

Video

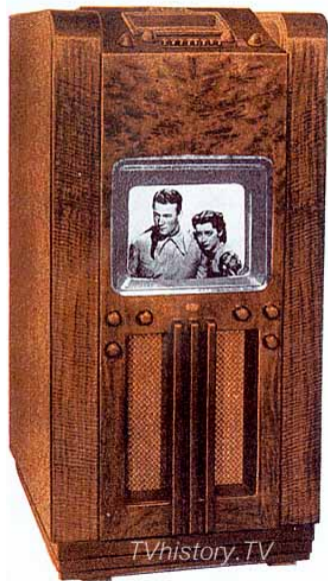
CSEE W4840

Prof. Stephen A. Edwards

Columbia University

Spring 2023

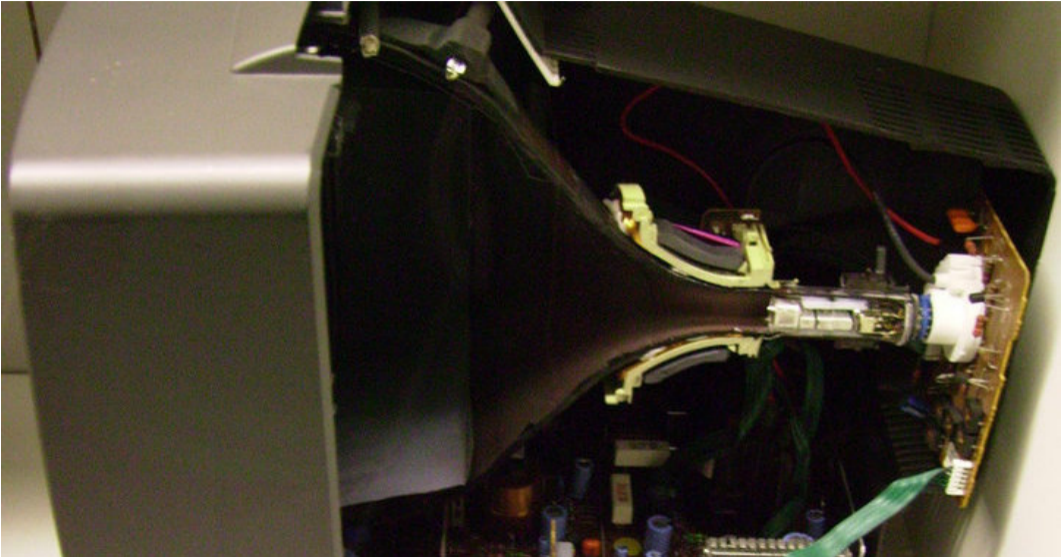
Television: 1939 Du Mont Model 181



The Model 181 is a high console model which provides television sight and sound entertainment with a selection of four (4) television channels. The black and white picture of pleasing contrast is reproduced on the screen of the 14 inch teletron, and measures 8 inches by 10 inches. The beautifully grained walnut cabinet of pleasing modern design measures 48 $\frac{5}{8}$ inches high, 23 inches wide and 26 inches deep. It is completely A.C., operated from standard 110 volt 60 cycle power lines. Twenty-two (22) tubes including the Du Mont Teletron are employed in the superhetrodyne circuit. A dynamic speaker is used for perfect sound reproduction. In addition, a three-band superhetrodyne all wave radio is provided for standard radio reception. This receiver employs 8 tubes, is completely A.C. operated from 110 volt 60 cycle power lines. Push button and manual tuning are provided. An individual dynamic speaker is used for broadcast sound reproduction.

