PRINCIPLES OF TELEVISION ENGINEERING /02

Scanning, Resolution, Bandwidth, TV Systems

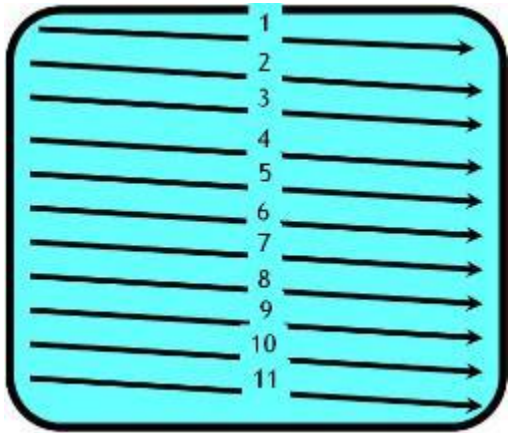
ECE 523E – ANTENNA & RADIOWAVE PROPAGATION

Tuesday, 29 September 2026

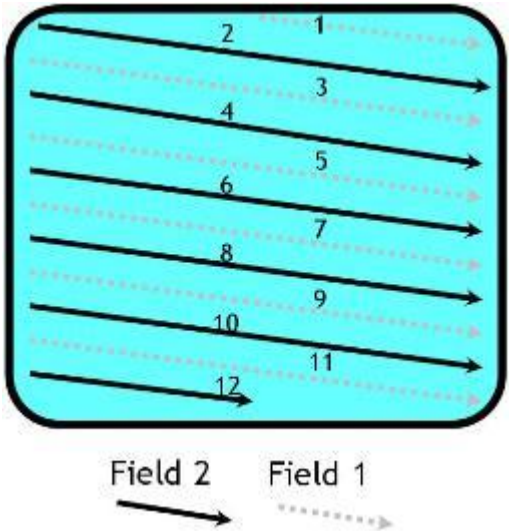
TYPES OF SCANNING

There are two types of scanning:

1. **Progressive scanning** (also called non-interlaced scanning) is a format of displaying, storing, or transmitting moving images in which all the lines of each frame acquired and displayed in sequence.

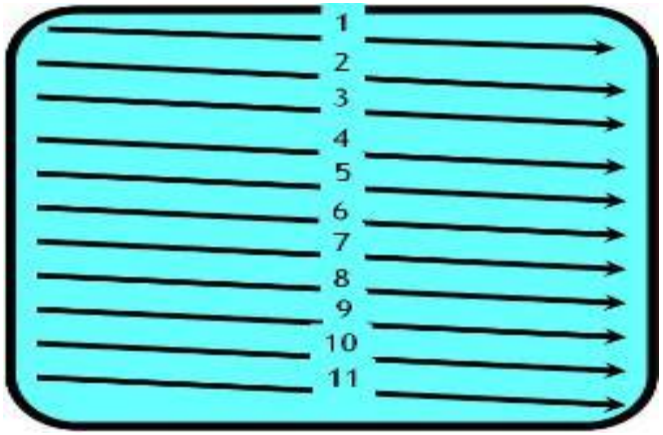


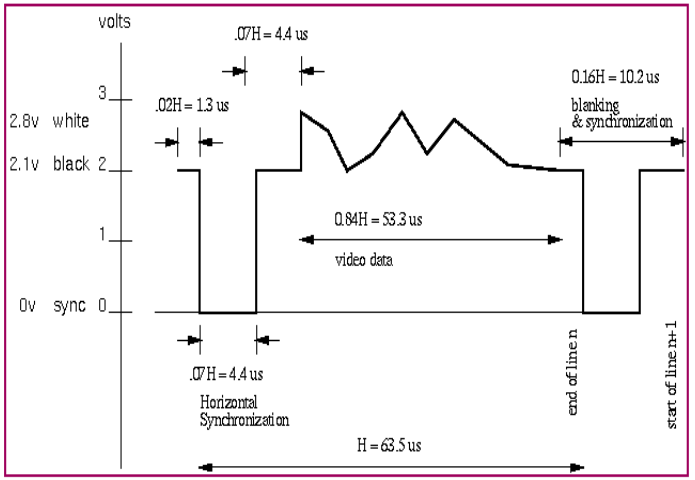
2. **Interlaced scanning** in which one-half of the horizontal pixel rows are refreshed in one cycle and the other half in the next, meaning that two complete scans are required to display the screen image.

