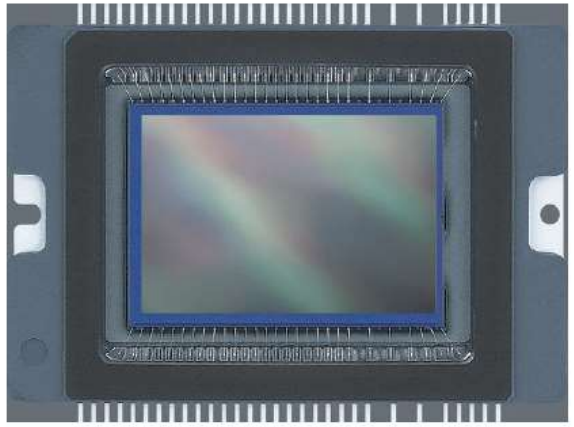
Multimedia Systems

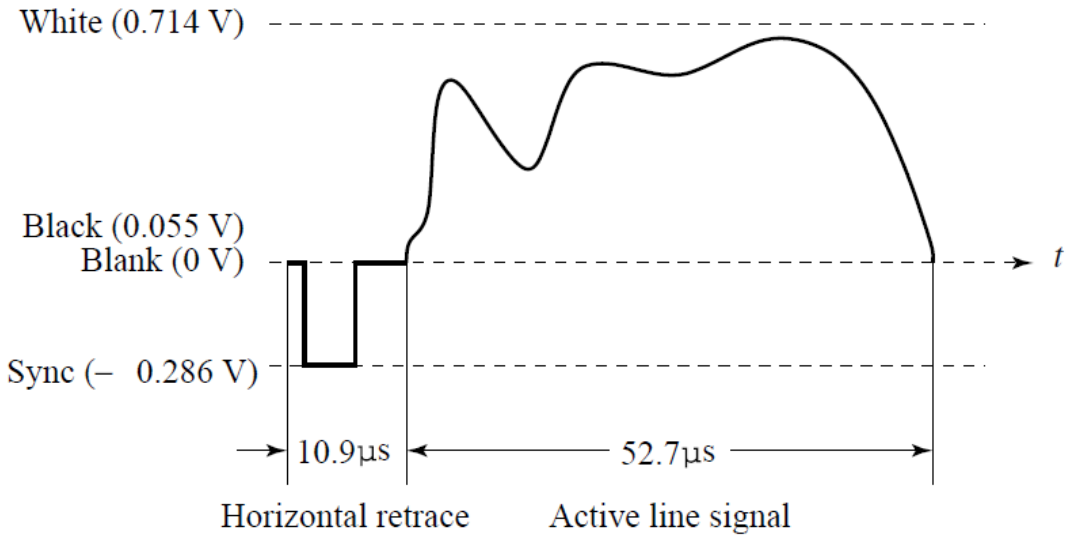
Media Representation: Video

Dr. Mojtaba Aajami

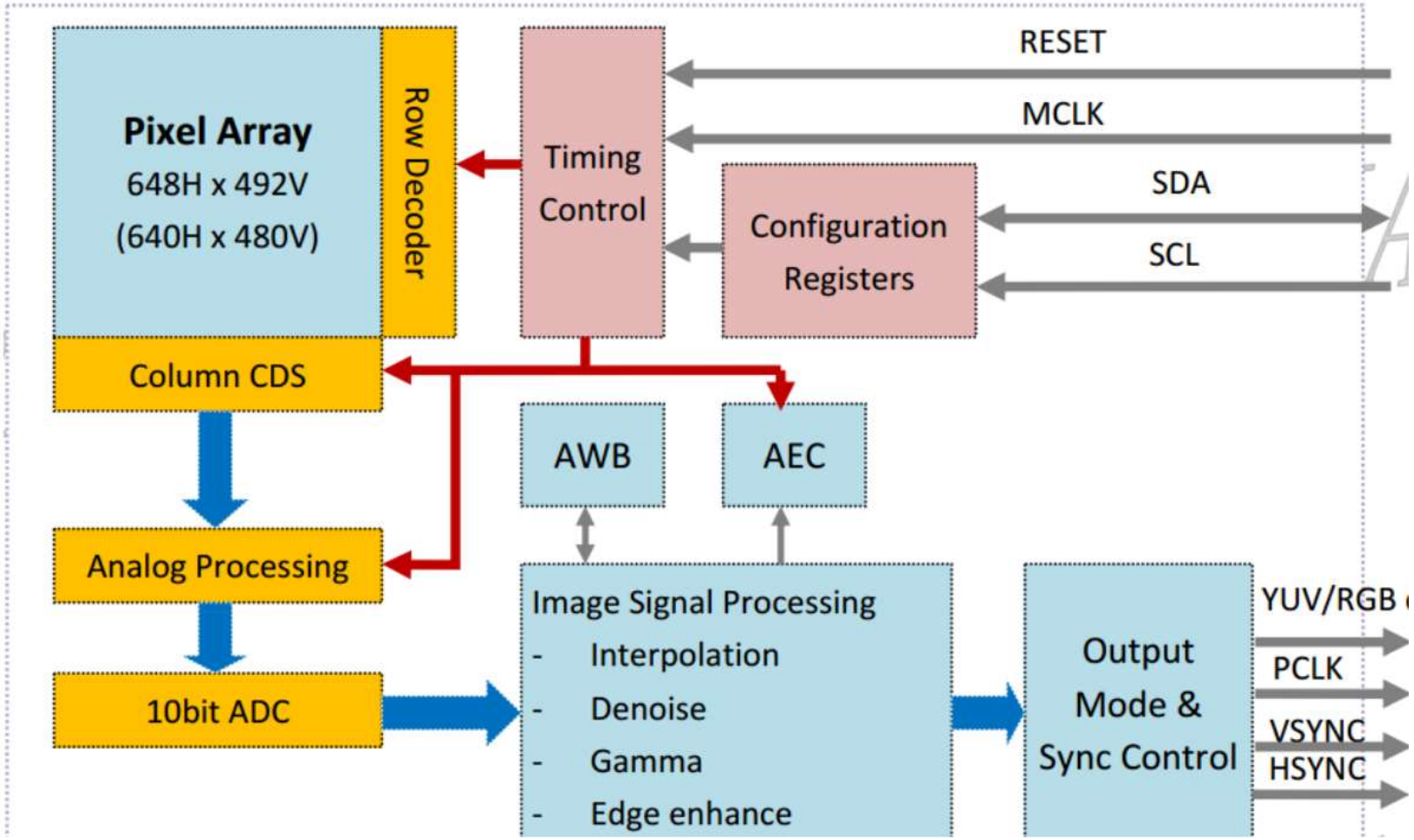
Review - Camera

- CCD/CMOS are just sensor type
- Usually 2d matrix array
- Scan through each point to produce electronical signal
- Digital camera has Analog to Digital conversion





