

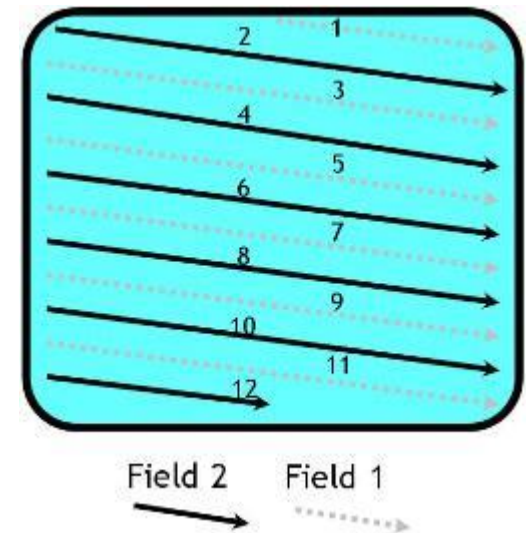
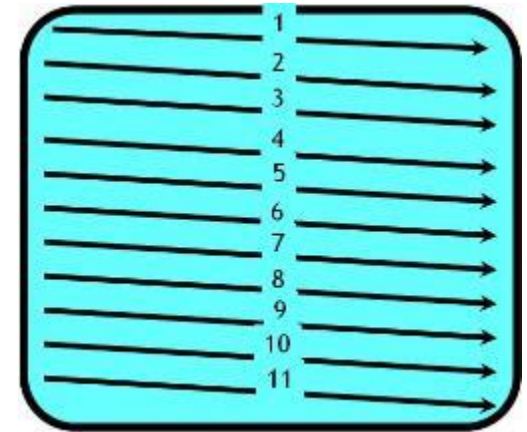
PRINCIPLES OF TELEVISION ENGINEERING /02

**ECE 516E – ANTENNA & RADIOWAVE PROPAGATION
Monday, 10 November 2025**

TYPES OF SCANNING

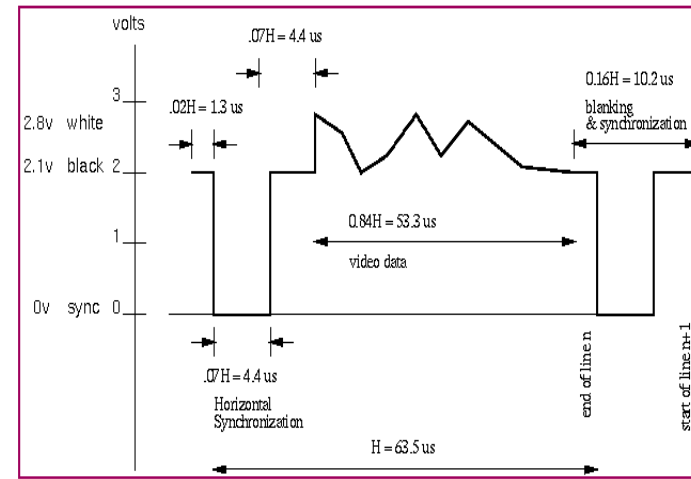
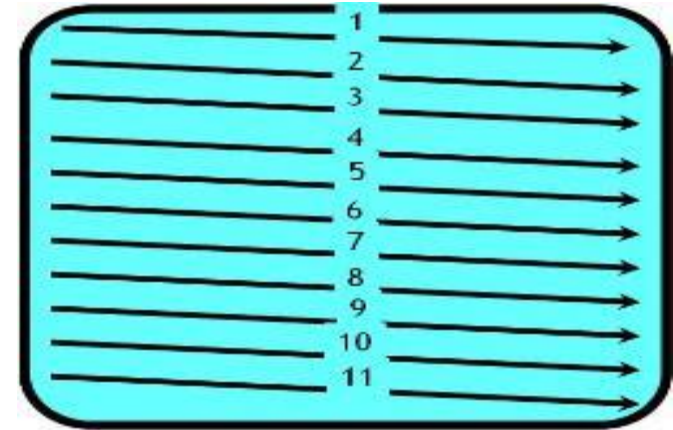
There are two types of scanning:

- 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.