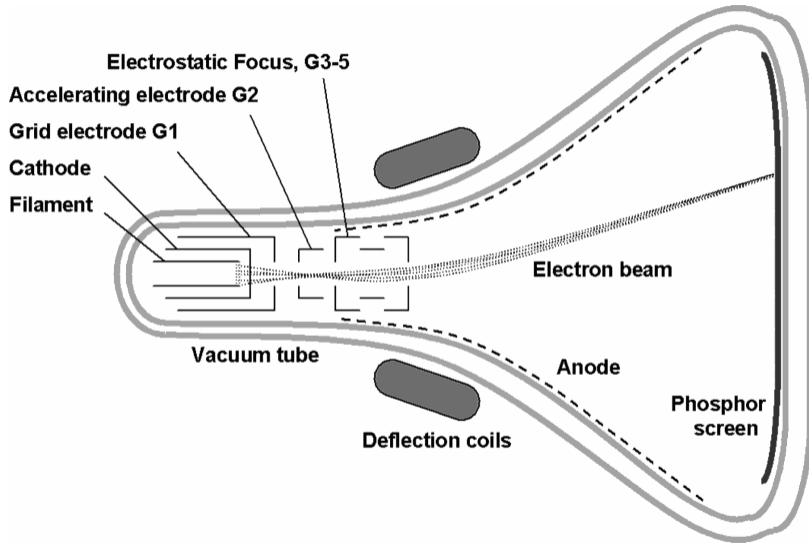
*Model
181*

Inside a CRT



London Science Museum/renaissancechambara

Inside a CRT



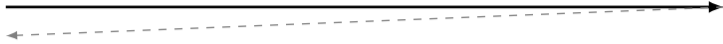
Vector Displays



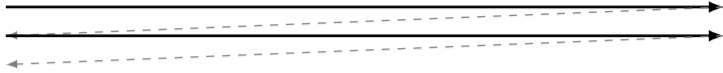
Raster Scanning



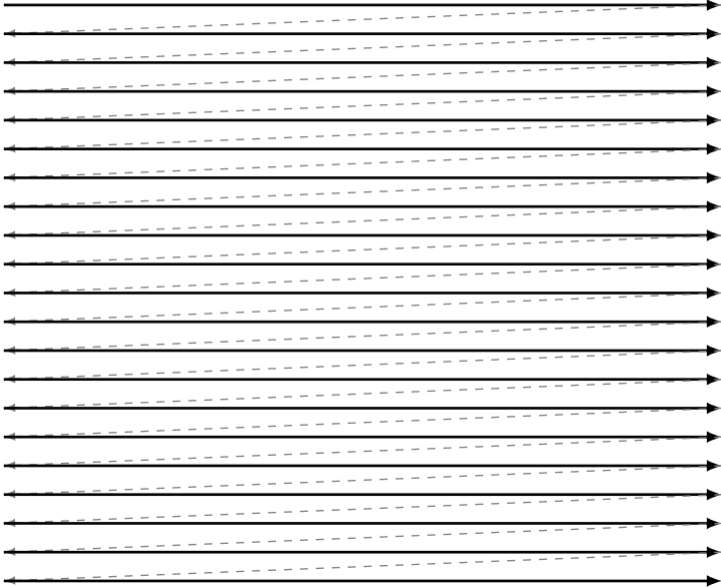
Raster Scanning



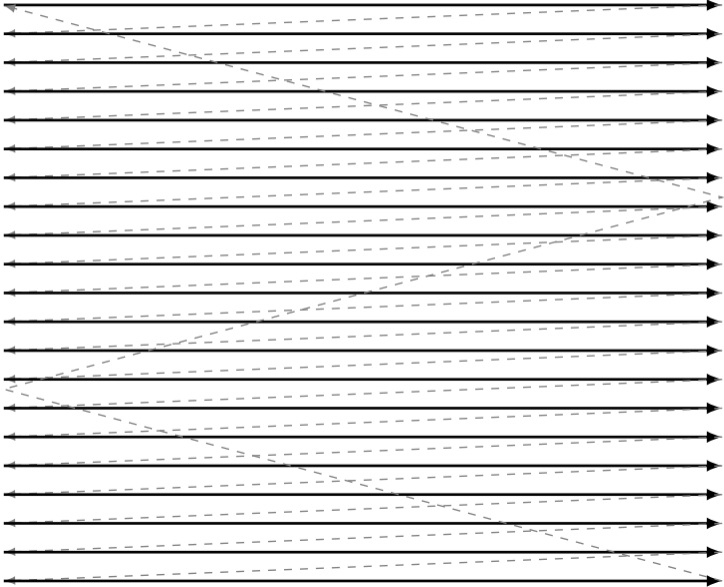
Raster Scanning



Raster Scanning



Raster Scanning



NTSC or RS-170

Originally black-and-white

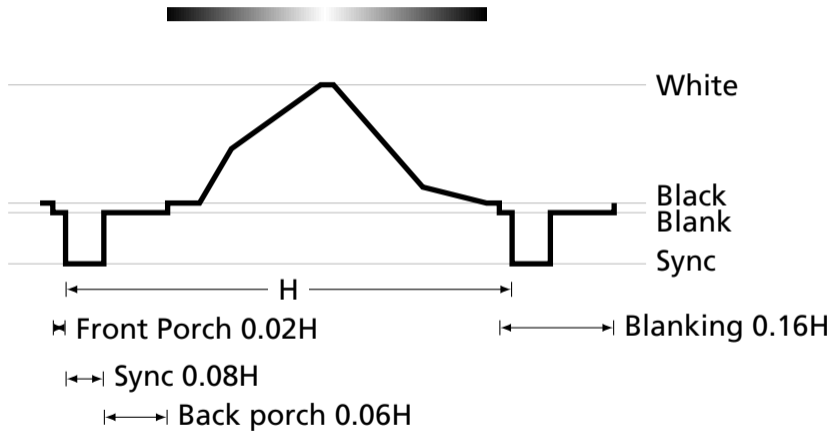
60 Hz vertical scan frequency

