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FPGA Art

Project FPGA-Entwurfstechnik in winter term 2016/17

Features

- Paint images
- VGA output
- PS/2 Mouse input
- Different color palettes

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1 Introduction

This project develops a painting program on an *Altera Cyclone II* FPGA using the *Altera DE2 Development and Educational Board*.

The image output is provided by a VGA port with a resolution of 800×600 pixels, painting is done with a PS/2 mouse. Four different color palettes are available. The whole project is written in VHDL and completely implemented in hardware.

2 Overview

The design is divided logically into several modules as shown as in Figure 1. The modules are separately discussed further down.

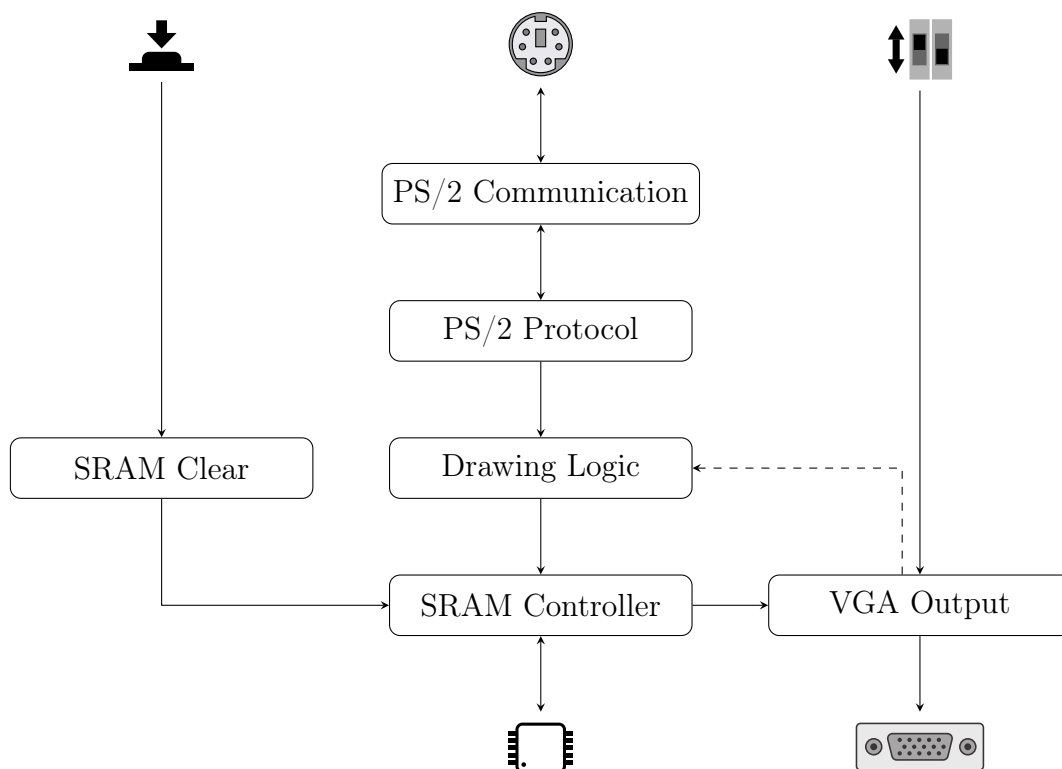


Figure 1: Block diagram of the modules and the external components, namely *push button*, *PS/2 port*, *switches*, *VGA port* and *SRAM* (clockwise from top left). The arrows indicate the flow of data (excluding control signals).

2.1 SRAM Controller

This asynchronous module manages the access to the physical SRAM. It exposes two ports: One port is for reading and writing, the other for reading only. The read-only port has priority over the second one, so if there is a request at that port, a possible request at the other port will be stalled.

2.2 VGA Output

The VGA Output module generates the video-signal for the monitor. It uses a 40 MHz clock to provide an output with a resolution of 800×600 pixels at 60 frames per second and a color

depth of 24 bit. The displayed cursor is rendered into the image at this module, too. It provides a port to read the current color under the cursor. Furthermore it can switch between several look-up tables for color encodings and display the color palette for the selected one. The overlay image shown on top of the palette is inserted also by this module. The image is read from a RAM block on the FPGA which is filled while programming the bitstream. A tool to convert arbitrary images (800×20) to a usable memory initialization file (mif) is included.

The pixel-pipeline consists of two steps: First the color index is either read from the SRAM, from the overlay or generated on the fly for the palette. The selected color is buffered in a register. In the same step the position of the current pixel is compared to the cursor position and the result is also buffered in a register. The second step of the pipeline consists of the LUT which converts the color index to a R, G and B value and an inverter which optionally inverts the color if the current position is within the cursor. The whole pipeline is shown in Figure 2.