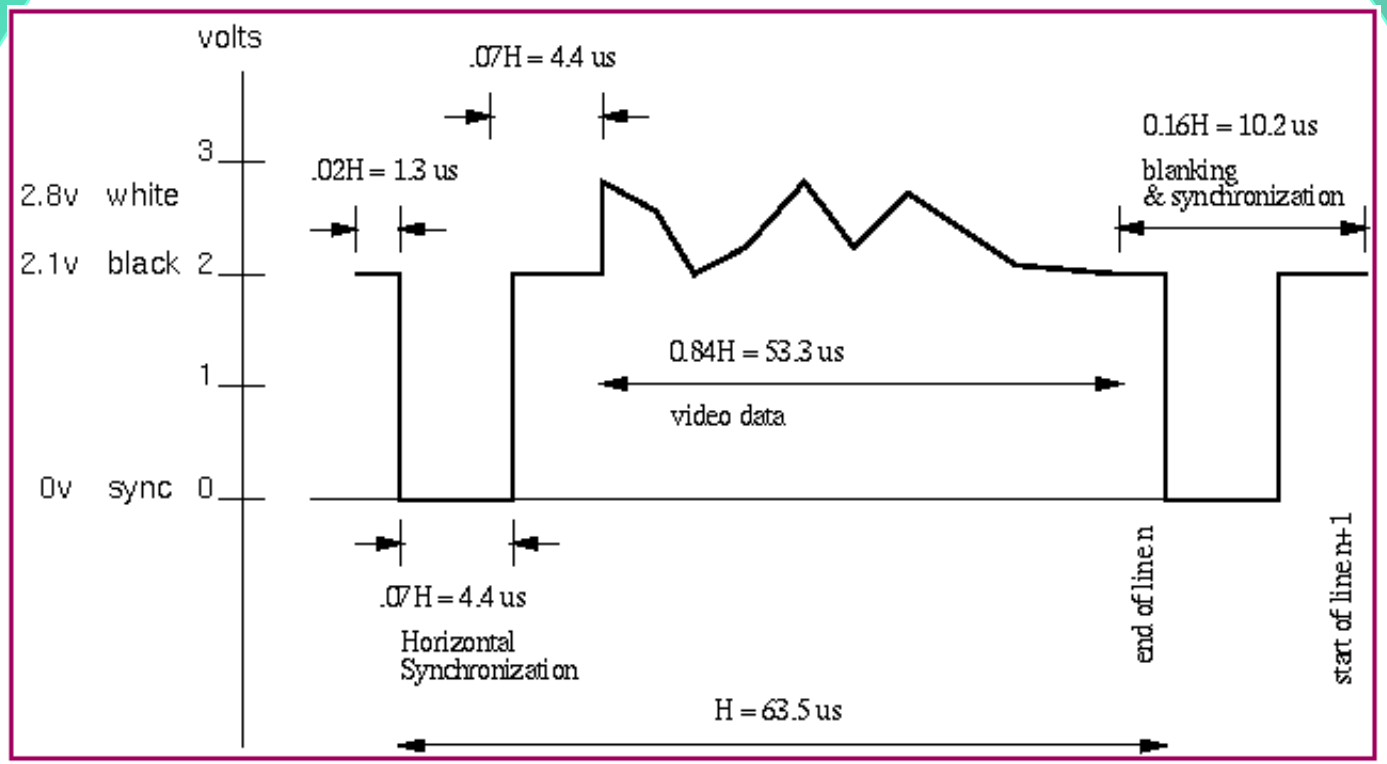


PROGRESSIVE SCANNING

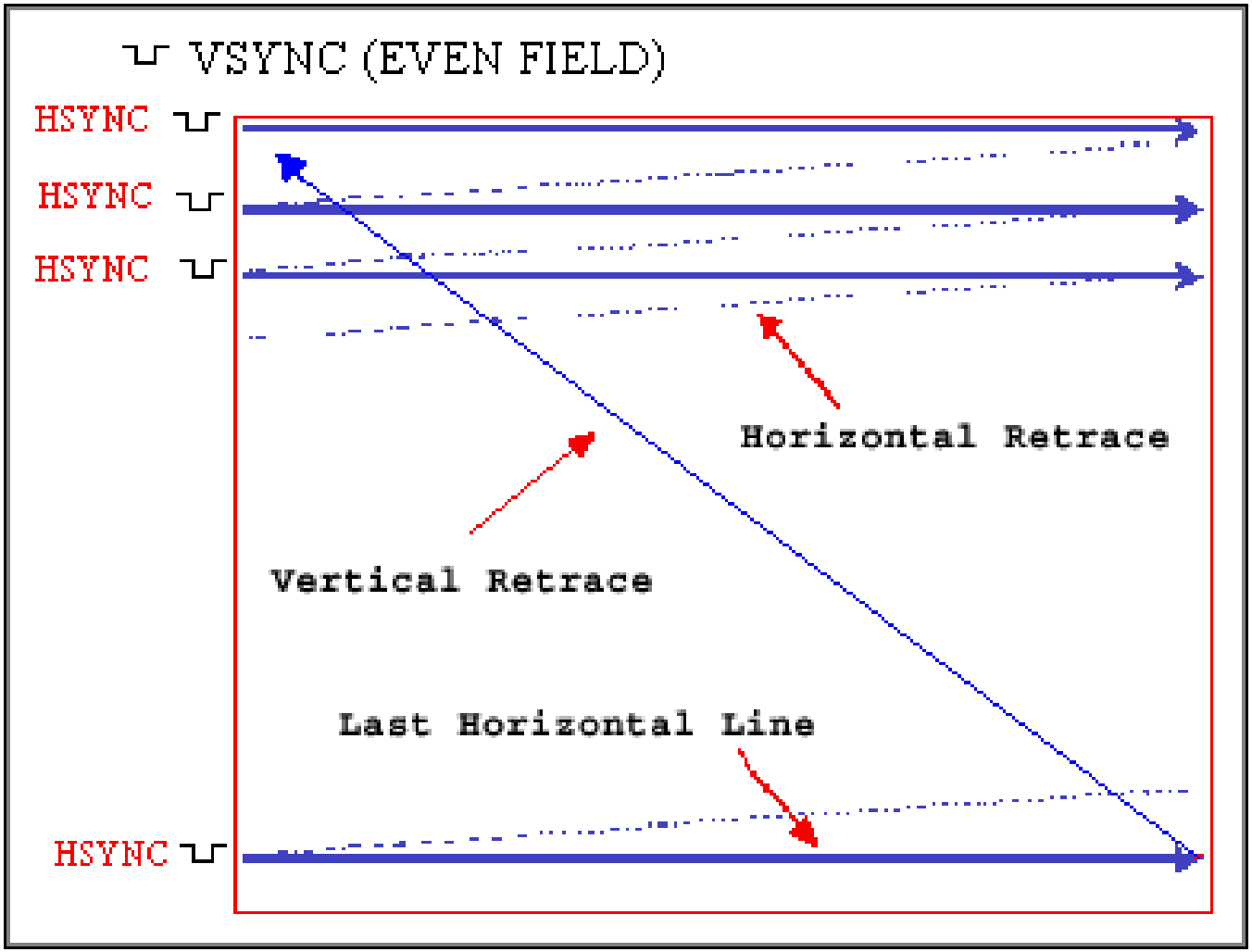
- During scanning horizontal and vertical beam deflection circuits operate simultaneously.
- On reaching the end of each line, searching spot retraces horizontally to the start of the succeeding line.
- To make the retrace invisible, a blanking pulse is supplied to the control grid of the electron gun.
- For picture tubes, the blanking signal and the synchronization signals are transmitted together with the video signal.






volts
3
2
1
0
2.8v white
2.1v black
0v sync
.07H = 4.4 us
.02H = 1.3 us
0.16H = 10.2 us
blanking
& synchronization
0.84H = 53.3 us
video data
.07H = 4.4 us
Horizontal
