

Revision: March 28, 2008

Overview

The VGA Reference Component generates the signals to display an image on a standard VGA display. It can manage both 640x480 and 800x600 resolutions and is compatible with both CRT and LCD displays.

The VGA signals and timing described here refer to the electron beam scanning the screen of the CRT VGA display. The actual image is composed of a sequence of horizontal lines that are constantly refreshed.

The screen-refresh process begins at the top left corner and paints one pixel at a time from left to right. At the end of the first row, the row increments and the column address is reset to the first column. Once the entire screen has been painted, the refresh process begins again. The video signal redraws the screen 60 times per second. This refresh rate allows image motion and reduces screen flicker. Refresh rates higher than 60Hz are used in PC monitors.

Functional Description

The VGA component is structured in three sub-modules: the `vga_controller_640_60` manages the 640x480 resolution, the `vga_controller_800_60` manages the 800x600 resolution, and the `vga_selector` selects the correct outputs for each resolution. The two controllers work similarly.

The vertical and horizontal sync pulse signals (VS and HS) indicate the beginning of a new frame or row.

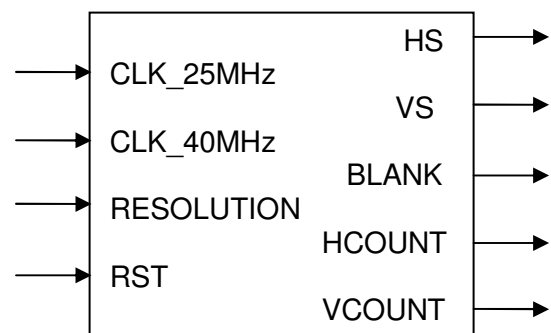


Figure 1
The VGA Component

The vertical sync signal tells the monitor to start displaying a new frame, and the monitor starts at the upper left corner with pixel (0,0). The horizontal sync signal tells the monitor to start displaying a new line from the left edge of the screen. While the beam is returning to the left column to start another horizontal scan, pixel data is not displayed and the RGB signals are all set to zero (the color black).

Port Definitions

<code>rst</code>	global reset signal
<code>clk_25MHz</code>	input, 25MHz clock signal generated by a DCM
<code>clk_40MHz</code>	input, 40MHz clock signal generated by a DCM
<code>resolution</code>	input, from <code>resolution_switcher</code> selects active resolution
<code>hs</code>	output, to monitor, selected horizontal sync signal
<code>vs</code>	output, to monitor, selected vertical sync signal
<code>blank</code>	output, to clients, selected blank signal
<code>hcount</code>	output, 11 bits, to clients, selected horizontal pixel counter
<code>vcount</code>	output, 11 bits, to clients, selected vertical lines counter