Review - Camera

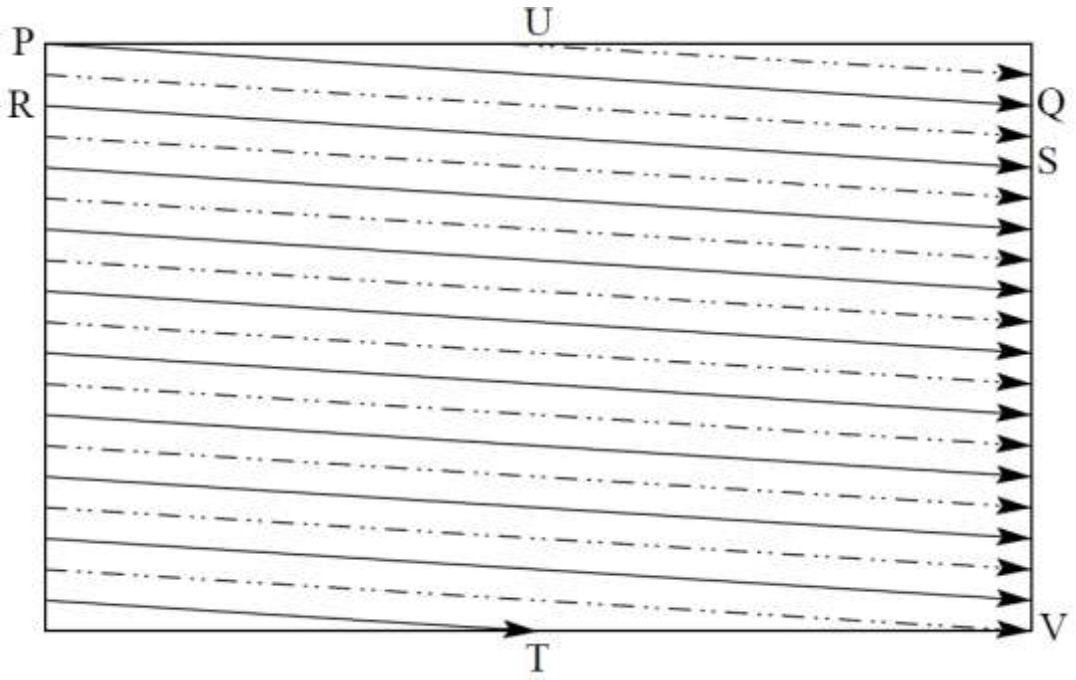


Analog Video

- An analog signal f(t) samples a time-varying image
- Progressive scanning
  - Traces through a complete picture (a frame) row-wise for each time interval.
- Interlaced scanning
  - Odd-numbered lines traced first, and then the even numbered lines.
  - “odd" and “even" fields - two fields make up one frame
  - Widely used in traditional (non-digital) TV

Interlaced Scan

- First the solid (odd) lines are traced, P to Q, then R to S, etc., ending at T; then the even field starts at U and ends at V.
- The jump from Q to R, etc. is called the **horizontal retrace**, during which the electronic beam in the CRT is blanked.
- The jump from T to U or V to P is called the **vertical retrace**.



Interlaced Scan

- Because of interlacing, the odd and even lines are displaced in time from each other and generally not noticeable except when very fast action is taking place on screen, when blurring may occur.
- For example, in the following video, the moving helicopter is blurred more than the still background.