Synchronization
end of line n
start of line n+1
H = 63.5 us

HORIZONTAL Vs VERTICAL RETRACE IN PROGRESSIVE SCANNING

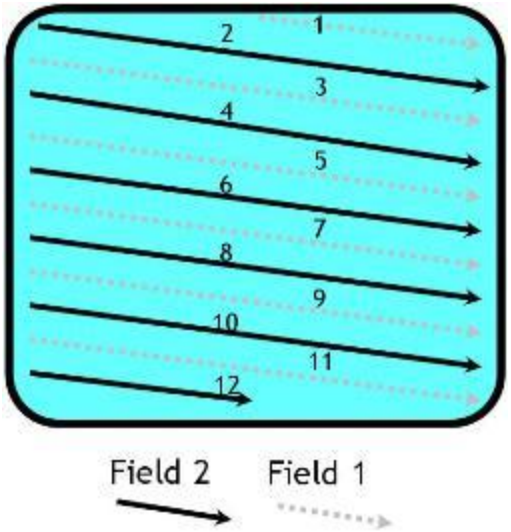


PROBLEMS OF PROGRESSIVE SCANNING

- In progressive scanning, 25 frames/sec are scanned. The scanning beam takes 1.280 msec to retrace to the top. The blanking makes the screen to appear black.
- This results in dark interruptions at a rate of 25 dark periods per second.
- Since persistence of vision is more for dark pictures, these interruptions become visible as flicker on screen.
- **Flicker can be removed using progressive scanning** by increasing the rate of scanning to say 50frames/sec, but this results in higher bandwidth.