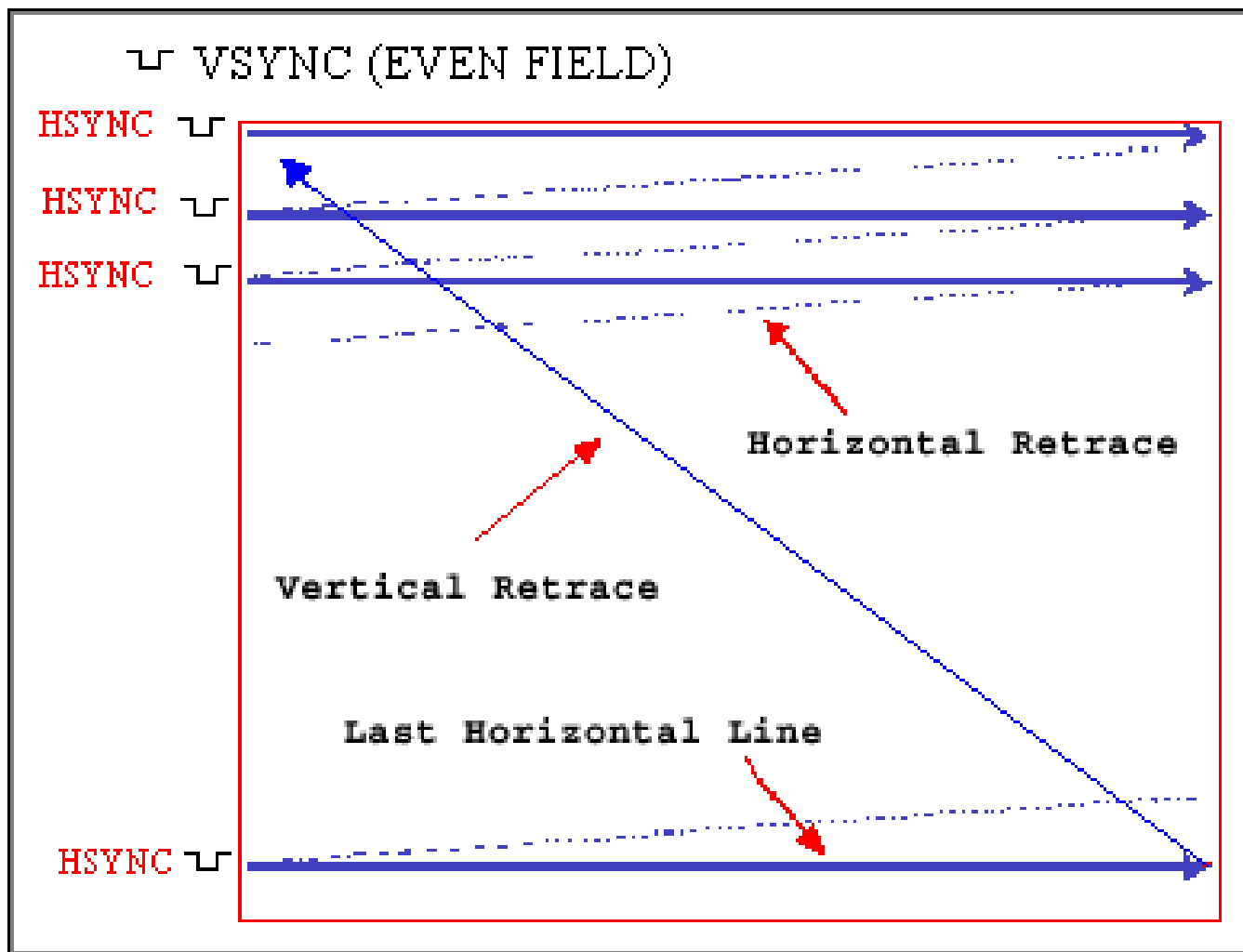


PROGRESSIVE SCANNING

- 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.



