

# Video

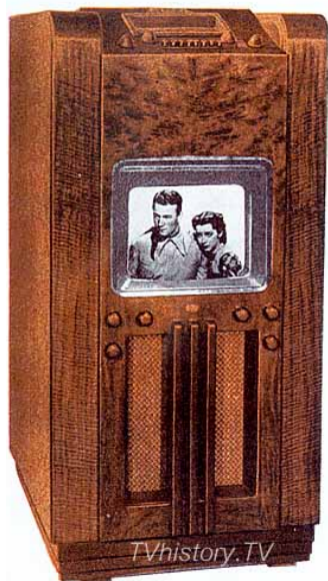
CSEE W4840

Prof. Stephen A. Edwards

Columbia University

Spring 2022

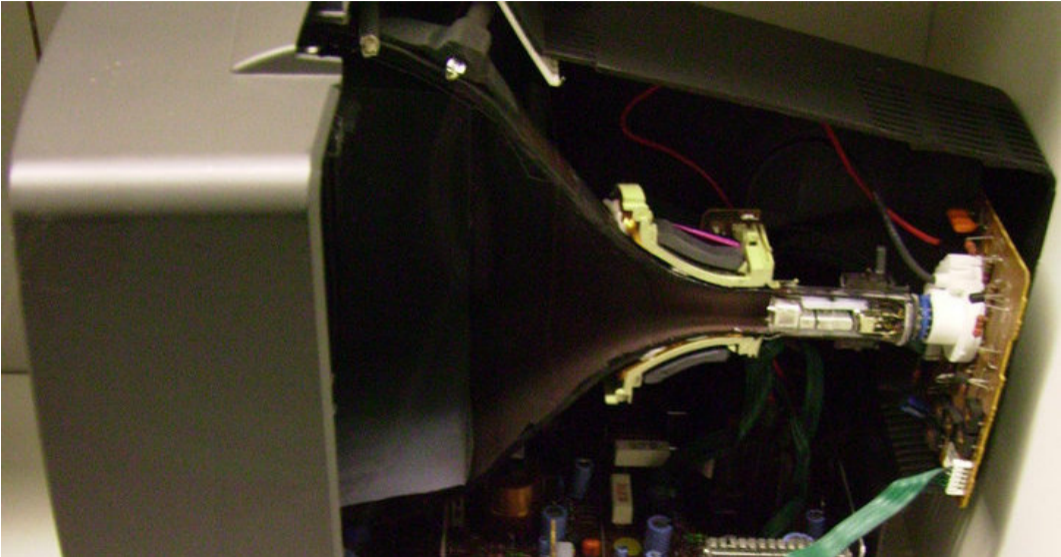
## Television: 1939 Du Mont Model 181



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.

