

Laboratory 6: VGA and UART

(This lab is partly taken from Pitchaya Sitti-Amorn, Ph.D. And also revised by TA2019s2 team)

Objectives

1. Understand how to use FPGA to interface with external devices
2. Understand serial communication

Background

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

VGA

VGA protocol is designed when computer monitors still used cathode ray tube (CRT) devices. In those times, 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 VGA Port section of the BASYS3 reference¹).

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. You can also get code and more information from embeddedthoughts².

Note. Please make sure that you understand H-Sync, V-Sync, and related signals. You may find it in a quiz.

Universal Asynchronous Receiver/Transmitter

Universal Asynchronous Receiver/transmitter or UART is a computer protocol that enables 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.

¹ <https://reference.digilentinc.com/basys3/refmanual>

² <https://embeddedthoughts.com/2016/07/29/driving-a-vga-monitor-using-an-fpga/>

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.

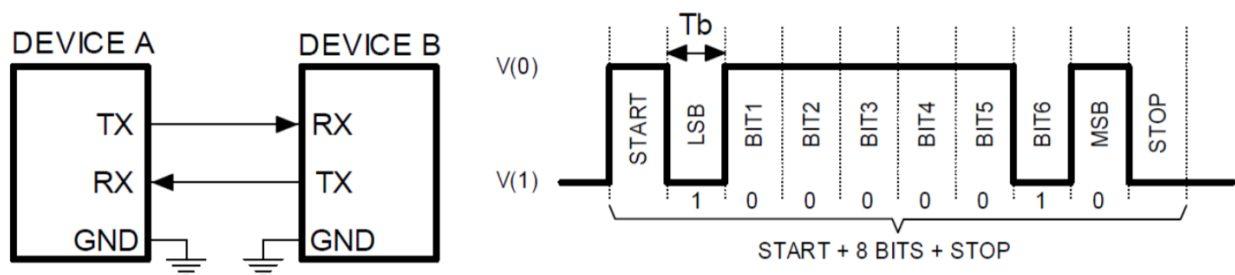
Exercises

1. VGA: Either modify the example code or rewrite your own code so that the board will display white circle with radius of 100 pixels in the middle of the screen (centered at $x=320$, $y=240$).
2. UART: You will be implementing a simple program that receive UART inputs, receiving 'w', 'a', 's', and 'd' and then move the circle from part 1 up, left, down, and right by 1 pixel respectively. And receiving 'c', 'm', 'y', and space to change circle color to cyan, magenta, yellow, and white respectively.

If the key pressed is matched to any action, transmit the uppercase letter of each action (e.g. if you pressed 'w', you should send 'W' back to your computer), except space that you should transmit the letter 'Z' back to your computer. But if not, don't transmit anything back.

You may choose any baudrate 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 before doing this part.

Note: You might need a terminal software to connect your computer to BASYS3. On Linux (and Mac OS X), try minicom or screen. On Windows, try RealTerm³, TerraTerm, or PuTTY.



³ <https://sourceforge.net/projects/realterm/>