15.75 kHz horizontal frequency

$$\frac{15.75 \text{ kHz}}{60 \text{ Hz}} = 262.5 \text{ lines per field}$$

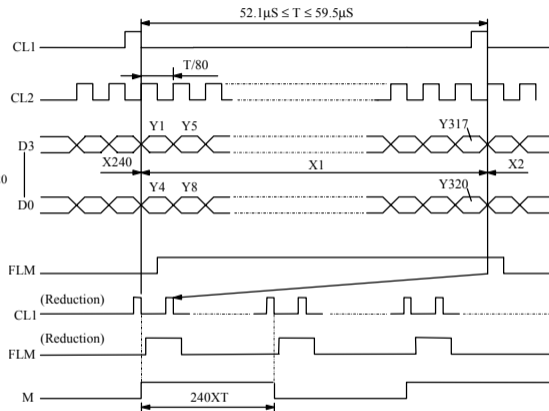
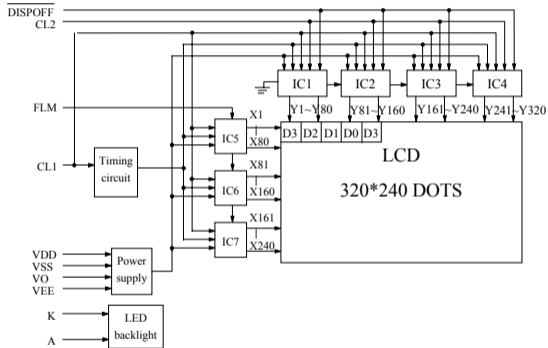
| | |
|-------|---------|
| White | 1 V |
| Black | 0.075 V |
| Blank | 0 V |
| Sync | - 0.4 V |

A Line of B&W Video



LCDs Also Use Raster Scanning

32F50 320 × 240 Monochrome LCD Module



4-bit parallel interface

CL2: word clock

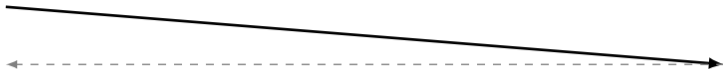
CL1: "horizontal sync"

FLM: "vertical sync"

