

# Computer Science 141

## Lab #1: Introduction to the lab

### 1 General Information

Find another student and sit by a computer station. You should see a digital oscilloscope, a digital signal generator, a protoboard with the XSA-3S1000 board and a power supply. The station should be logged on - if it's not, ask your TF to log in for you. Please be careful with the equipment and keep all the components within the workstation.

### 2 Introduction to the oscilloscope

Turn on the scope. After a while you should see a black grid. The oscilloscope is up and running. Press the yellow "CH 1 MENU" button a few times to see a yellow waveform on the screen. The scope is displaying the signal that the yellow probe is receiving at the end. Right now the probe is connected to anything. What is the waveform showing? When you handle the oscilloscope, you will pretty soon realize that the "AUTO SET" button will be your best friend - it stabilizes the waveform and does some magic to make sure it looks pretty and doesn't clip out of the screen. But it's more fun if we learn a few manual functions of the oscilloscope.

The five color buttons correspond to five channels of the oscilloscope (the red button performs mathematical transformations of the first two channels, and we won't worry about it yet). You only have two probes, so the only two relevant channels are Channel 1 and 2. Pressing the color buttons will activate the channel (the menu on the right of the waveform will change), and either turn the waveform display on or off.

Turning the yellow knob will change the vertical scale of the oscilloscope. Make sure the "Volts/Div" option is set to "Coarse" (change it with the middle button next to the screen if it's not) so that turning the knob will make substantial changes in the scale. The knob on the right (the one that says "SEC/DIV") will change the horizontal scale.

Next, turn on the signal generator. A signal generator is, quite intuitively, a device which outputs a signal having specific characteristics. You can then display the signal on, say, the oscilloscope.

Set up the signal generator so that it outputs a sine wave with a frequency of 500 Hz with an amplitude of 0.5V and no offset. Connect the black connector of the signal generator to the black connector of the yellow signal of the oscilloscope. Both the oscilloscope and the signal generator treat this as a reference point (we call it "GROUND"). Connect the red connector of the generator to the probe of the oscilloscope. Press the Auto Set button. Make sure the oscilloscope shows the correct frequency information. Play with the frequency and see the corresponding changes being made on the oscilloscope display.

Now press the red "MATH MENU" button and set the function to be performed to "FFT". The oscilloscope just performed a Fast Fourier Transform on your signal! You should see one peak, corresponding to the frequency to which you set your signal generator. What will happen if you change the signal to be a square wave?

### 3 Introduction to the XSA3S1000 board

Plug your power supply unit into an outlet on the lab bench and its output plug into the power jack on the side of the board. The 7-segment LED display should glow slightly and/or some segments may actually be lit.

Using a wire stripper as demonstrated by your TF, cut two 5-inch pieces of the wire (to be found in the lab kit or in the lab room, in the corner), one red and the other black, and strip the insulation about 1/4 inch from each end. Using one of these, connect the +3.3 pin of the XSA3S1000 (by running the red wire from the protoboard sockets adjacent to the pin) to a point on the top horizontal row of the board. This will provide a voltage of +3.3 volts. The internal connections of the protoboard are shown below in Figure 1. Connect the GND pin (guess what, it signifies ground or 0 reference volts) to a lower horizontal row using the piece of black wire. You will use these rows to insert +3.3 and 0 volts into your circuits as they are built on the board. They will be called the POWER and GND busses hereafter. They are marked by red and black lines next to each one.

Note: We used red for POWER and black for GND because it is important to be able to quickly identify the functions of wires running in a circuit. A technique called "color-coding" is used in electronics work. The color of a wire marks it as power, ground, input, output, etc. so its function can be very quickly identified. This will be very important when you build large circuits and have to troubleshoot them. Learn how to do it now! We reserve red for POWER and black for GND. It is important that you be consistent. NEVER use just one color wire for a big circuit.

With another wire connect the reference clip of the scope lead to GND. (Why should you do this?) Do the same for the test lead itself. The line displayed on the scope is the 0 reference line. Line it up with a horizontal reticule line from which all voltages will be measured. Then put the test lead (with its wire) on the POWER bus and measure the voltage there. Is it exactly +3.3? Now connect the logic probe by connecting its two wires to POWER and GND. Test the logic levels at different pins starting first with the GND and POWER pins.

Now disconnect the board from the power supply. Then connect your XSA3S1000 to one of the lab computers using the parallel cable (there should be one already connected to the computer). There is a socket on the board for a parallel cable. Now reconnect the power supply.

We will now download a program to your XSA3S1000 board. First, download and extract the "lab01-flashdata.zip" file from the class website's *resources* page. Next, start *Gxsload* - this is a tool for downloading code to your XSA3S1000 board. Drag *test\_vga.bit* into the FPGA/CPLD field and drag *image.xes* into the RAM field in *Gxsload*. Also make sure that you've selected XSA-3S1000 as your board type and you've correctly specified your connection type (LPT1 for the parallel cable, USB0 for the USB adapter). Click the Load button to download your code to the board. Finally, connect a monitor to the VGA port on your XSA31000 board to make sure your code downloaded properly. Find a TF and show him your result!

Don't worry if you don't understand why this works. The goal of this section is to make sure your XSA3S1000 board works and to teach you how to download code. We'll teach you how to design your own code in future labs.

## 4 Introduction to integrated circuits

Your TF will give you a chip implementing an unknown combinational logic circuit (Hardware Black Box). Your task is to determine the function computed by the circuit and to draw up the datasheet associated with the chip. Consult the diagram on board to see your chip inputs and outputs. Use the CS141 interface for your input signals and use the logic probe to find your output signals. Draw the truth table and try to infer the function the black box implements.

## 5 Endgame

You should always demonstrate and discuss your working circuits with your TF.

After your TF ok's your work, please clean up your bench space. The TF will show you where you can leave your wires for others to use. Disconnect your equipment from the wall socket and remove the oscilloscope leads.

**Always leave your lab area neat!**