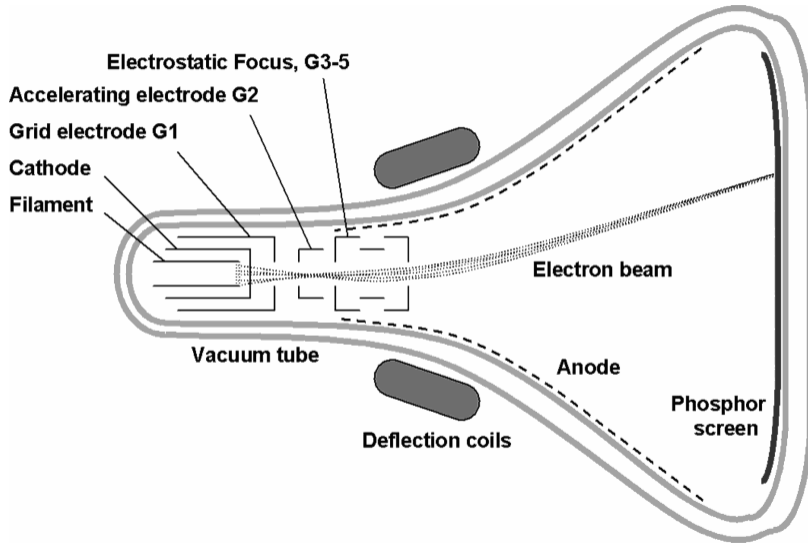
*Model  
181*

# Inside a CRT



London Science Museum/renaissancechambara

# Inside a CRT



# Vector Displays



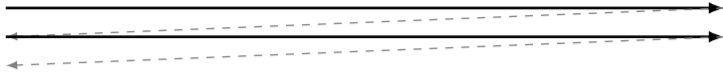
# Raster Scanning



# Raster Scanning

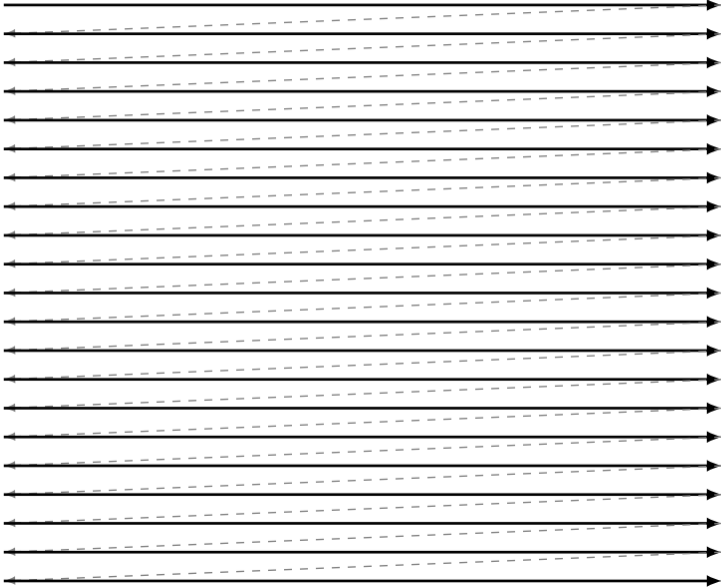


# Raster Scanning

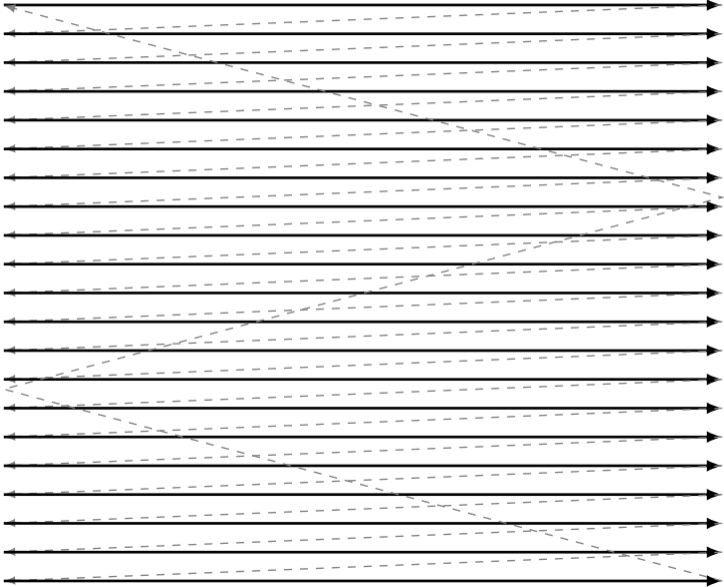




# Raster Scanning



# Raster Scanning



## NTSC or RS-170

Originally black-and-white

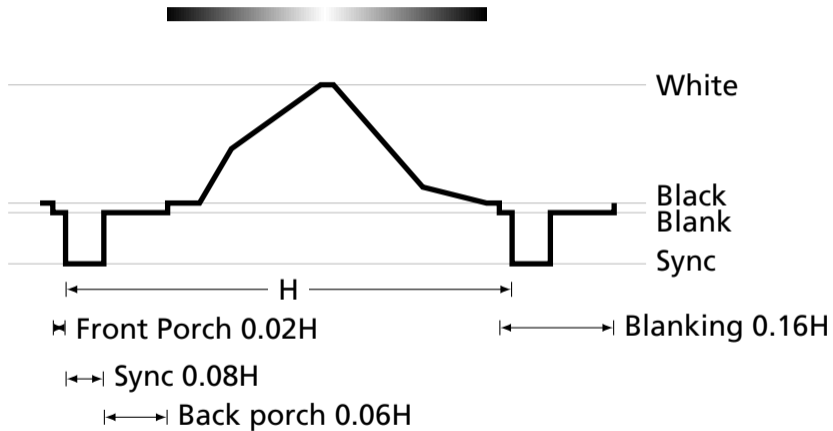
60 Hz vertical scan frequency