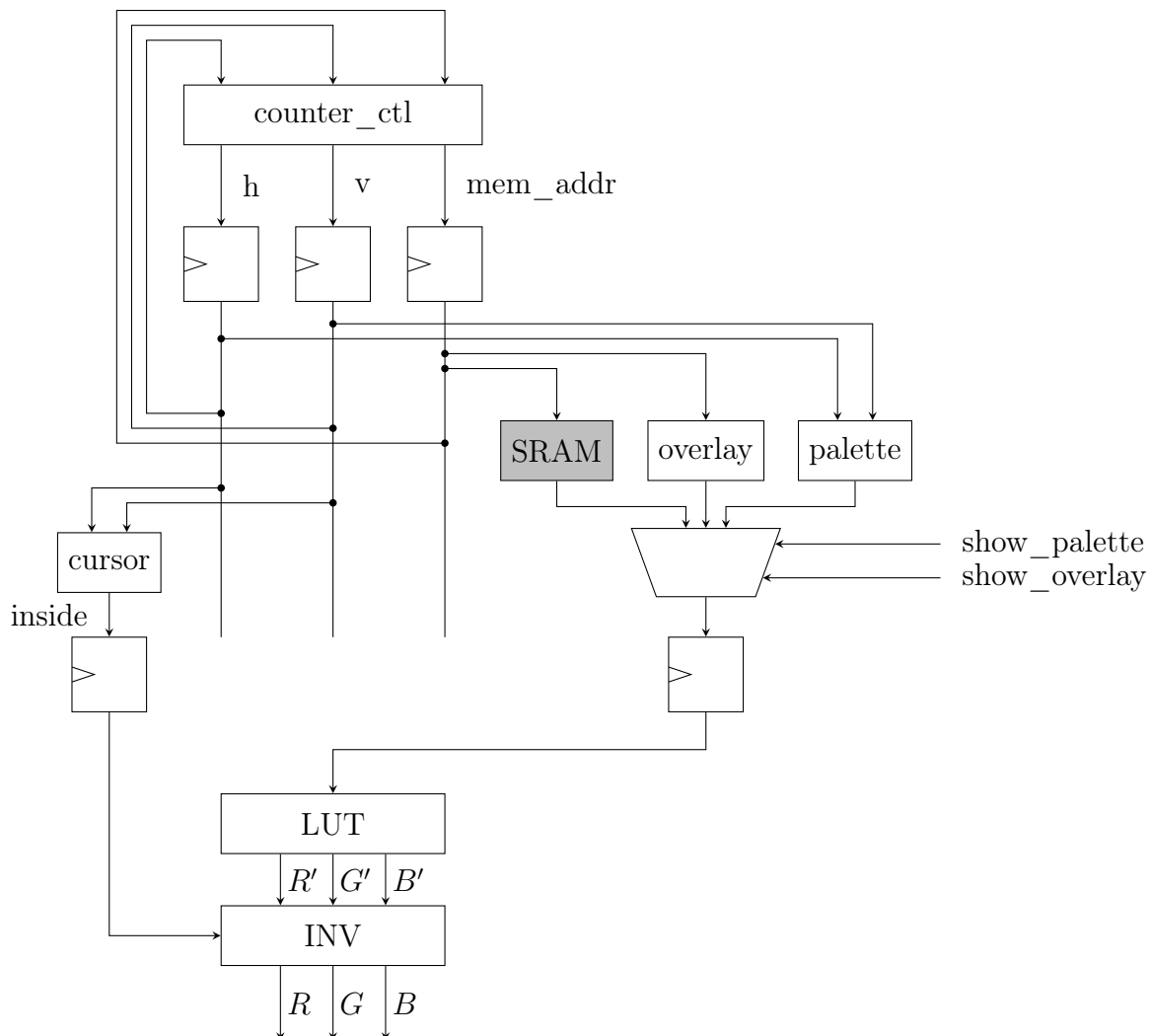


Figure 2: The pixel-pipeline in the VGA module.

2.3 PS/2 Communication

This module communicates with the hardware PS/2 mouse. It sends and receives single PS/2 packages and checks the parity. It is clocked with 200 kHz. A faster clock-rate leads to wrongly read values because the pull-up resistors of the PS/2 data and clock lanes are too weak to pull them up fast enough.

2.4 PS/2 Protocol

The PS/2 protocol module resets the mouse, sets it into streaming-mode and interprets the received PS/2 packages. It provides the current position of the cursor and the state of the mouse-buttons.

2.5 Drawing logic

This main-module connects most of the other modules for providing the drawing logic. As the mouse buttons change it will trigger the SRAM (for drawing) or the VGA (for color palette) modules accordingly.

2.6 SRAM Clear

While enabled, the SRAM Clear module resets the whole SRAM to zeros.

3 Quick Setup

1. Plug in the power cord of the DE2 Board.
2. Connect USB blaster to a computer.
3. Plug in the PS/2 Mouse¹ to the PS/2 port at the top right.
4. Connect the VGA-Port of the DE2 Board with the VGA Port of a monitor, which supports a resolution of 800×600 pixels at 60 Hz and turn on the monitor.
Optional: Tighten the screws of the VGA plug.
5. Turn on the DE2 Board by pressing the big red button.
6. Use the Quartus Programmer to program the bitstream onto the FPGA.
7. To clear the screen press KEY3 on the DE2 board.
8. Select your favorite color palette by switching SWITCH17 and SWITCH16 on the DE2 Board.
9. Press and hold the right mouse button to display the color palette and hover the mouse over the color you want to select and release the button.
10. Draw by holding down the left mouse button.
11. Repeat the last two steps until the image is complete.
12. Adore your painting.

¹**Notice:** Do not use a USB Mouse with a USB-to-PS/2-Adapter, it may permanently destroy the board!

4 Appendix