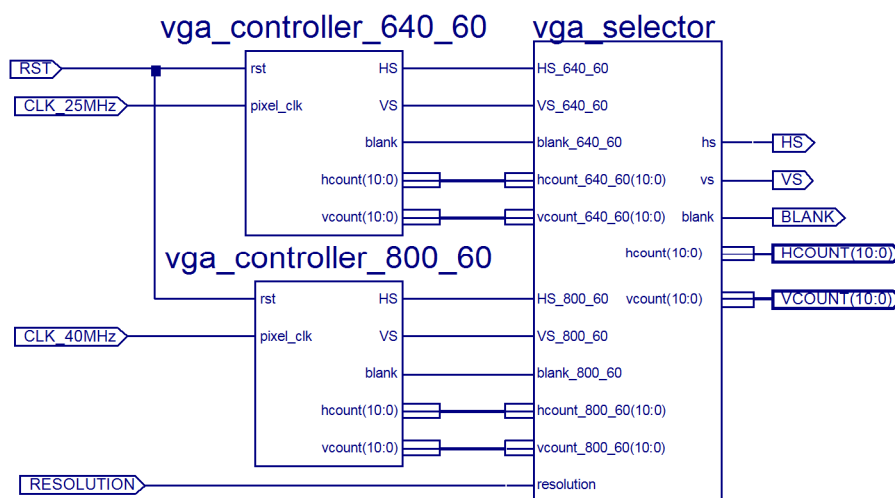


Figure 2
VGA Component Structure

The VGA Controller 640x480

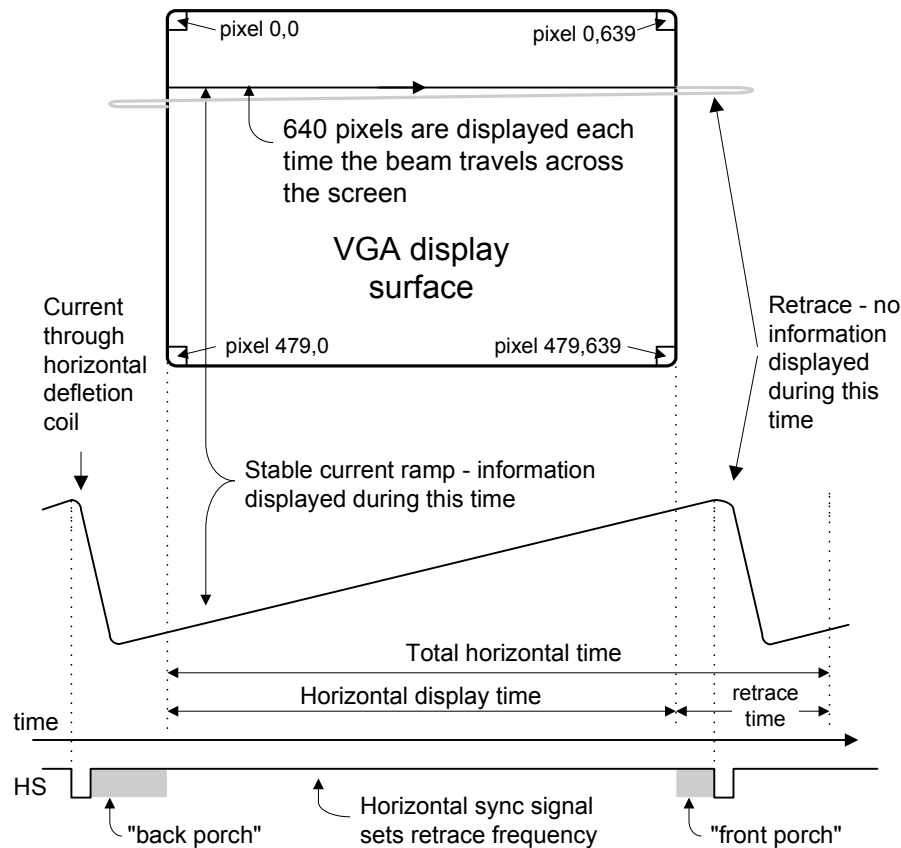
The vga_controller_640_60 uses a 25Mhz clock to generate the video sync pulses for the 640x480 60Hz mode. It also provides horizontal and vertical counters for the currently displayed pixel and a blank signal that is active when the pixel is not inside the visible screen (the color outputs are reset to 0).

The blank signal is delayed one pixel clock period (40ns) from when the pixel leaves the visible screen to account for the pixel pipeline delay. This delay happens because the color data does not arrive at the monitor pins at the same time as the counters indicating the currently displayed pixel (memory read delays, synchronization delays).

Timings for sync pulse width and front- and back-porch intervals are based on observations of VGA displays. Porch intervals are the pre- and post-sync pulse times during which information cannot be displayed. See Figure 3 for the signal timings.

Port Definitions for the VGA Controller 640x480

rst	global reset signal
pixel_clk	input, 25MHz clock signal generated by a DCM
HS	output, to monitor, horizontal sync pulse
VS	output, to monitor, vertical sync pulse
hcount	output, to clients, 11 bits, horizontal count of the currently displayed pixel (even if not in visible area)
vcount	output, to clients, 11 bits, vertical count of the currently active video line (even if not in visible area)
blank	output, to clients, active when pixel is not in visible area



Symbol	Parameter	Vertical Sync			Horizontal Sync	
		Time	Clocks	Lines	Time	Clocks
T_s	Sync pulse time	16.7ms	416,800	521	32 μ s	800
T_{disp}	Display time	15.36ms	384,000	480	25.6 μ s	640
T_{pw}	VS pulse width	64 μ s	1,600	2	3.84 μ s	96
T_{fp}	VS front porch	320 μ s	8,000	10	640 ns	16
T_{bp}	VS back porch	928 μ s	23,200	29	1.92 μ s	48

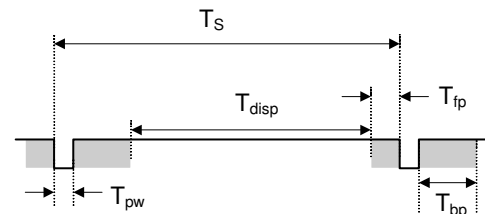


Figure 3
Timings for Sync Pulse (640X480 mode)

The VGA Controller 800x600

The vga_controller_800_60 uses a 25Mhz clock to generate the video sync pulses for the 800x600 60Hz mode. The functionality is similar to the vga_controller_640_60 component.

Port Definitions for the VGA Controller 800x600

rst	global reset signal
pixel_clk	input, 40MHz clock signal generated by a DCM
HS	output, to monitor, horizontal sync pulse
VS	output, to monitor, vertical sync pulse

hcount	output, to clients, 11 bits, horizontal count of the currently displayed pixel (even if not in visible area)
vcount	output, 11 bits, to clients, to clients, vertical count of the currently active video line (even if not in visible area)
blank	output, active when pixel is not in visible area

The VGA Selector

The vga_selector contains the logic that selects between the output of the VGA controllers depending on the resolution used. Depending on the input signal resolution, the output signals from the VGA controllers are selected and sent to other logic components in the design that need these outputs, or to the monitor. If the resolution pin is set high, the 800x600 resolution is selected and if low, the 640x480 resolution is selected.

Port Definitions for the VGA Selector

resolution	input, from resolution_switcher selects active resolution
HS_640_60	input, from vga_controller_640_60, if the horizontal sync signal for 640x480
VS_640_60	input, from vga_controller_640_60, vertical sync signal for 640x480
HS_800_60	input, from vga_controller_800_60, horizontal sync signal for 800x600
VS_800_60	input, from vga_controller_800_60, vertical sync signal for 800x600
blank_640_60	input, from vga_controller_640_60, blank signal for 640x480
blank_800_60	input, from vga_controller_800_60, blank signal for 800x600
hcount_640_60	input, 11 bits, from vga_controller_640_60, horizontal pixel counter for 640x480
hcount_800_60	input, 11 bits, from vga_controller_800_60, horizontal pixel counter for 800x600
vcount_640_60	input, 11 bits, from vga_controller_640_60, vertical lines counter for 640x480
vcount_800_60	input, 11 bits, from vga_controller_800_60, vertical lines counter for 800x600
hs	output, to monitor, selected horizontal sync signal
vs	output, to monitor, selected vertical sync signal
blank	output, to clients, selected blank signal
hcount	output, 11 bits, to clients, selected horizontal pixel counter
vcount	output, 11 bits, to clients, selected vertical lines counter