15.75 kHz horizontal frequency

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

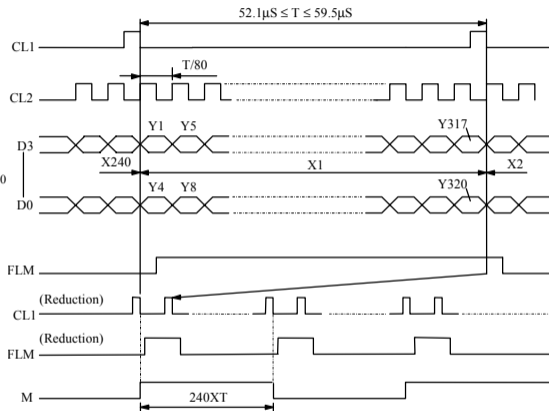
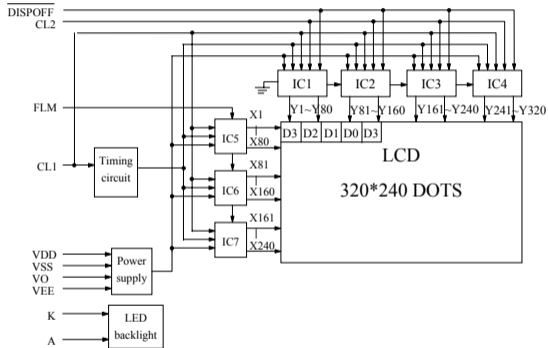
|       |         |
|-------|---------|
| White | 1 V     |
| Black | 0.075 V |
| Blank | 0 V     |
| Sync  | - 0.4 V |

# A Line of B&W Video



# LCDs Also Use Raster Scanning

## 32F50 320 × 240 Monochrome LCD Module



4-bit parallel interface

CL2: word clock

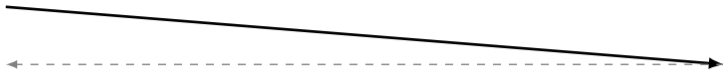
CL1: "horizontal sync"

FLM: "vertical sync"