Example of Interlaced Scan

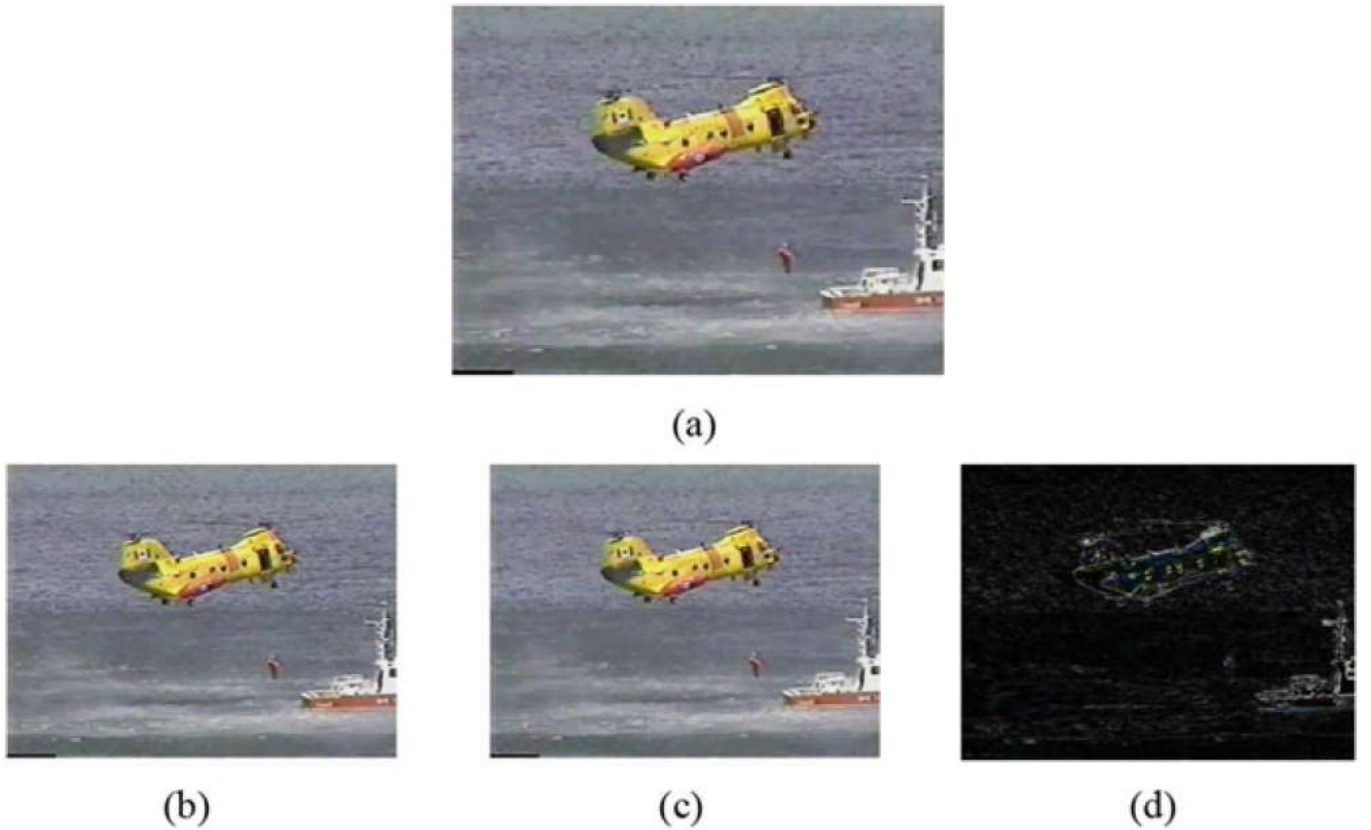


Fig. 5.2 Interlaced scan produces two fields for each frame: **a** The video frame; **b** Field 1; **c** Field 2; **d** difference of fields