INTERLACED SCANNING

1. Problems of Progressive Scanning can be rephrased as follows:
   a) The brighter the still image presented to the viewer, the shorter the persistence of vision.
   b) If the time interval between pictures is longer than the period of persistence of vision then the image flickers.
2. The solution was to arrange for two "flashes" per frame as follows:
   a) A single frame is scanned twice.
   b) The first scan includes only the odd lines, the next scan includes only the even lines.



ADVANTAGES OF INTERLACED SCANNING

The advantages of Interlaced scanning over progressive scanning are:

1. Interlaced scanning displays only half the image at a time, effectively reducing the bandwidth requirement by a factor of 2. This greatly reduces the complexity of the entire broadcasting and display system.
2. At a fixed bandwidth, interlaced scanning has twice the refresh rate as compared to progressive scanning. This helps when viewing objects in motion, as interlacing updates their position on the screen more often and minimized flicker.

Visual display systems based on interlacing became popular over the years, and are currently the most widely used systems.

DIGITAL TV (DTV) STANDARDS

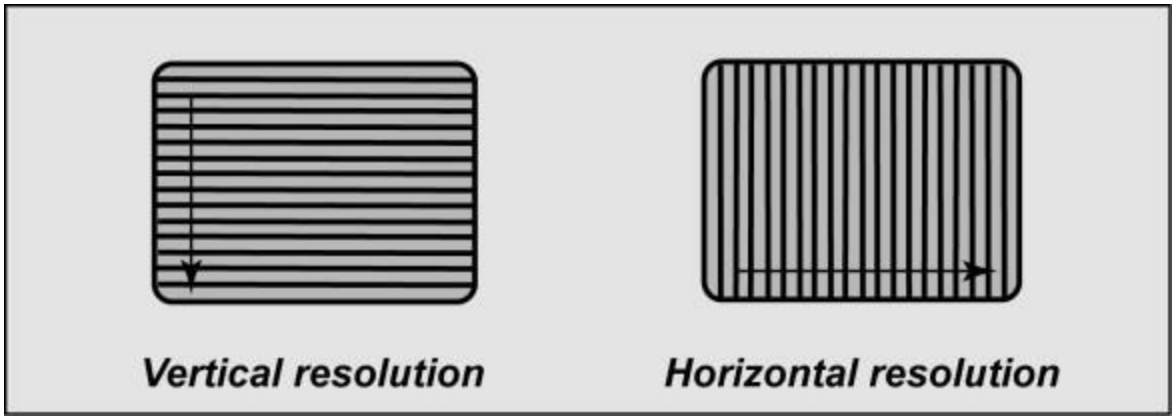
DTV standards include 480p,480i/p,720p and 1080i.

DTV standard	Aspect Ratio	Pixels per Horizontal Line	Vertical Pixels	Scan Rate in Hz
480p	4:3	640	480	24,30,60
480i/p	4:3 OR 16:9	704	480	24,30,60
720p	16:9	1280	720	24,30,60
1080i	16:9	1920	1080	24 OR 30 Hz

p in 480i/p stands for "progressive" and i stands for "interlaced scanning".

TV RESOLUTION (GENERAL)

1. Resolution is the property of a TV system to display fine details.
2. The higher the resolution, the more details we can see.
3. The resolution depends on:
   a) Number of active scanning lines,
   b) Quality of the camera,
   c) Quality of the monitor
   d) Quality of the transmitting media.



VERTICAL RESOLUTION

TV resolution refers to the ability to distinguish between two closely spaced pixels.

Vertical resolution refers to the ability of the scanning system in resolving picture detail in the vertical direction.

$$v_r = N_a \times k$$

where

N_a is the number of active lines

k is the resolution factor (also called the Kell factor)

Example: In the case of 625 lines, $N_a = 585$ lines, assuming k = 0.69, the vertical resolution is given by

$$v_r = 585 \times 0.69 = 400\ lines$$

HORIZONTAL RESOLUTION

- **Horizontal resolution** refers to the ability of the scanning system in resolving picture detail in the horizontal direction.

$$H_r = v_r A$$

where A is the aspect ratio.

