Television: 1939 Du Mont Model 181

The Model 181 is a high-quality radio which provides television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc. The Model 181 was a high-quality radio which provided television signals and sound transmission. It was produced by the firm of Du Mont under license from CBS, Inc.

Vector Displays

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
**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 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
International Standards

Computer Video: VGA

VGA Timing

Mode | Resolution | Vertical | Horizontal | Pixel Clock
--- | --- | --- | --- | ---
VGA | 640x480 | 70 Hz | 31.5 kHz | 25.175 MHz
VGA | 640x400 | 70 Hz | 31.5 kHz | 25.175 MHz
VGA | 640x480 | 59.94 Hz | 31.469 kHz | 25.175 MHz
SVGA | 800x600 | 56 Hz | 37.8 kHz | 40 MHz
SVGA | 800x600 | 60 Hz | 37.8 kHz | 40 MHz
SVG | 800x600 | 72 Hz | 48.0 kHz | 50 MHz
XGA | 1024x768 | 60 Hz | 48.5 kHz | 65 MHz
SXGA | 1280x1024 | 61 Hz | 64.2 kHz | 110 MHz
HDTV | 1920x1080 | 60 Hz |  |  
UXGA | 1600x1200 | 70 Hz | 105.77 kHz | 220 MHz
WUXGA | 1920x1200 | 70 Hz | 87.5 kHz | 230 MHz

Detailed VGA Timing

Challenge: A white rectangle

Let's build a VHDL module that displays a 640 x 480 VGA raster with a white rectangle in the center against a blue background.

Horizontal Timing

Implementation: Interface

Constants
-- Horizontal position (0-800)
signal Hcount : std_logic_vector(9 downto 0);
-- Vertical position (0-524)
signal Vcount : std_logic_vector(9 downto 0);
signal EndOfLine, EndOfField : std_logic;

signal vga_hblank, vga_hsync, vga_vblank, vga_vsync : std_logic; -- Sync. signals

begin

HCounter : process (clk, reset) begin
if reset = '1' then
    Hcount <= (others => '0');
elsif clk'event and clk = '1' then
    if EndOfLine = '1' then
        Hcount <= (others => '0');
    else
        Hcount <= Hcount + 1;
    end if;
end if;
end process HCounter;

EndOfLine <= '1' when Hcount = HTOTAL - 1 else '0';

VCounter: process (clk, reset) begin
if reset = '1' then
    Vcount <= (others => '0');
elsif clk'event and clk = '1' then
    if EndOfLine = '1' then
        if EndOfField = '1' then
            Vcount <= (others => '0');
        else
            Vcount <= Vcount + 1;
        end if;
    end if;
end if;
end process VCounter;

EndOfField <= '1' when Vcount = VTOTAL - 1 else '0';

HSyncGen : process (clk, reset) begin
if reset = '1' then
    vga_hsync <= '1';
elsif clk'event and clk = '1' then
    if EndOfLine = '1' then
        vga_hsync <= '1';
    elsif Hcount = HSYNC - 1 then
        vga_hsync <= '0';
    end if;
end if;
end process HSyncGen;

HBlankGen : process (clk, reset) begin
if reset = '1' then
    vga_hblank <= '1';
elsif clk'event and clk = '1' then
    if Hcount = HSYNC + HBACK_PORCH then
        vga_hblank <= '0';
    elsif Hcount = HSYNC + HBACK_PORCH + HACTIVE then
        vga_hblank <= '1';
    end if;
end if;
end process HBlankGen;

VSyncGen : process (clk, reset) begin
if reset = '1' then
    vga_vsync <= '1';
elsif clk'event and clk = '1' then
    if EndOfLine = '1' then
        if EndOfField = '1' then
            vga_vsync <= '1';
        elsif Vcount = VSYNC - 1 then
            vga_vsync <= '0';
        end if;
    end if;
end if;
end process VSyncGen;

VBlankGen : process (clk, reset) begin
if reset = '1' then
    vga_vblank <= '1';
elsif clk'event and clk = '1' then
    if EndOfLine = '1' then
        if Vcount = VSYNC + VBACK_PORCH - 1 then
            vga_vblank <= '0';
        elsif Vcount = VSYNC + VBACK_PORCH + VACTIVE - 1 then
            vga_vblank <= '1';
        end if;
    end if;
end if;
end process VBlankGen;

rectangle <= rectangle_h and rectangle_v;

VideoOut: process (clk, reset) begin
if reset = '1' then
    VGA_R <= "0000000000";
end if;
end process VideoOut;

VGA_CLK <= clk;
VGA_HS <= not vga_hsync;
VGA_VS <= not vga_vsync;
VGA_SYNC <= '0';
VGA_BLANK <= not (vga_hsync or vga_vsync);
end rtl;