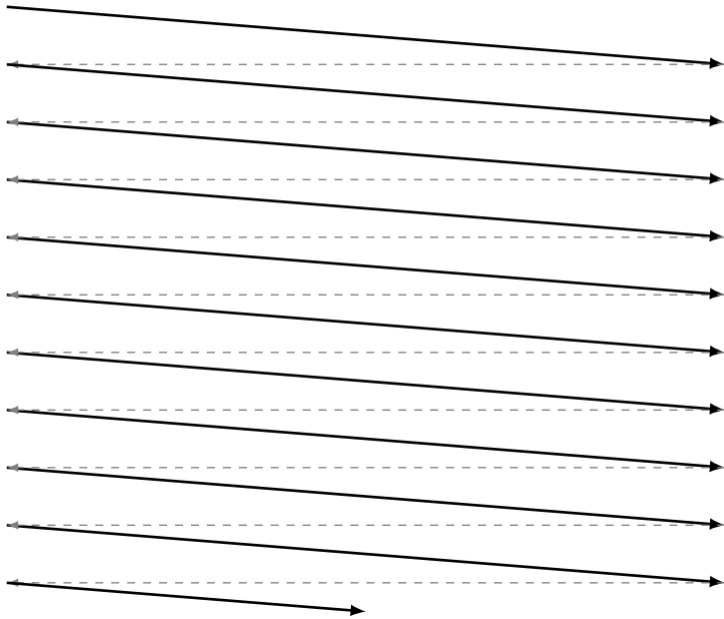
Interlaced Scanning



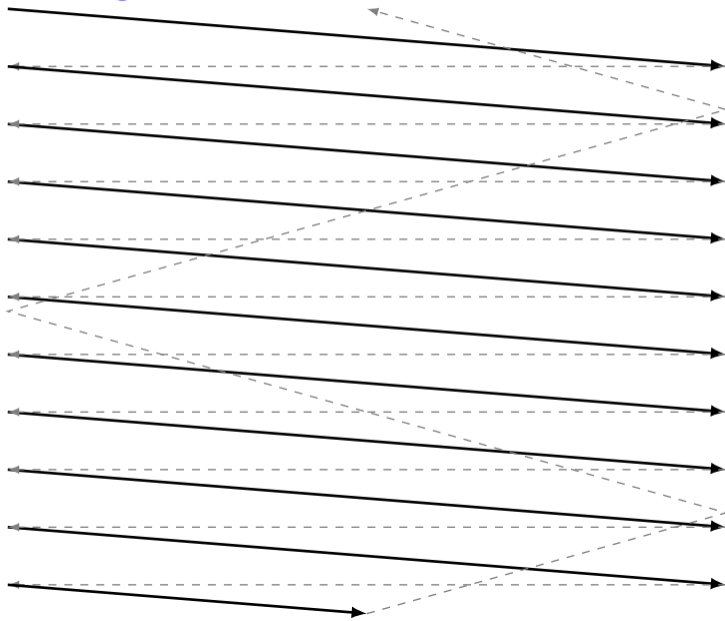
Interlaced Scanning



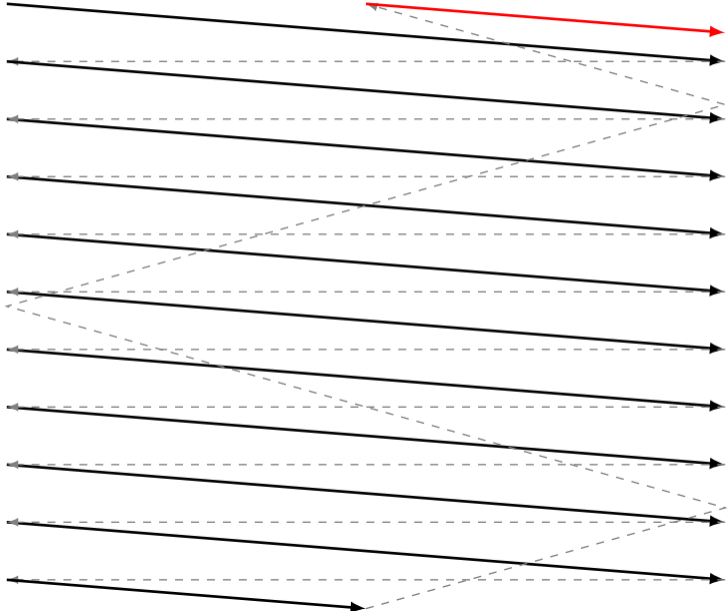
Interlaced Scanning



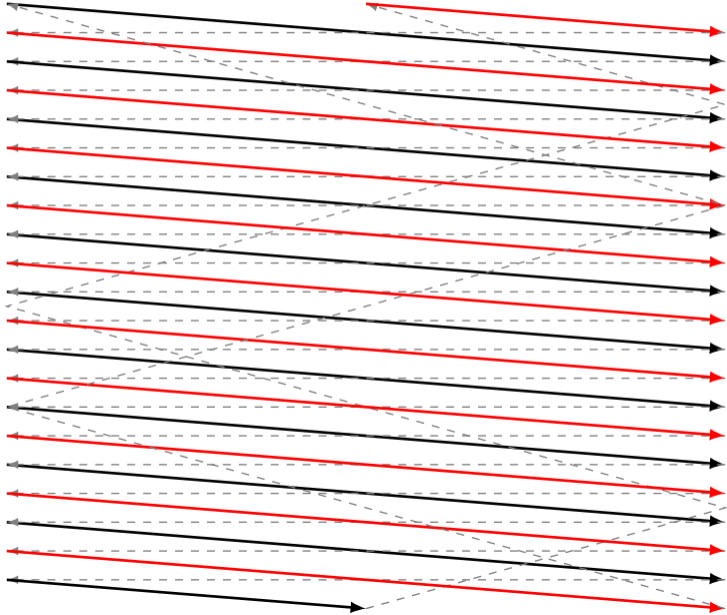
Interlaced Scanning



Interlaced Scanning



Interlaced Scanning



Color Television

Color added later: had to be backwards compatible.