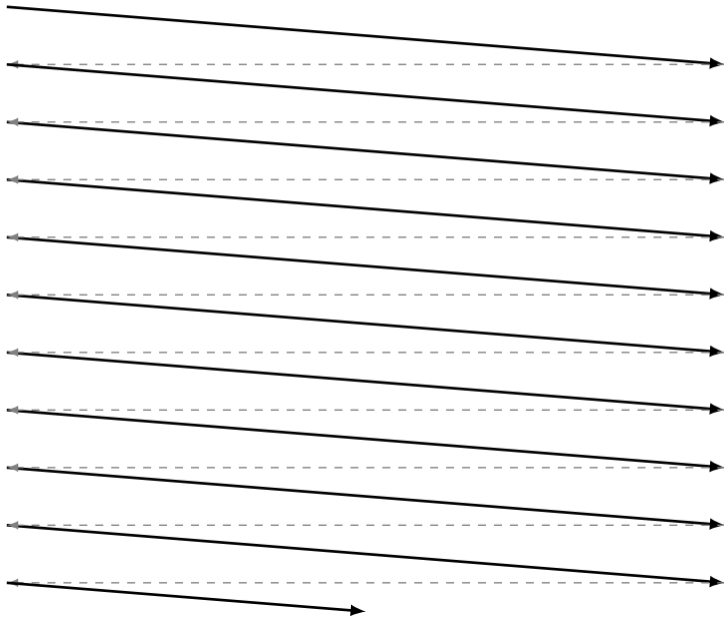
# Interlaced Scanning



# Interlaced Scanning

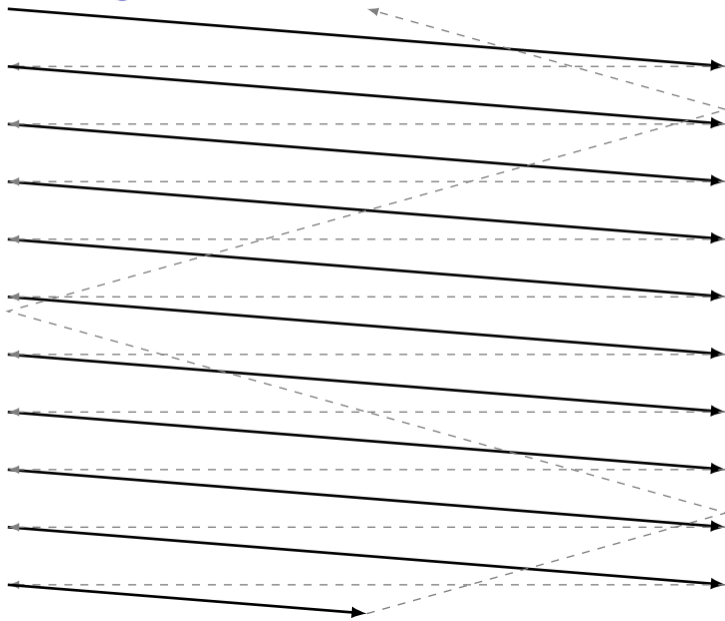


# Interlaced Scanning

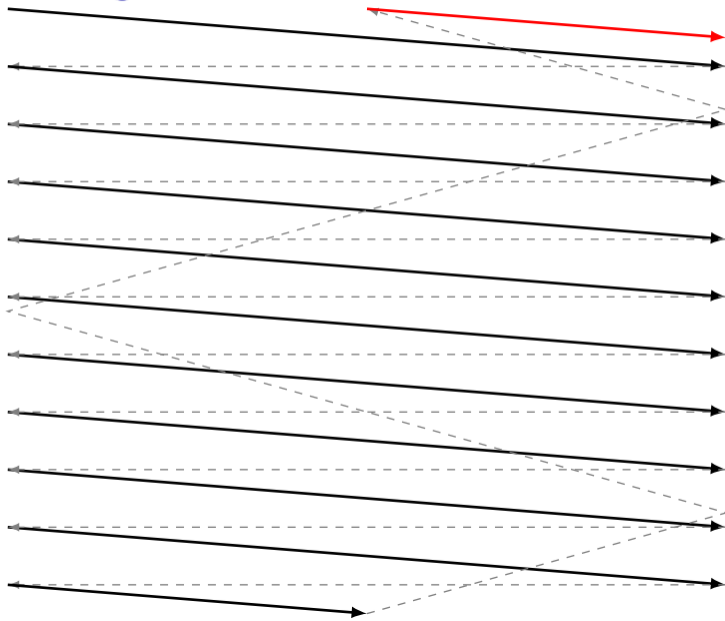




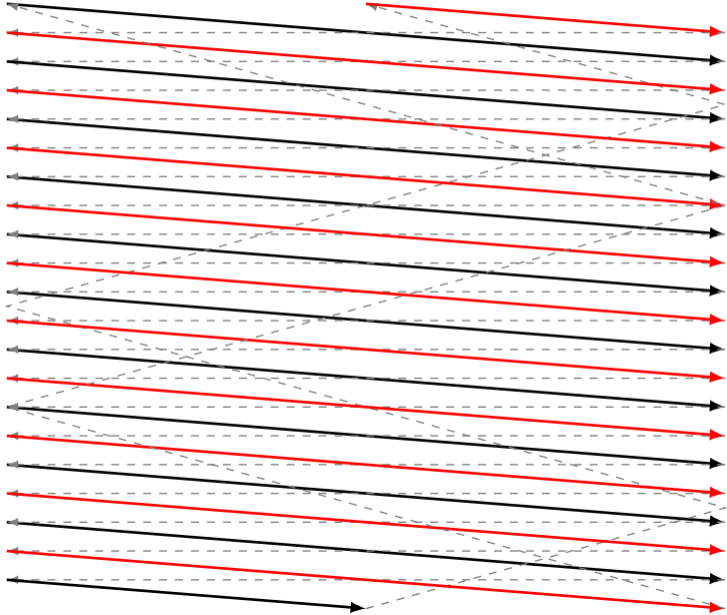