For standard TV, A = 4/3 and for digital system A = 16/9

- **Example:** In the case of standard 625-line TV, $N_a = 585$ lines, assuming k = 0.69, the horizontal resolution is given by:

$$H_r = v_r A = (N_a \times k)\text{A} = 585 \times 0.69 \times \frac{4}{3} = 533 \text{ lines}$$

BANDWIDTH OF VIDEO SIGNAL

- Video bandwidth refers to the highest frequency related to scanning two adjacent pixels.
- Video bandwidth depends on the horizontal resolution.

Let t be the time required to scan one line

If H_r is the horizontal resolution

Two pixels will be scanned in the time , T = $\frac{2t}{H_r}$

Video bandwidth is therefore given by

$$B_w = \frac{1}{T} = \frac{H_r}{2t}$$

EXAMPLE

- Find the bandwidth of a PAL television system given that the time required to scan one line is $52\mu sec$. Assume a Kell factor of 0.69

SOLUTION

For A PAL system, the number of active lines is 585. If the Kell factor is 0.69, then the horizontal resolution is given by

$$H_r = 0.69 \times 585 \times \frac{4}{3} = 538$$

The time required to scan 2 pixels is

$$T = \frac{2 \times 52 \times 10^{-6}}{538} = 0.193 \times 10^{-6}$$

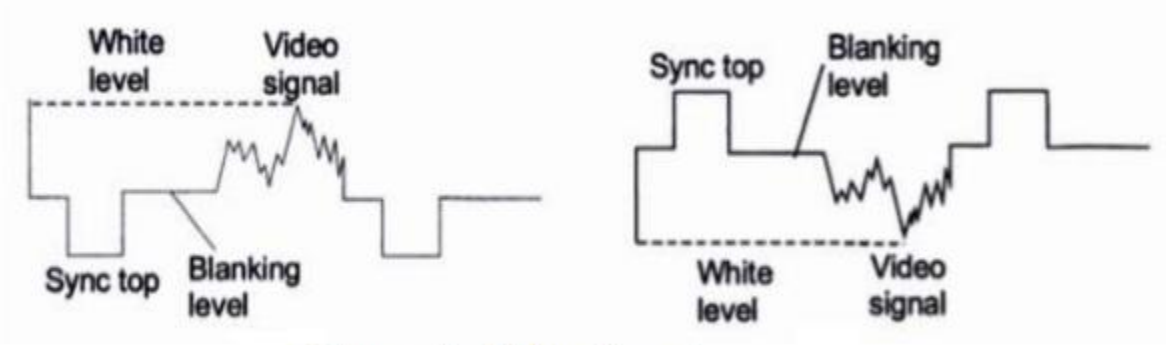
Video bandwidth, $B_v = \frac{1}{T} = 5.17\ MHz$

TONAL GRADATION

- **Tonal gradation** refers to the variation of brightness from one pixel to another.
- The factors that influence the tonal quality of a video signal are:
  1. **Contrast** – the difference in intensity between black and white parts of a picture over and above the brightness level.
  2. **Contrast ratio** – the ratio of minimum and maximum relative to the original picture.