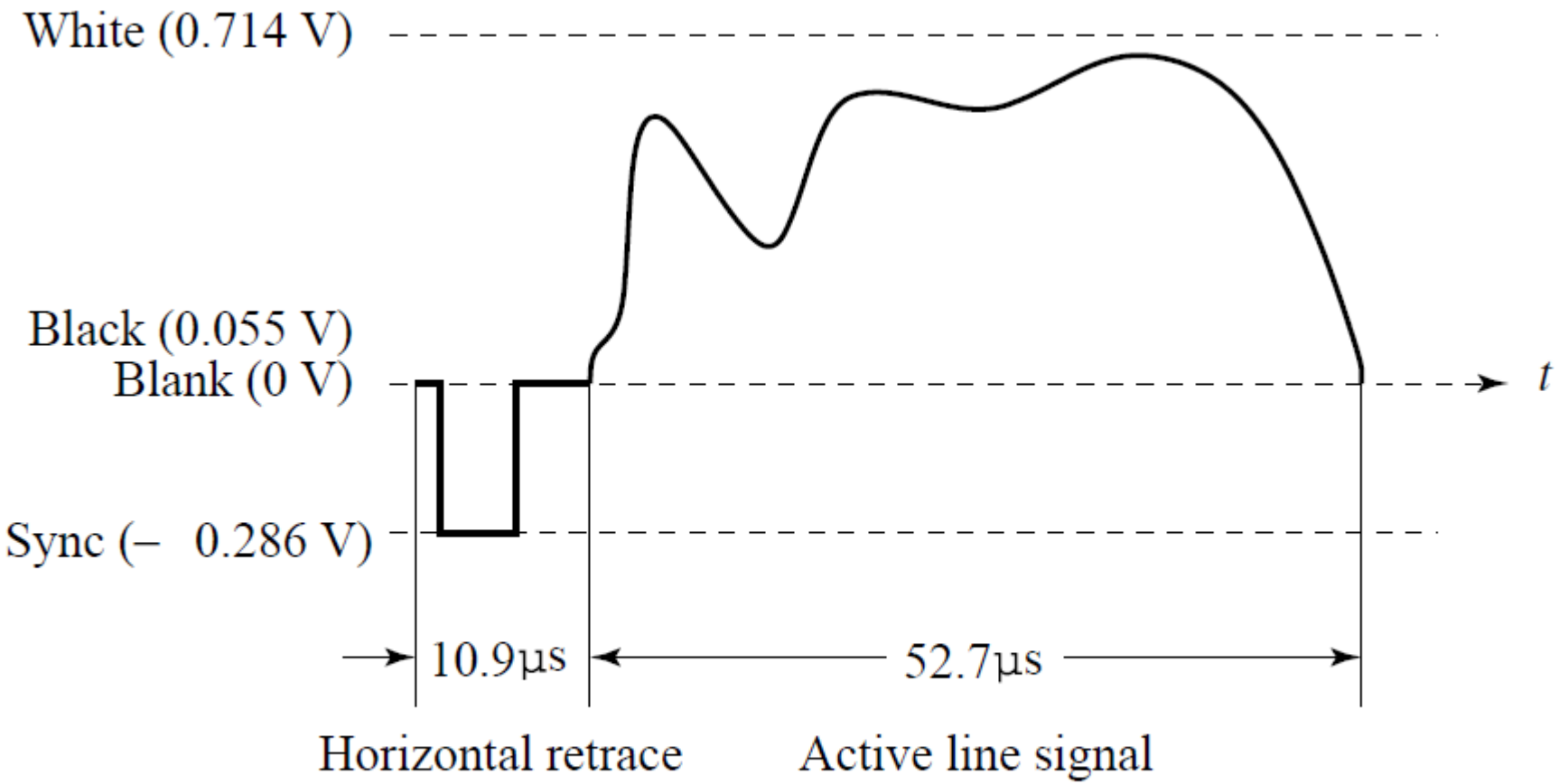
de-interlacing

- Since it is sometimes necessary to change the frame rate, resize, or even produce stills from an interlaced source video, various schemes are used to “de-interlace” it.
- The simplest de-interlacing method consists of discarding one field and duplicating the scan lines of the other field. The information in one field is lost completely using this simple technique.

Analog Video: NTSC

- NTSC (National Television System Committee) TV standard is mostly used in North America and Japan. It uses 4:3 **aspect ratio** and uses 525 scan lines per frame at 30 frames per second (fps).
  - More exactly, for historical reasons NTSC uses 29.97 fps.
- Interlaced scanning system, and each frame is divided into two fields, with 262.5 lines/field.
- The horizontal sweep frequency is $525 \times 29.97 \approx 15,734$ lines/s
- each line is swept out in $1/15{,}734\ \text{s} \approx 63.6\mu\text{s}$