Solution: continue to transmit a “black-and-white” signal and modulate two color “difference” signals on top of it

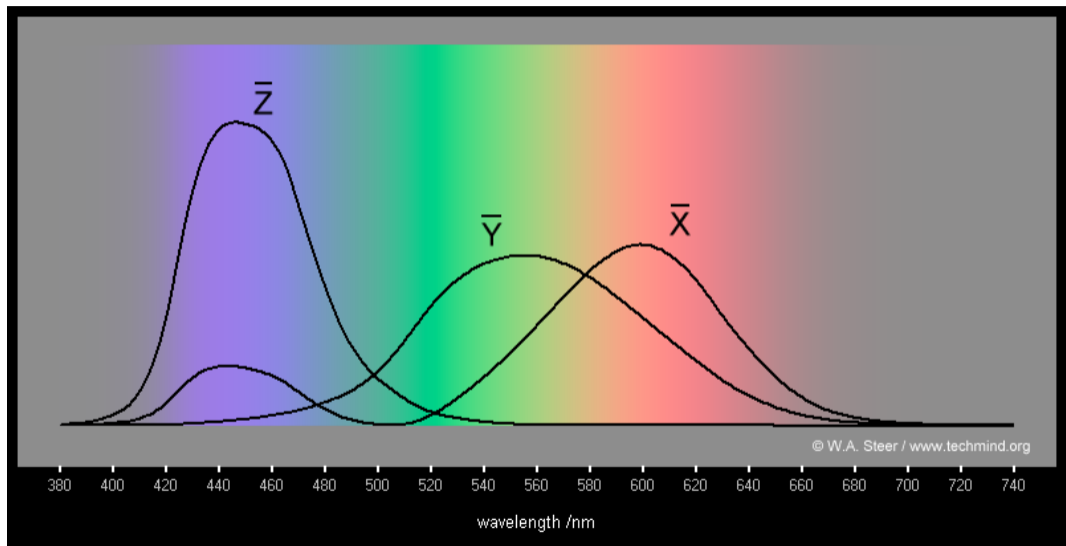
RGB vs. YIQ colorspaces

$$\begin{bmatrix} 0.30 & 0.59 & 0.11 \\ 0.60 & -0.28 & -0.32 \\ 0.21 & -0.52 & 0.31 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$