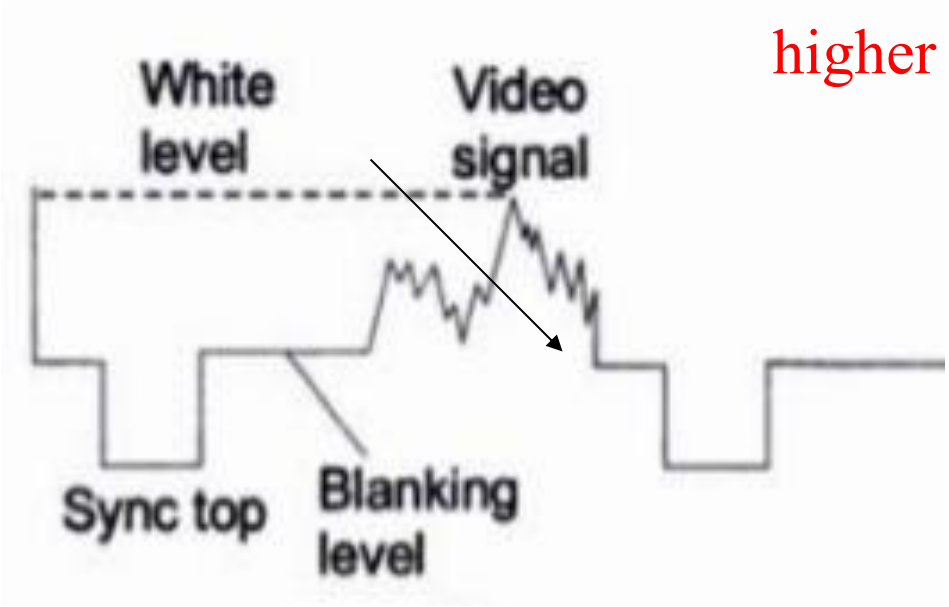
COMPOSITE VIDEO SIGNAL

1. **Composite video** is an analogue video transmission that carries standard definition video as a single channel.
2. Composite video signal comprises of
   a) luminance
   b) Blanking pulses to make retrace invisible
   c) Synchronization signals to align the camera and TV scanning.