HORIZONTAL Vs VERTICAL RETRACE IN PROGRESSIVE SCANNING

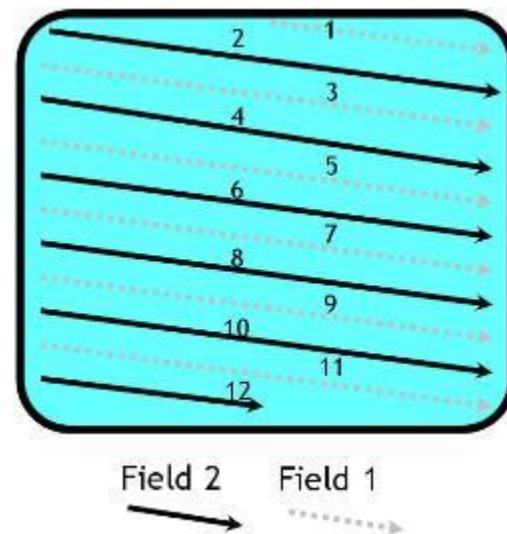


PROBLEMS OF PROGRESSIVE SCANNING

- In progressive scanning, a minimum of 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 from progressive scanning by increasing the rate of scanning to double, i.e 50frames/sec, but this results in higher bandwidth.**

DOUBLING THE PERCEIVED REFRESH RATE

- 1. Transmit a frame in two separate, interwoven parts called fields.**
 - **Field 1 (Odd Field):** Scan all odd-numbered lines (1, 3, 5, ...).
 - **Field 2 (Even Field):** Scan all even-numbered lines (2, 4, 6, ...).
- 2. Mathematical Advantage:**
 - **Frame Rate:** 30 Hz (Frames per second).
 - **Field Rate:** 60 Hz (Fields per second).
- 3. Advantage:** The screen is updated at 60 Hz (eliminating flicker) while the signal bandwidth is only that of a 30 Hz system.



COMPARISON: PROGRESSIVE Vs INTERLACED SCANNING

| FEATURE | PROGRESSIVE SCANNING | INTERLACED SCANNING |
|-------------------------|--|---|
| Scan Order | Lines 1, 2, 3, 4, ... in one pass. | Odd lines (Field 1), then Even lines (Field 2). |
| Flicker | More susceptible at lower rates. | Flicker is reduced due to higher field rate. |
| Bandwidth | Higher for the same perceived flicker. | ~50% less for similar flicker performance. |
| Motion Artifacts | Clean, full-resolution frames. | Interline Flicker & Line Crawl on sharp edges. |
| Complexity | Simpler signal processing. | More complex sync and display circuitry. |

DIGITAL TV (DTV) STANDARDS

Digital TV 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".

