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\% 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.
Inside a CRT

Electrostatic Focus, G3-5
Accelerating electrode G2
Grid electrode G1
Cathode
Filament
Vacuum tube
Electron beam
Deflection coils
Anode
Phosphor screen
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

Front Porch 0.02H

Sync 0.08H

Back porch 0.06H

Blanking 0.16H
LCDs Also Use Raster Scanning

32F50 320 × 240 Monochrome LCD Module

4-bit parallel interface
CL2: word clock
CL1: “horizontal 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 signals on top of it.
RGB vs. YIQ colorspace

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

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
YIQ color space with Y=0.5
International Standards

<table>
<thead>
<tr>
<th></th>
<th>lines</th>
<th>active lines</th>
<th>vertical res.</th>
<th>aspect ratio</th>
<th>horiz. res.</th>
<th>frame rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTSC</td>
<td>525</td>
<td>484</td>
<td>242</td>
<td>4:3</td>
<td>427</td>
<td>29.94 Hz</td>
</tr>
<tr>
<td>PAL</td>
<td>625</td>
<td>575</td>
<td>290</td>
<td>4:3</td>
<td>425</td>
<td>25 Hz</td>
</tr>
<tr>
<td>SECAM</td>
<td>625</td>
<td>575</td>
<td>290</td>
<td>4:3</td>
<td>465</td>
<td>25 Hz</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Green</td>
<td>Blue</td>
<td>ID2</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>RGND</td>
<td>GGND</td>
<td>BGND</td>
<td>(+5V)</td>
<td>GND</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>ID0</td>
<td>ID1</td>
<td>hsync</td>
<td>vsync</td>
<td>ID3</td>
</tr>
</tbody>
</table>

**ID2** | **ID0** | **ID1**
---|---|---
- | - | GND
- | GND | -
GND | GND | -

Monochrome, $< 1024 \times 768$
Color, $< 1024 \times 768$
Color, $\geq 1024 \times 768$

DDC1
ID2 Data from display
vsync also data clock

DDC2
ID1 I$^2$C SDA
# VGA Timing

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

- QVGA 320 x 240
- VGA 640 x 480
- PAL 768 x 576
- SVGA 800 x 600
- XGA 1024 x 768
- SXGA 1280 x 1024
- SXGA+ 1400 x 1050
- NTSC 720 x 480
- WVGA 800 x 480
- WVGA 854 x 480
- WSVGA 1024 x 600
- HD 720 1280 x 720
- WXGA 1280 x 768
- WXGA 1280 x 800
- WSXGA+ 1680 x 1050
- HD 1080 1920 x 1080
- 2K 2048 x 1080
- WUXGA 1920 x 1200
- UXGA 1600 x 1200
- QXGA 2048 x 1536
- SXGA+ 1400 x 1050
- UXGA 1600 x 1200
- WAUXA 1920 x 1200
- 2K 2048 x 1080
- 17:9
- 5:3
- 16:9
- 8:5
- 16:10
- 16:9
- 4:3
- 3:2
- 5:3
Detailed VGA Timing

640 × 480, "60 Hz"

<table>
<thead>
<tr>
<th>Pixels</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Front Porch</td>
</tr>
<tr>
<td>96</td>
<td>Horizontal Sync</td>
</tr>
<tr>
<td>40</td>
<td>Back Porch</td>
</tr>
<tr>
<td>8</td>
<td>Left border</td>
</tr>
<tr>
<td>640</td>
<td>Active</td>
</tr>
<tr>
<td>8</td>
<td>Right border</td>
</tr>
<tr>
<td>800</td>
<td>total per line</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lines</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Front Porch</td>
</tr>
<tr>
<td>2</td>
<td>Vertical Sync</td>
</tr>
<tr>
<td>25</td>
<td>Back Porch</td>
</tr>
<tr>
<td>8</td>
<td>Top Border</td>
</tr>
<tr>
<td>480</td>
<td>Active</td>
</tr>
<tr>
<td>8</td>
<td>Bottom Border</td>
</tr>
<tr>
<td>525</td>
<td>total per field</td>
</tr>
</tbody>
</table>

Active-low Horizontal and Vertical sync signals.
For a 25.175 MHz pixel clock,

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSYNC</td>
<td>96 pixels</td>
</tr>
<tr>
<td>BACK_PORCH</td>
<td>48</td>
</tr>
<tr>
<td>HACTIVE</td>
<td>640</td>
</tr>
<tr>
<td>FRONT_PORCH</td>
<td>16</td>
</tr>
<tr>
<td>HTOTAL</td>
<td>800</td>
</tr>
</tbody>
</table>