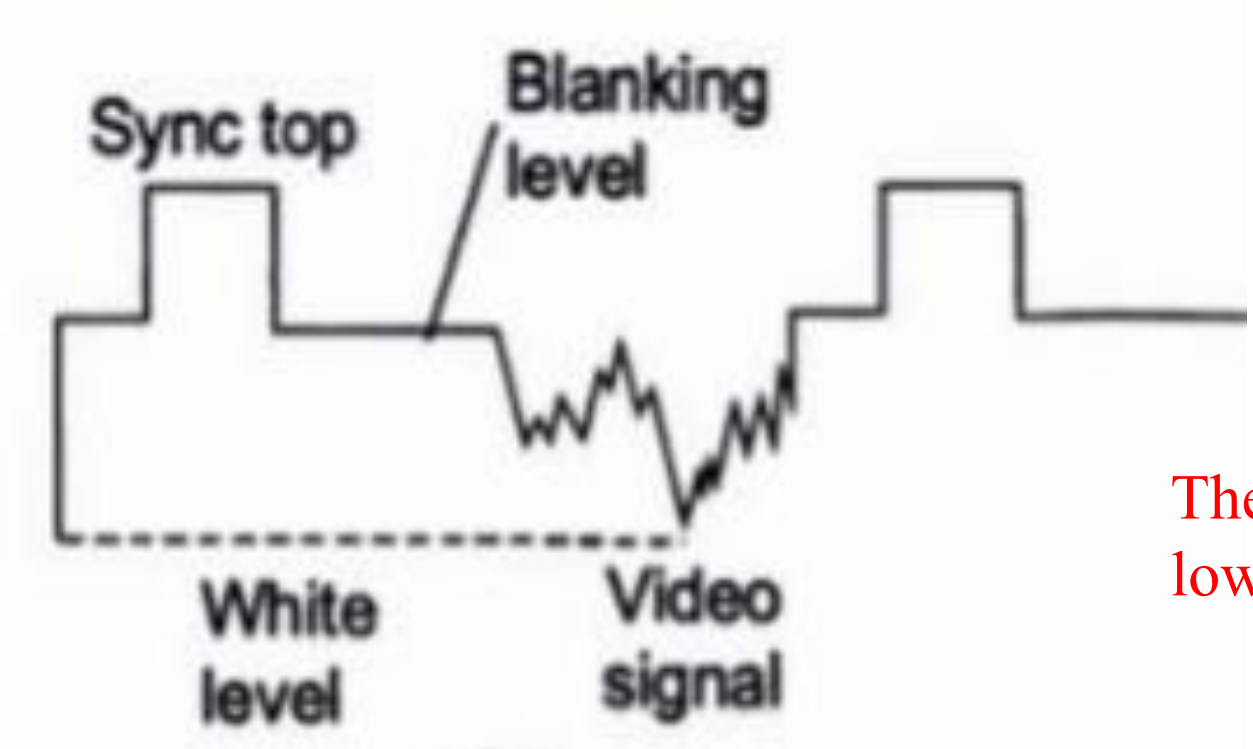
Composite Video Signal

COMPOSITE VIDEO SIGNAL – POSITIVE POLARITY



The whiter the scene, the higher the amplitude

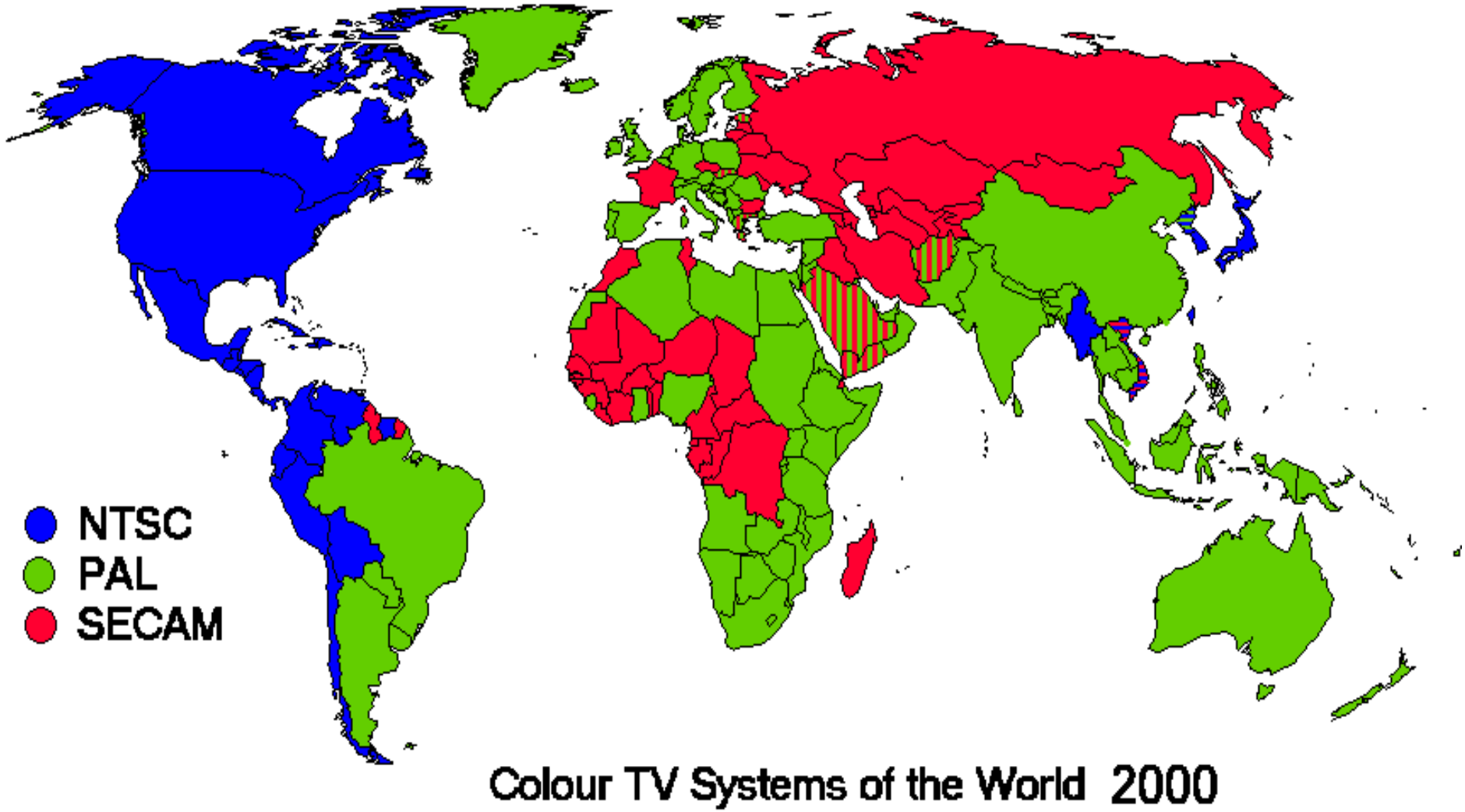
COMPOSITE VIDEO SIGNAL – NEGATIVE POLARITY



The whiter the scene, the lower the amplitude

In most TV systems, negative polarity is used.

COMMON TV SYSTEMS



TELEVISION SYSTEMS / 01

NTSC STANDARD

(**N**ational **T**elevision **S**tandards **C**ommittee)

- Standard for U.S., Japan, and Korea
- 4 X 3 Aspect Ratio
- 525 Lines
- 30 Frames per Second

TELEVISION SYSTEMS / 02

PAL SYSTEM

(Phase Alternating Line)

- 4 X 3 Aspect Ratio
- 625 Lines
- 25 Frames Per Second
- There are variants: PAL-B, -G, -H, -N
- Used in Continental Europe and Parts of Africa, Middle East & South America

Notes (Comparison with NTSC)

- More Lines = Better Resolution
- Fewer Frames/second = More "Flicker"