Analog Video: NTSC



Electronic signal for one NTSC scan line

Color Model and Modulation of NTSC

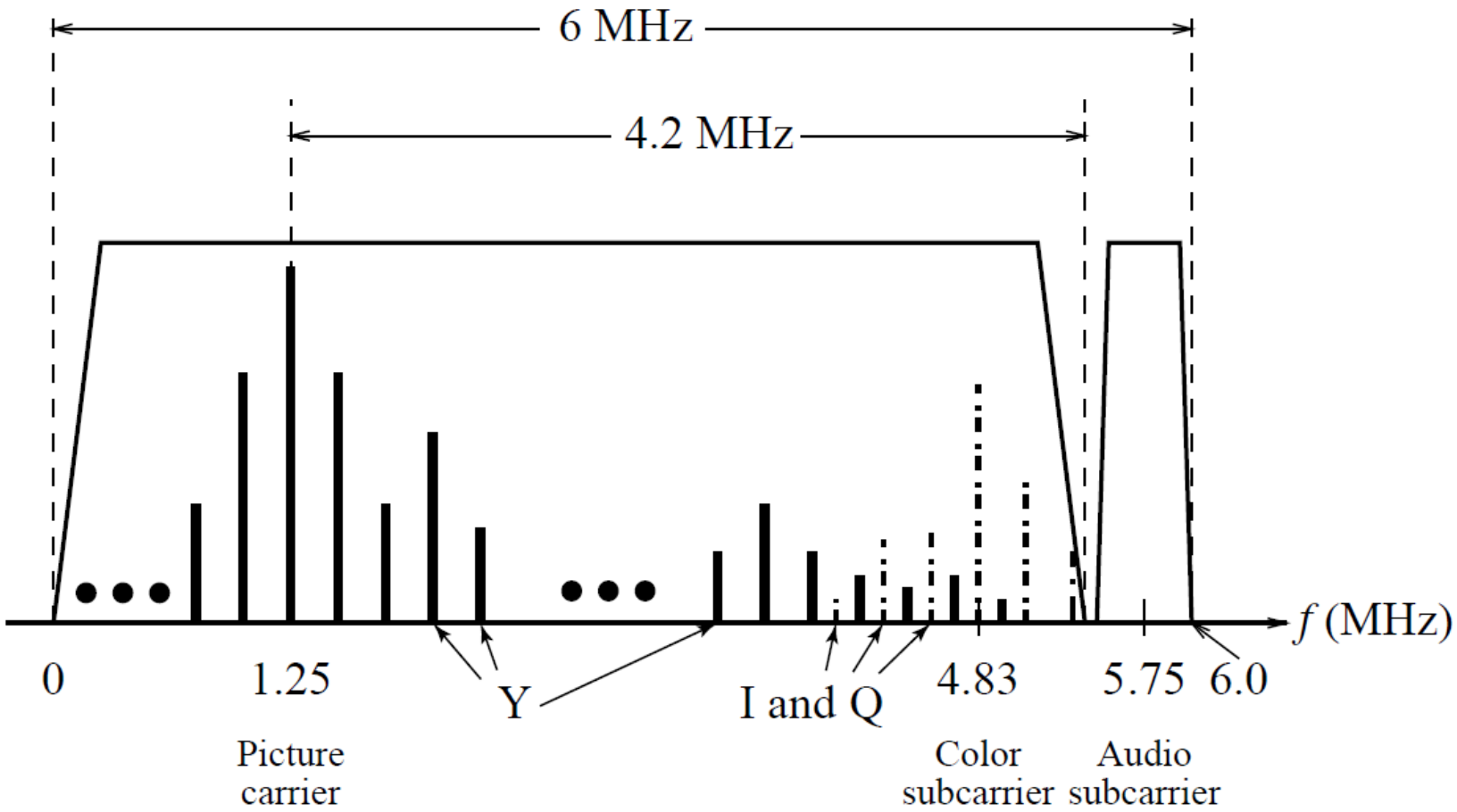
- NTSC uses the YIQ color model, and the technique of **quadrature modulation** is employed to combine (the spectrally overlapped part of) *I* (in-phase) and *Q* (quadrature) signals into a single chroma signal *C*:

$$C = I\cos(\mathrm{F_{sc}}t) + Q\sin(\mathrm{F_{sc}}t)$$

- This modulated chroma signal is also known as the **color subcarrier**, whose magnitude is $\sqrt{I^2 + Q^2}$, and phase is $\tan^{-1}(Q/I)$. The frequency of *C* is $F_{sc} \approx 3.58$ MHz.
- The NTSC composite signal is a further composition of the luminance signal *Y* and the chroma signal as defined below:

$$\text{composite} = Y + C = Y + I\cos(\mathrm{F_{sc}}t) + Q\sin(F_{sc}t)$$

NTSC spectrum



Decoding NTSC Signals

- The first step in decoding the composite signal at the receiver side is the separation of *Y* and *C*.
- After the separation of *Y* using a low-pass filter, the chroma signal *C* can be demodulated to extract the components *I* and *Q* separately.
- To extract *I*:

1. Multiply the signal C by $2\cos(F_{sc}t)$, i.e.,

$$\begin{aligned} C \cdot 2\cos(F_{sc}t) &= I \cdot 2\cos^2(F_{sc}t) + Q \cdot 2\sin(F_{sc}t)\cos(F_{sc}t) \\ &= I \cdot (1 + \cos(2F_{sc}t)) + Q \cdot 2\sin(F_{sc}t)\cos(F_{sc}t) \\ &= I + I \cdot \cos(2F_{sc}t) + Q \cdot \sin(2F_{sc}t) \end{aligned}$$

Decoding NTSC Signals

2) Apply a low-pass filter to obtain I and discard the two higher frequency ($2F_{sc}$) terms.

- Similarly, Q can be extracted by first multiplying C by $2\sin(F_{sc}t)$ and then low-pass filtering.