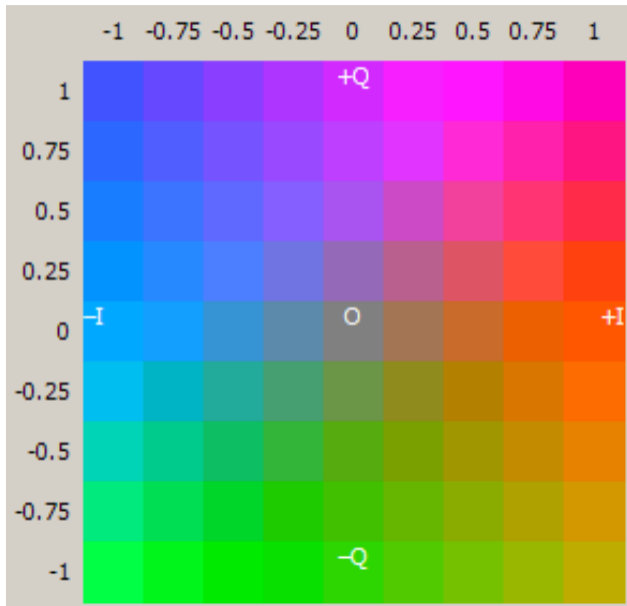
Y baseband 4 MHz “black-and-white” signal

I as 1.5 MHz, Q as 0.5 MHz at 90°: modulated at 3.58 MHz

CIE Color Matching Curves



YIQ color space with $Y=0.5$



International Standards

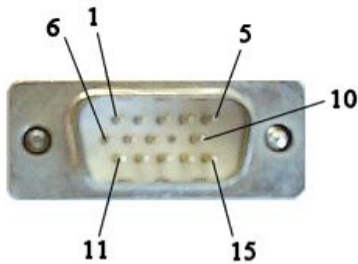
| | lines | active lines | vertical res. | aspect ratio | horiz. res. | frame rate |
|-------|-------|--------------|---------------|--------------|-------------|------------|
| NTSC | 525 | 484 | 242 | 4:3 | 427 | 29.94 Hz |
| PAL | 625 | 575 | 290 | 4:3 | 425 | 25 Hz |
| SECAM | 625 | 575 | 290 | 4:3 | 465 | 25 Hz |

PAL: Uses YUV instead of YIQ, flips phase of V every other line

SECAM: Transmits the two chrominance signals on alternate lines; no quadrature modulation

Computer Video: VGA

| | | | | |
|-----------|------------|-------------|-------------|-----------|
| 1 Red | 2 Green | 3 Blue | 4 ID2 | 5 GND |
| 6 RGND | 7 GGND | 8 BGND | 9 (+5V) | 10 GND |
| 11 ID0 | 12 ID1 | 13 hsync | 14 vsync | 15 ID3 |



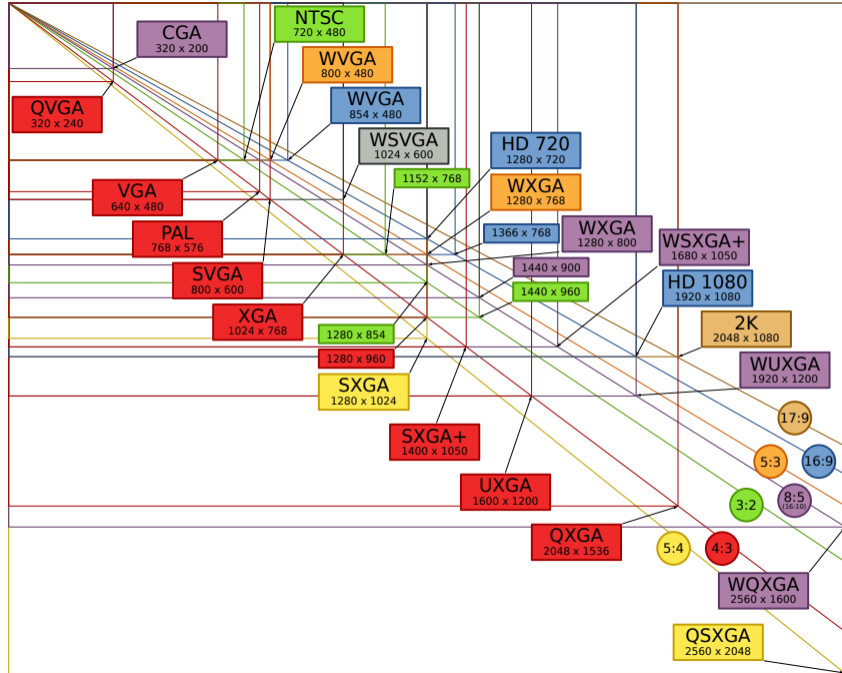
| | | | |
|------------|------------|------------|---------------------------------|
| ID2 | ID0 | ID1 | |
| - | - | GND | Monochrome, $< 1024 \times 768$ |
| - | GND | - | Color, $< 1024 \times 768$ |
| GND | GND | - | Color, $\geq 1024 \times 768$ |