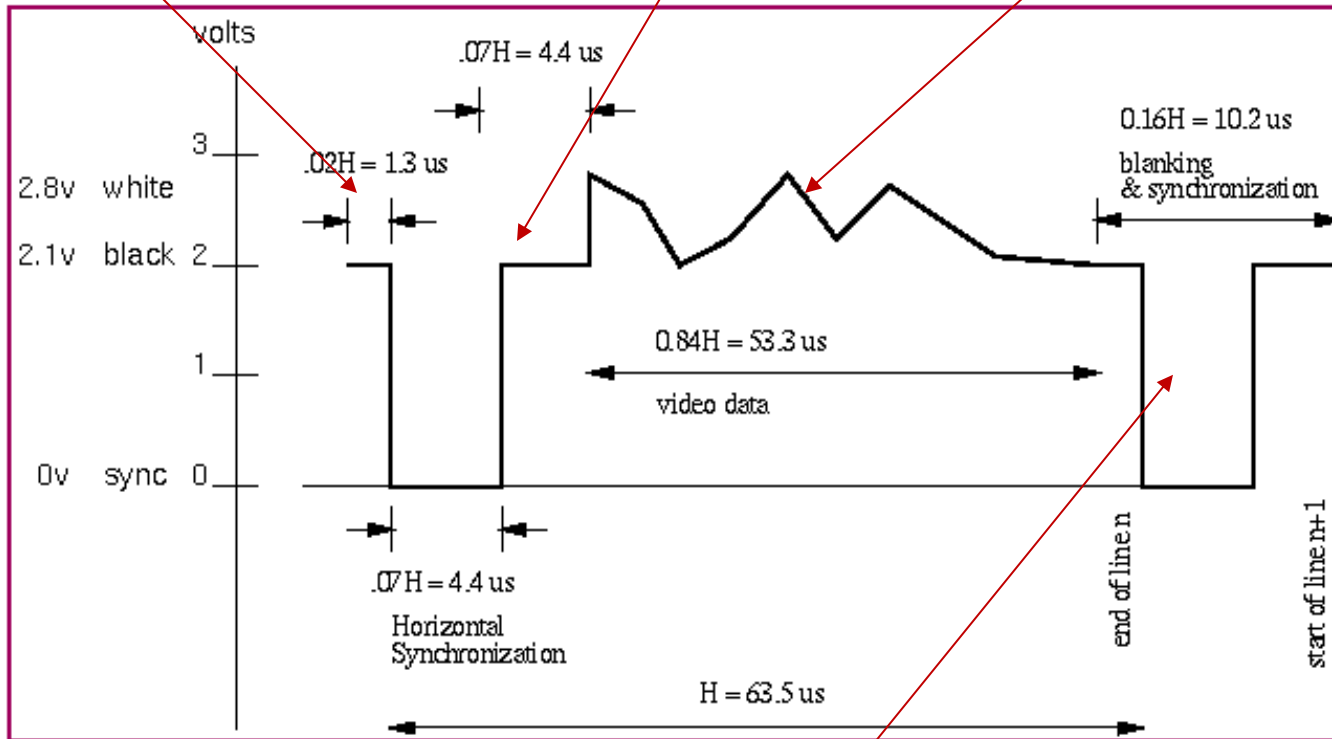
SYNCHRONIZATION: LOCKING THE RECEIVER TO THE TRANSMITTER

1. **Objective:** Receiver's scan must be perfectly aligned with the transmitter's scan.
2. **The Solution:** Synchronization pulses are embedded in the video signal.
 - **Horizontal Sync Pulse:** Triggers the start of a new line. Located in the horizontal blanking interval.
 - **Vertical Sync Pulse:** Triggers the start of a new field. A much wider pulse, located in the vertical blanking interval.

Front Porch

Back Porch

Video Signal



"Blacker than Black": Sync pulses are at a voltage level below the black reference level of the picture.

COMPOSITE VIDEO SIGNAL

The complete signal containing all information needed to reconstruct the image standardized as follows:

1. Voltage Levels (Standard for NTSC):

- **~0.714 V:** Peak White Level (100 IRE)
- **~0 V:** Blanking Level (0 IRE)
- **-0.286 V:** Sync Tip Level (-40 IRE)

2. Signal Composition:

- **Active Video:** Varying amplitude between black and white.
- **Front Porch & Back Porch:** Blanking periods before and after the sync pulse.
- **Sync Pulses:** The timing signal.

BLANKING-HIDING THE RETRACE

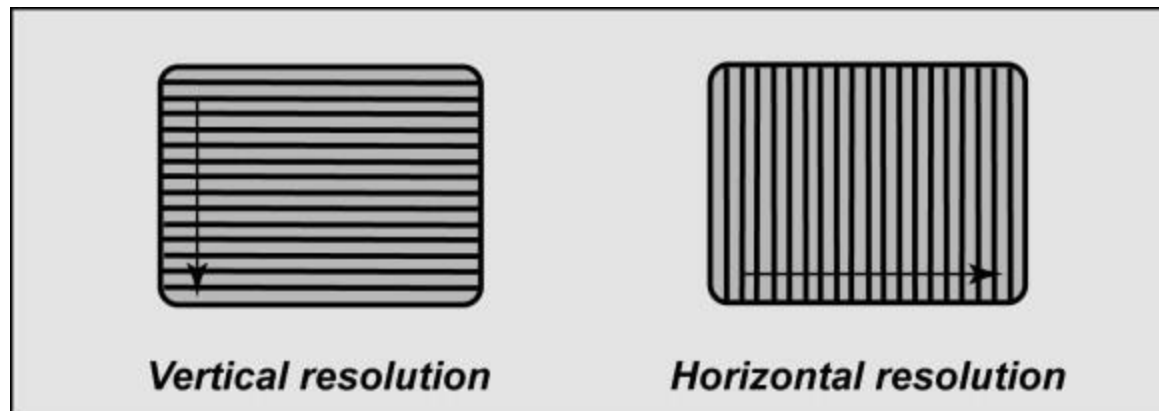
- 1. Blanking** turns off the imaging beam during horizontal and vertical retrace periods to prevent retrace lines on the screen.
- 2. Horizontal Blanking:**
 - Duration: $\sim 10\text{-}11 \mu\text{s}$ per line.
 - Contains: Front porch, sync pulse, and back porch.
- 3. Vertical Blanking:**
 - Duration: $\sim 20\text{-}25$ lines per field.
 - Contains: The vertical sync pulse, pre- and post-equalizing pulses, and time that can be used for other signals (e.g., Closed Captioning, V-Chip data).
- 4. Impact of Blanking:** The total number of lines scanned (N_{total}) is greater than the number of visible lines (N_{visible}).

