2110264: Digital Design and Verification

1 Laboratory 8: External Hardware Control

Objectives

- Understand how to use FPGA to interface with external devices

- Understand serial communication

2 Description

One used of the FPGA is to interface with an external devices that require precising timing. In this lab, we will be looking at two devices: VGA (Display), and a serial communication (UART).

2.1 VGA

VGA protocol is designed when the computer monitors still used cathode ray tube (CRT) devices. In those time, most of the controls are actually analog. While FPGA cannot output the analog signal to control the VGA port directly, it can be used with a resistor ladder to create a simple digital to analog signal (DAC) (See `https://reference.digilentinc.com/basys3/refmanual`, VGA Port section) .

And due to the analog design of the VGA signal, it will also require precise timing. In this lab, you will be interfacing with the VGA and make some adjustments from the given code. The code is in MyCourseville. You can also get code and more information from `https://embeddedthoughts.com/2016/07/29/driving-a-vga-monitor-using-an-fpga/`

2.2 Universal Asynchronous Receiver/transmitter

Universal Asynchronous Receiver/transmitter or UART is a computer protocol that enable data transfer between two devices. UARTs are commonly used with the electrical layer standard such as TIA, RS-232, RS-422 or RS-485. The board you have in the lab has a UART port through the USB.

The minimal communication requirement by UART uses only two wires, `TX` and `RX`. Figure 1 shows a typical UART communication.

In order for a device to send the data out, both devices must use the same clock rate (baud), data bit size, parity and stop bits. `http://www.unm.edu/~zbaker/ece238/slides/UART.pdf` provides a good details on the protocol.

In order to communicate with the UART on the Basys 3 board, you will need to install some serial communication software such as Putty, Tera Term, etc. You can also find more information about the USB-UART Bridge on the Basys 3 in the reference manual.

3   Lab Problems

1. VGA: The first task is a very simple one, download the file from CourseVille, synthesis, and upload the code to the FPGA. Explain to TA what the program does.

2. VGA: Now, you can either rewrite your own code or change the existing code so that the board will display gradient between two colors setting by the switches. The gradient can be changed back and forth between horizontal to vertical via a push-button.

3. UART: You will be implementing a simple program that receive UART inputs, add one to each input character, then return to the UART. If you test this with a console. For example, if you type "abcde" in the console, you should receive "bcdef".

   You may choose any buadrate you would like to use. I recommend testing with 9600bps or 115200bps.

   You may also want to test the loopback, i.e. wiring TX and RX together.

4. Extra Credit: If you change b) so that it display Hue : The following color:

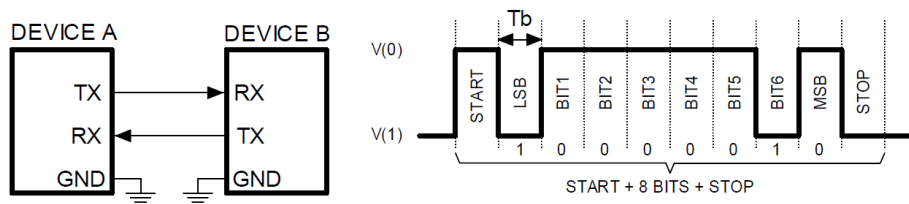   and also animate it, i.e. rotating the color.

4   Report

There is no report this week.

Figure 1: A UART format with 8N1