DDC1 ID2 Data from display
vsync also data clock

DDC2 ID1 I²C SDA
ID3 I²C SLC

VGA Timing

| Mode | Resolution | Vertical | Horizontal | Pixel Clock |
|-------|------------|----------|------------|-------------|
| VGA | 640×350 | 70 Hz | 31.5 kHz | 25.175 MHz |
| VGA | 640×400 | 70 Hz | 31.5 kHz | 25.175 MHz |
| VGA | 640×480 | 59.94 Hz | 31.469 kHz | 25.175 MHz |
| SVGA | 800×600 | 56 Hz | 35.2 kHz | 36 MHz |
| SVGA | 800×600 | 60 Hz | 37.8 kHz | 40 MHz |
| SVGA | 800×600 | 72 Hz | 48.0 kHz | 50 MHz |
| XGA | 1024×768 | 60 Hz | 48.5 kHz | 65 MHz |
| SXGA | 1280×1024 | 61 Hz | 64.2 kHz | 110 MHz |
| HDTV | 1920×1080i | 60 Hz | | |
| UXGA | 1600×1200 | 60 Hz | 75 kHz | 162 MHz |
| UXGA | 1600×1200 | 85 Hz | 105.77 kHz | 220 MHz |
| WUXGA | 1920×1200 | 70 Hz | 87.5 kHz | 230 MHz |



Detailed VGA Timing

640 × 480, "60 Hz"

25.175 MHz Dot Clock
31.469 kHz Line Frequency
59.94 Hz Field Frequency

| Pixels | Role |
|--------|-----------------|
| 8 | Front Porch |
| 96 | Horizontal Sync |
| 40 | Back Porch |
| 8 | Left border |
| 640 | Active |
| 8 | Right border |

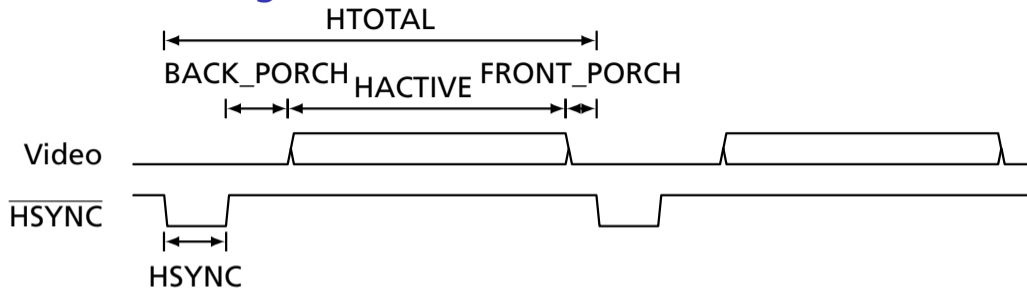
| | |
|-----|----------------|
| 800 | total per line |
|-----|----------------|

| Lines | Role |
|-------|---------------|
| 2 | Front Porch |
| 2 | Vertical Sync |
| 25 | Back Porch |
| 8 | Top Border |
| 480 | Active |
| 8 | Bottom Border |

| | |
|-----|-----------------|
| 525 | total per field |
|-----|-----------------|

Active-low Horizontal and Vertical sync signals.

Horizontal Timing



For a 25.175 MHz pixel clock,

| | |
|-------------|-----------|
| HSYNC | 96 pixels |
| BACK_PORCH | 48 |
| HACTIVE | 640 |
| FRONT_PORCH | 16 |
| <hr/> | |
| HTOTAL | 800 |