ANALOG RASTER Vs DIGITAL PIXEL GRID

1. **Analog scanning** was an elegant, real-time solution to a complex bandwidth-limited problem.
2. **Modern digital video standards:**
 - Are still defined by their scanning structure, e.g. 1080i, 720p where p and i suffixes directly denote Progressive and Interlaced.
 - **Deinterlacing** is necessary for displaying interlaced video on progressive displays (LCD, OLED).
3. **Converting from analog to digital standards** is a complex engineering problem aimed at reconstruct the missing lines and to eliminate artifacts.

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

$$v_r = 585 \times 0.69 = 400 \text{ lines}$$

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:

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

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 $52\mu\text{sec}$. 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

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

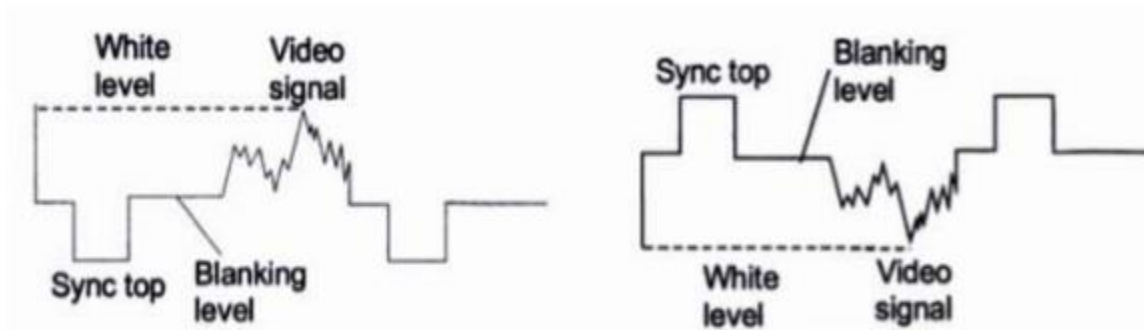
Video bandwidth, $B_v = \frac{1}{T} = 5.17 \text{ MHz}$

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.

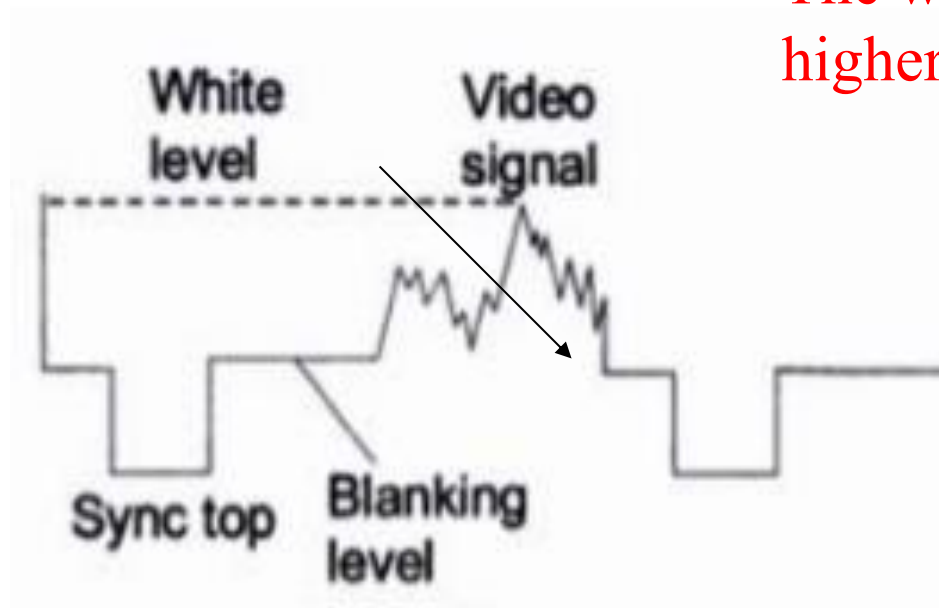
COMPOSITE VIDEO SIGNAL

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.