TELEVISION SYSTEMS / 03

SECAM System

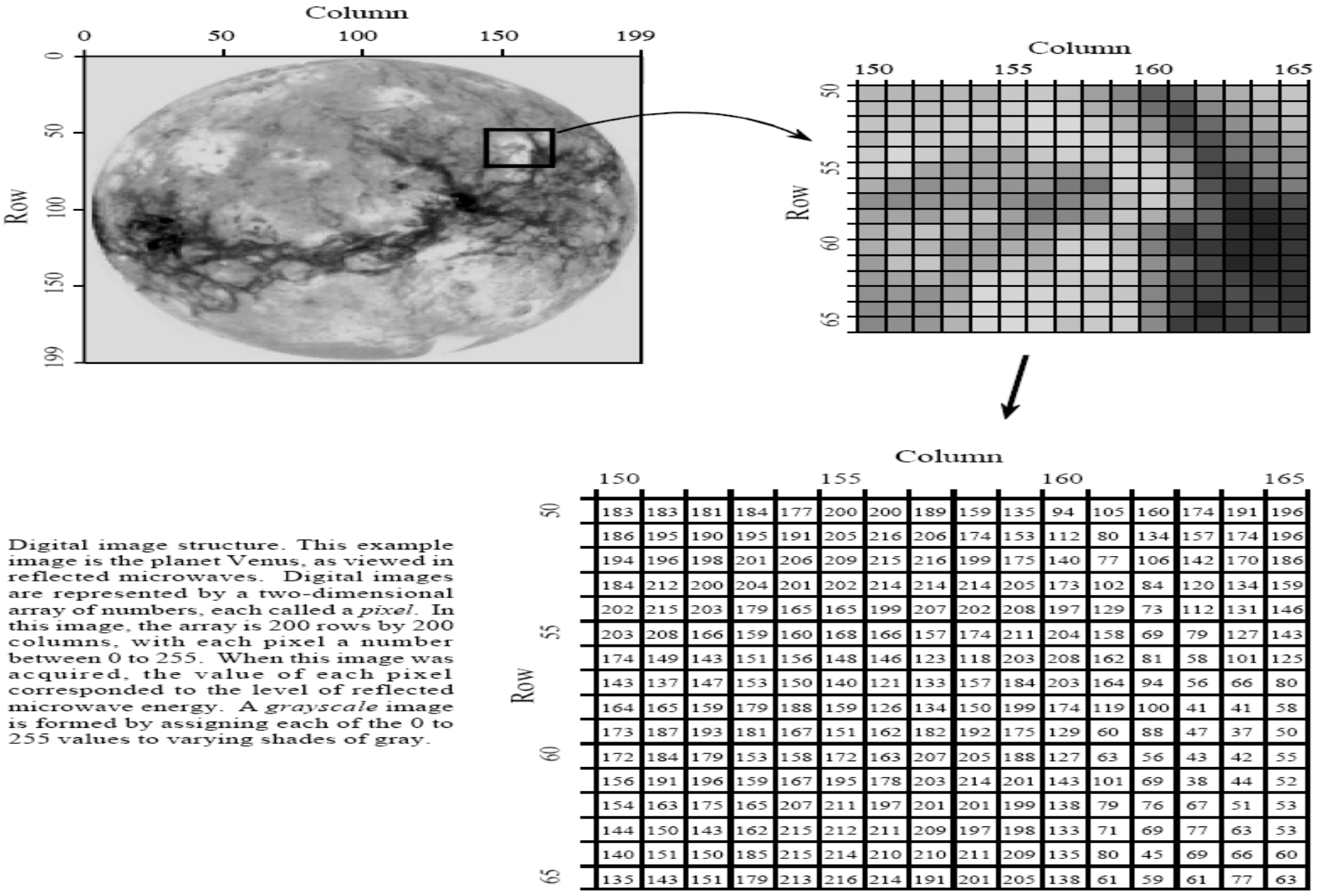
(Sequential Color and Memory)

- 4 X 3 Aspect Ratio
- 625 Lines
- 25 Frames Per Second
- Used in France, Eastern Europe and Parts of the Middle East & Africa

Notes (Comparison with NTSC)

- More Lines = Better Resolution
- Fewer Frames/Fields = More "Flicker"

TELEVISION IMAGE FORMATION



Digital image structure. This example image is the planet Venus, as viewed in reflected microwaves. Digital images are represented by a two-dimensional array of numbers, each called a *pixel*. In this image, the array is 200 rows by 200 columns, with each pixel a number between 0 to 255. When this image was acquired, the value of each pixel corresponded to the level of reflected microwave energy. A *grayscale* image is formed by assigning each of the 0 to 255 values to varying shades of gray.