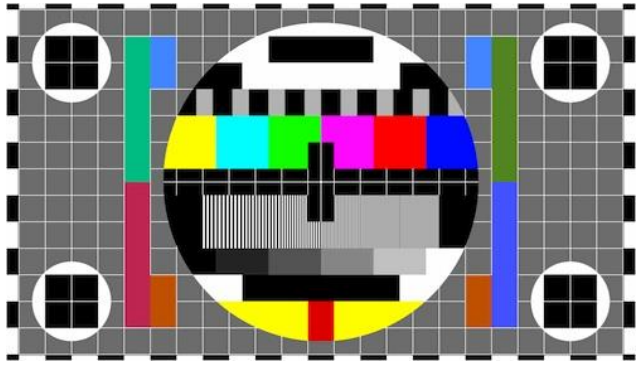

The END

Digital Video Broadcasting