# Interlaced Scanning



# 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

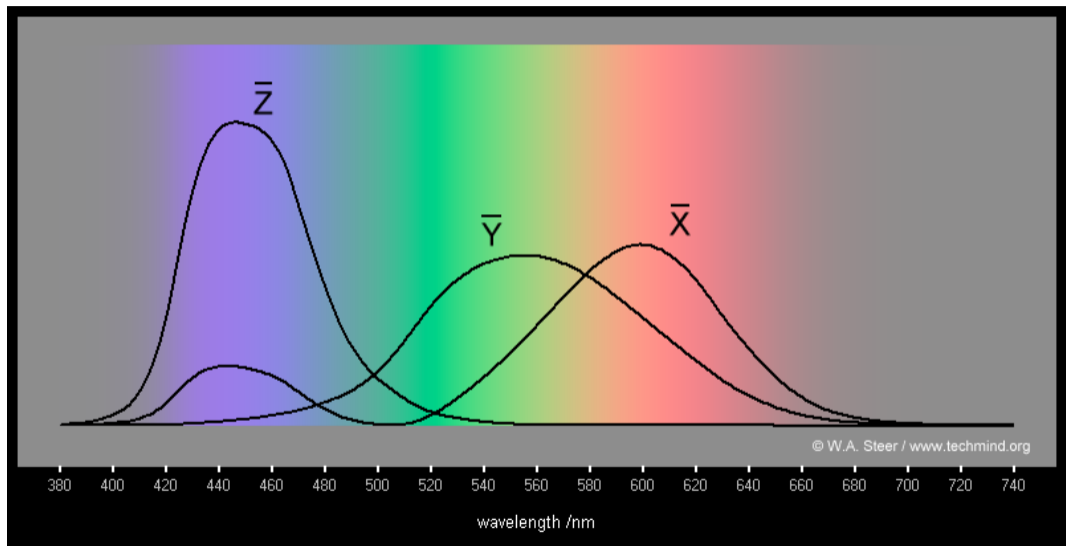
RGB vs. YIQ colorspaces

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

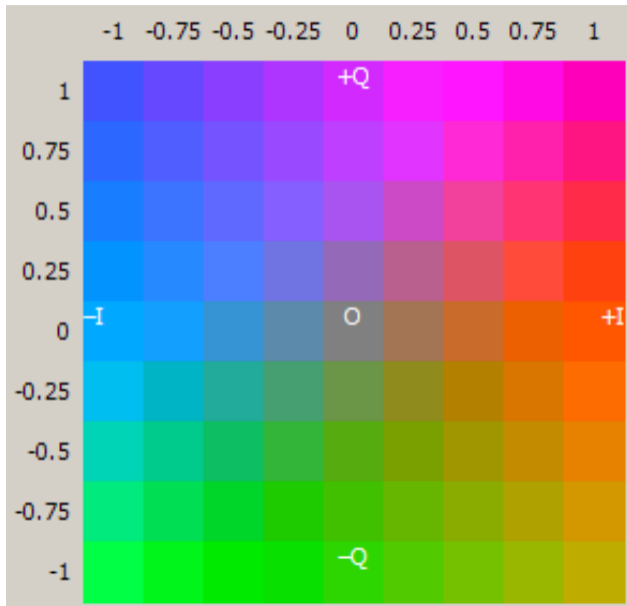
Y baseband 4 MHz “black-and-white” signal