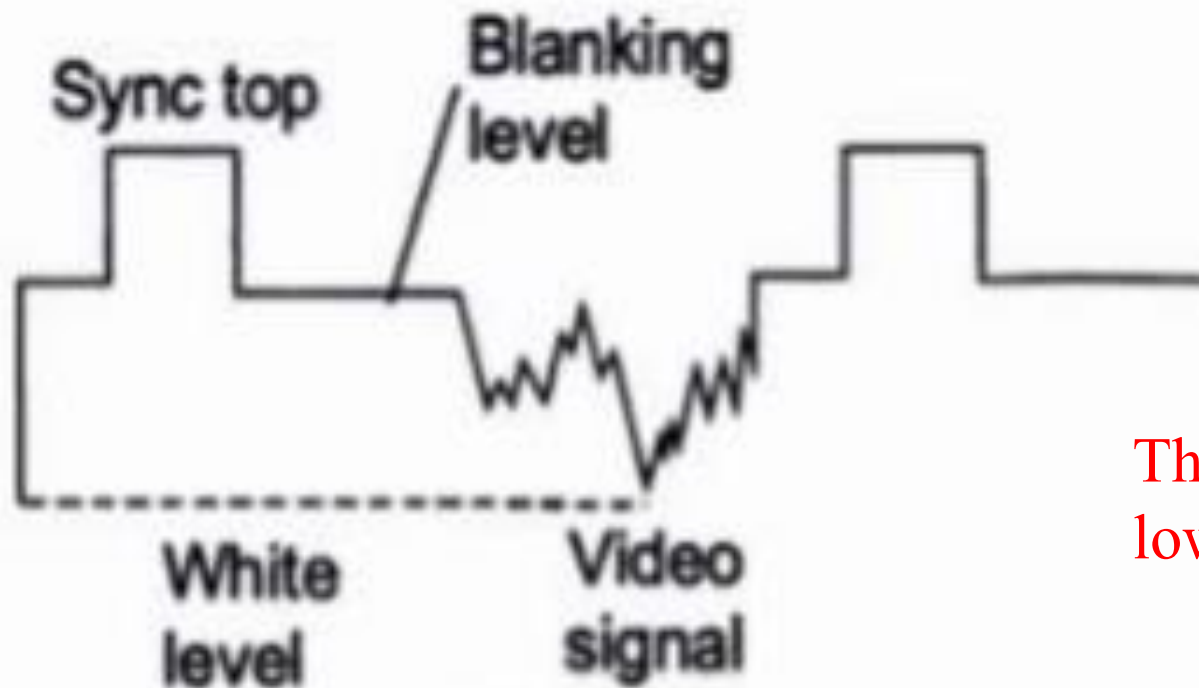
Composite Video Signal

COMPOSITE VIDEO SIGNAL – POSITIVE POLARITY



The whiter the scene, the higher the amplitude

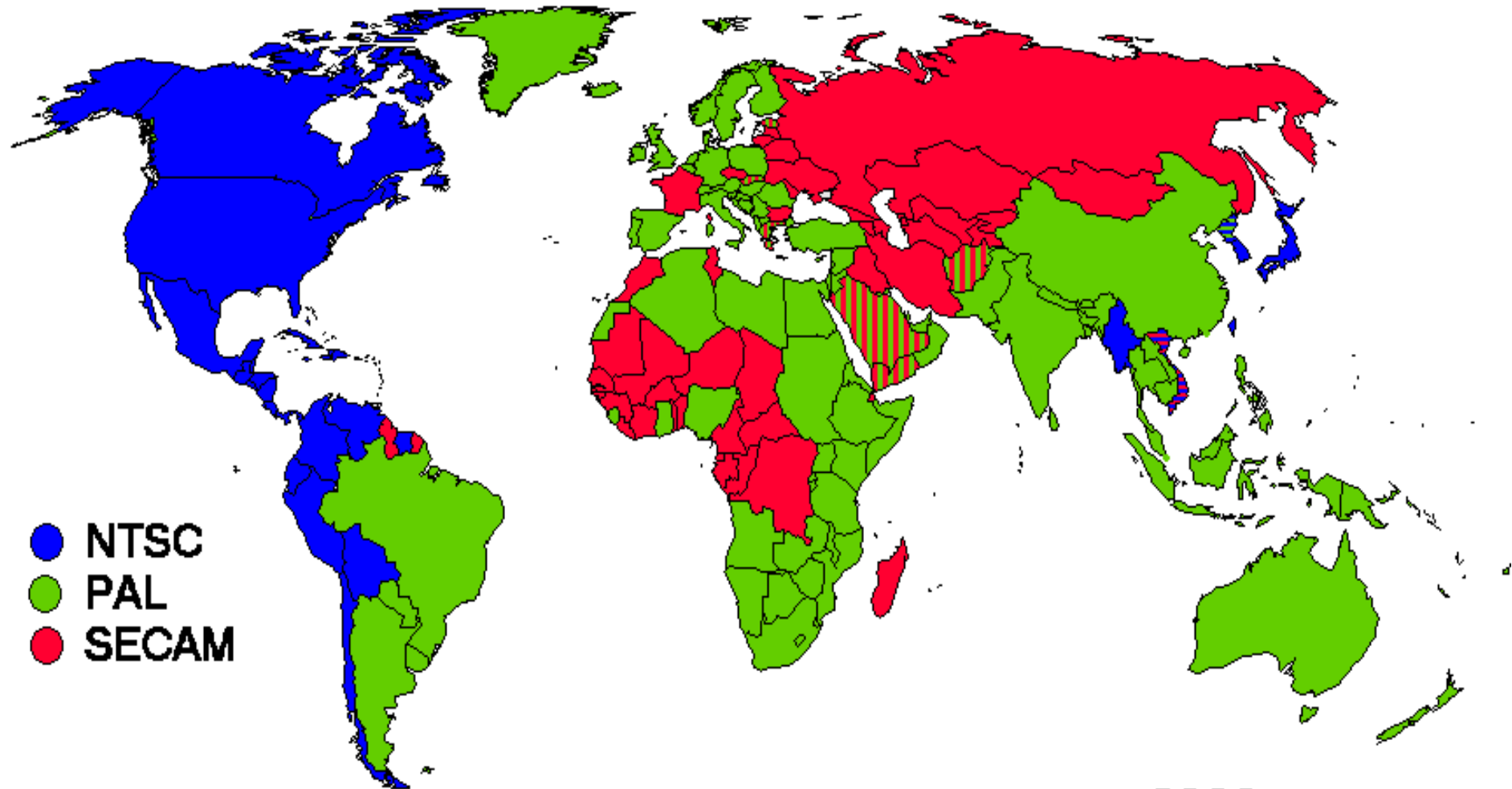
COMPOSITE VIDEO SIGNAL – NEGATIVE POLARITY



The whiter the scene, the lower the amplitude

In most TV systems, negative polarity is used.

COMMON TV SYSTEMS



Colour TV Systems of the World 2000

TELEVISION SYSTEMS / 01

NTSC STANDARD

(National Television Standards Committee)

