467 / Project 2-a

Purpose: The purpose of this assignment is three fold:

- Learn about the VGA interface by building a RAMDAC

Your assignment (for all of Project 2) is to build a VGA display card. This card will be very much like a VGA display adapter you might put into your computer in the late 1980's with the following differences:

- Instead of a PCI interface your card will have a serial interface. This serial interface will talk to a computer and you will write a small host program to send it some pixels.
- Your card will render to a 640x480 display but will use a 256x256 frame buffer (more on this later).
- Your card will have two frame buffers, an "on screen" and an "off screen" one.

Project 2 is split into two projects (Project 2-a and Project 2-b) each of which is a week in duration. Project 2-a is to build the VGA timing and memory-address generator, the DAC, and the connector. Project 2-b is all the rest.

Useful documentation:

http://www.epanorama.net/documents/pc/vga_timing.html

RAMDAC:

The RAMDAC component consists of two sub-components: (1) a timing component that clocks the screen and drives the I/O to the framebuffer, and (2) the DAC digital-to-analog converter. To do this project start with the first component and then the second.

Display to the screen involves generating 5 signals on a precisely timed clock. These signals are: vertical-sync (vsync), horizontal-sync (hsync), red, green and blue. For this class we will be using a black and white frame buffer so you can generate just three signals (vsync, hsync, and color). Two of the three signals are passed to the monitor in digital form (vsync and hsync), while color is an analog signal who's amplitude determines the brightness of the pixel being drawn. All of these signals must be generated according to the timing requirements of the display mode of the monitor. All display modes use a common signaling method. This is:

Vsync: [vblank][vfp][data][vbp]
Hsync: [hblank][hfp][data][hbp]
Color: [data]

The abbreviations stand for: vblank (vsync-blank), vfp (vsync-front-porch), vbp (vsync-back-porch), hblank (hsync-blank), hfp (hsync-front-porch), hbp (hsync-back-porch).

For the 640x480 display mode vsync and hsync should be held high except during vblank (for vsync) and hblank (for hsync). Drawing to the screen involves first starting a new frame by dropping vsync low for the vblank. Vsync is then held high for the rest of the frame. For each scanline of the frame hsync is dropped low for hblank and then held high for the remainder of the scan line. Finally, color is altered according to the pixel clock to set the brightness of each pixel. For our class we will use a master clock frequency of 50mhz, which when you divide by two is close enough to the pixel clock frequency of the 640x480 display mode (which is 25.1 something). You should look at the links provided above to determine the width of the vblank, vftp, vbp, hblank, hfp and hbp segments.

To test the RAMDAC without the framebuffer interface route the address bits of the pixel being accessed back into the data input bits of the RAMDAC. This will give you a nice vertical line pattern on the screen with which to test your DAC.

Route your digital output pins through a driver chip prior to the register DAC. This is for two reasons: It will isolate the FPGA from the analog DAC; thus incorrect wiring will only smoke the drive chip. It will restore the logic back up to 5v and drive sufficiently

There are several ways to build a DAC. The method we will use is to build something called an R-2R ladder DAC. Instead of using an output driver (an op-amp) to drive the screen after digital to analog conversion we will simplify the process a little and use a (digital) driver chip prior to the R-2R network. This works because the driver chip will drive between 0-5V and the color pin to the VGA interface should swing between 0-0.7V, hence we do not need an op-amp to amplify the drive voltage.

For R we will use 1% variation 59ohm resistors and for 2R we will use 1% 118ohm resistors. Normally we use 5% variation resistors in our circuits but we need a higher precision to achieve better color fidelity for our DAC.

You will need to build a VGA connector. There are a lot of ways to do this, but you will need to spend some time with the soldiering station.

Build and test your project. Your project is graded on a) seeing it work (you should get a nice vertical line pattern), and b) one-on-one interviews with.

For this project 2-a do not use any existing cores from the net, including those from opencores.org. Please build the timing stuff from scratch.