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

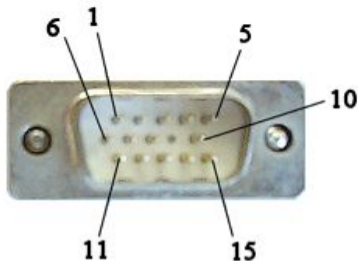
|       | lines | active lines | vertical res. | aspect ratio | horiz. res. | frame rate |
|-------|-------|--------------|---------------|--------------|-------------|------------|
| NTSC  | 525   | 484          | 242           | 4:3          | 427         | 29.94 Hz   |
| PAL   | 625   | 575          | 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<br>Red  | 2<br>Green | 3<br>Blue   | 4<br>ID2    | 5<br>GND  |
| 6<br>RGND | 7<br>GGND  | 8<br>BGND   | 9<br>(+5V)  | 10<br>GND |
| 11<br>ID0 | 12<br>ID1  | 13<br>hsync | 14<br>vsync | 15<br>ID3 |



|            |            |            |                        |
|------------|------------|------------|------------------------|
| <b>ID2</b> | <b>ID0</b> | <b>ID1</b> |                        |
| -          | -          | GND        | Monochrome, < 1024×768 |
| -          | GND        | -          | Color, < 1024×768      |
| GND        | GND        | -          | Color, ≥ 1024×768      |

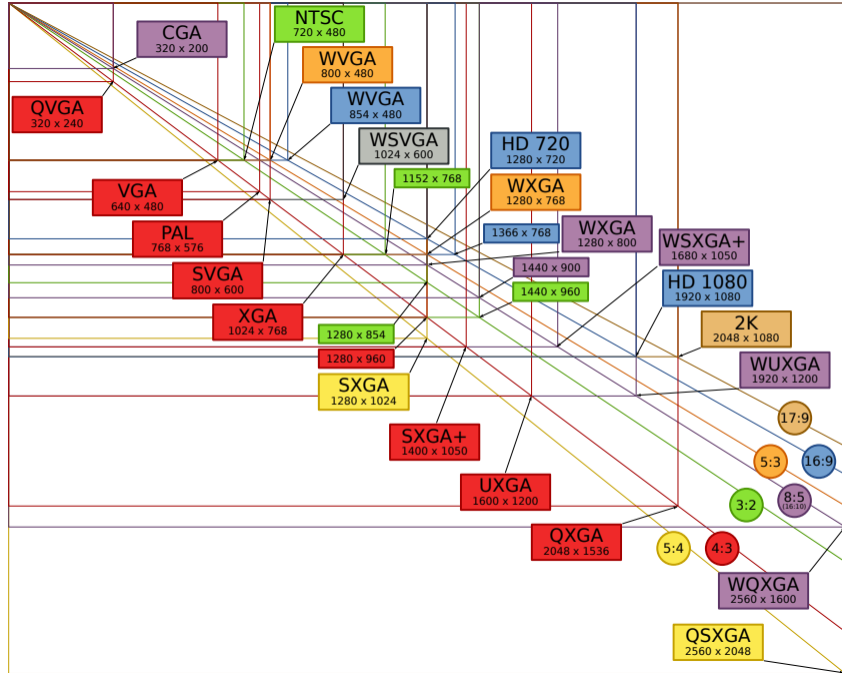
DDC1 ID2 Data from display  
vsync also data clock

DDC2 ID1 I<sup>2</sup>C SDA  
ID3 I<sup>2</sup>C 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"

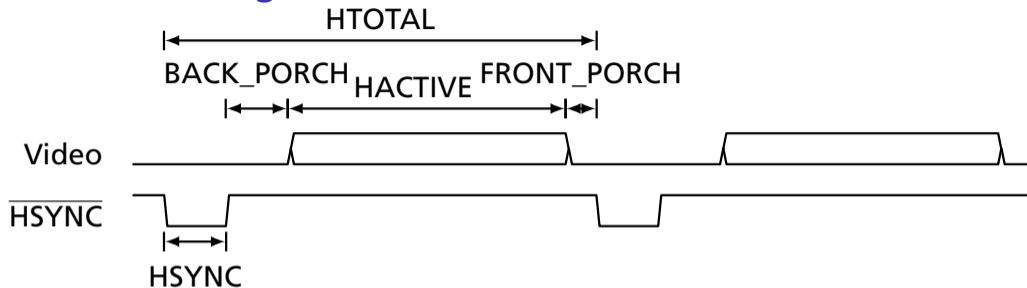
25.175 MHz Dot Clock  
31.469 kHz Line Frequency  
59.94 Hz Field Frequency

| 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       |