- 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

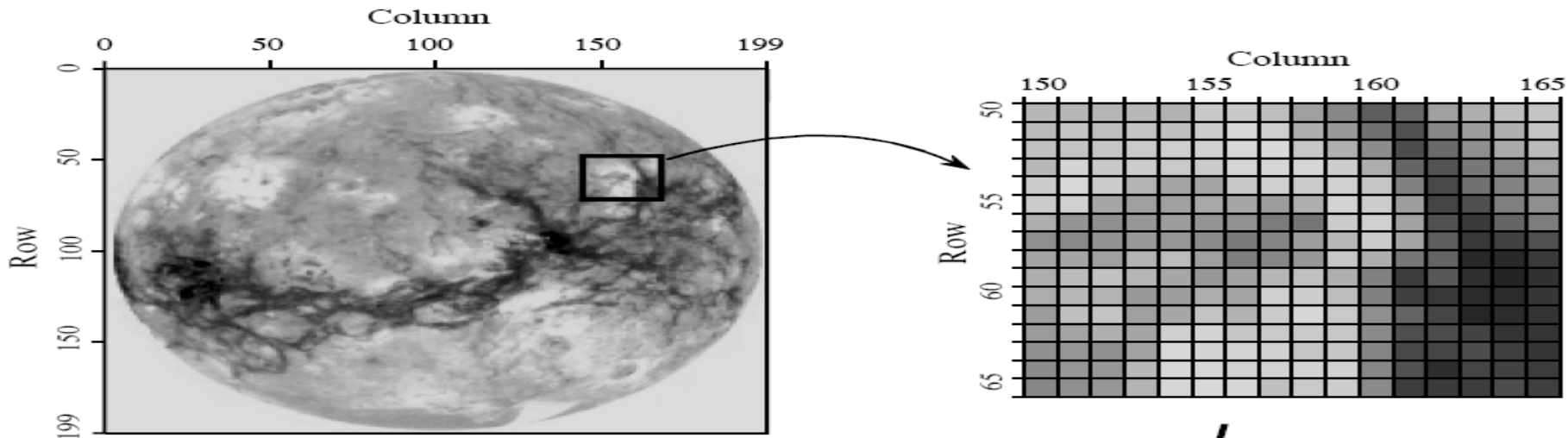
(Sequential Color and Memory)

- 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.

| | | Column | | | | | | | | | | | | | | | |
|-----|----|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | 150 | 155 | 160 | 165 | | | | | | | | | | | | |
| Row | 50 | 183 | 183 | 181 | 184 | 177 | 200 | 200 | 189 | 159 | 135 | 94 | 105 | 160 | 174 | 191 | 196 |
| | | 186 | 195 | 190 | 195 | 191 | 205 | 216 | 206 | 174 | 153 | 112 | 80 | 134 | 157 | 174 | 196 |
| | 55 | 194 | 196 | 198 | 201 | 206 | 209 | 215 | 216 | 199 | 175 | 140 | 77 | 106 | 142 | 170 | 186 |
| | | 184 | 212 | 200 | 204 | 201 | 202 | 214 | 214 | 214 | 205 | 173 | 102 | 84 | 120 | 134 | 159 |
| | | 202 | 215 | 203 | 179 | 165 | 165 | 199 | 207 | 202 | 208 | 197 | 129 | 73 | 112 | 131 | 146 |
| | 60 | 203 | 208 | 166 | 159 | 160 | 168 | 166 | 157 | 174 | 211 | 204 | 158 | 69 | 79 | 127 | 143 |
| | | 174 | 149 | 143 | 151 | 156 | 148 | 146 | 123 | 118 | 203 | 208 | 162 | 81 | 58 | 101 | 125 |
| | | 143 | 137 | 147 | 153 | 150 | 140 | 121 | 133 | 157 | 184 | 203 | 164 | 94 | 56 | 66 | 80 |
| | | 164 | 165 | 159 | 179 | 188 | 159 | 126 | 134 | 150 | 199 | 174 | 119 | 100 | 41 | 41 | 58 |
| | | 173 | 187 | 193 | 181 | 167 | 151 | 162 | 182 | 192 | 175 | 129 | 60 | 88 | 47 | 37 | 50 |
| | 65 | 172 | 184 | 179 | 153 | 158 | 172 | 163 | 207 | 205 | 188 | 127 | 63 | 56 | 43 | 42 | 55 |
| | | 156 | 191 | 196 | 159 | 167 | 195 | 178 | 203 | 214 | 201 | 143 | 101 | 69 | 38 | 44 | 52 |
| | | 154 | 163 | 175 | 165 | 207 | 211 | 197 | 201 | 201 | 199 | 138 | 79 | 76 | 67 | 51 | 53 |
| | | 144 | 150 | 143 | 162 | 215 | 212 | 211 | 209 | 197 | 198 | 133 | 71 | 69 | 77 | 63 | 53 |
| | | 140 | 151 | 150 | 185 | 215 | 214 | 210 | 210 | 211 | 209 | 135 | 80 | 45 | 69 | 66 | 60 |
| | | 135 | 143 | 151 | 179 | 213 | 216 | 214 | 191 | 201 | 205 | 138 | 61 | 59 | 61 | 77 | 63 |