Crowd Supply

Course Workbook 2

Table of Contents

About this Workbook

This workbook is designed to be used in conjunction with the Crowd Supply lab two workshop.

The contents of this workbook are created by Adiuvo Engineering & Training, Ltd.

If you have any questions about the contents, or need assistance, please contact Adam Taylor at adam@adiuvoengineering.com.

Pre-Lab

Workshop Prerequisites

Required Hardware

The following hardware is required to complete this series of labs

1. Digilent Basys3 development board
2. VGA Cable and other monitor
3. Terminal Program (e.g. Tera Term)

Downloads and Installations

Step 1 – Download and install the following at least one day prior to the workshop. This may take a significant amount of time and drive space.

Vitis 2020.2 – Includes Vivado	Download
Source Project Files	Download

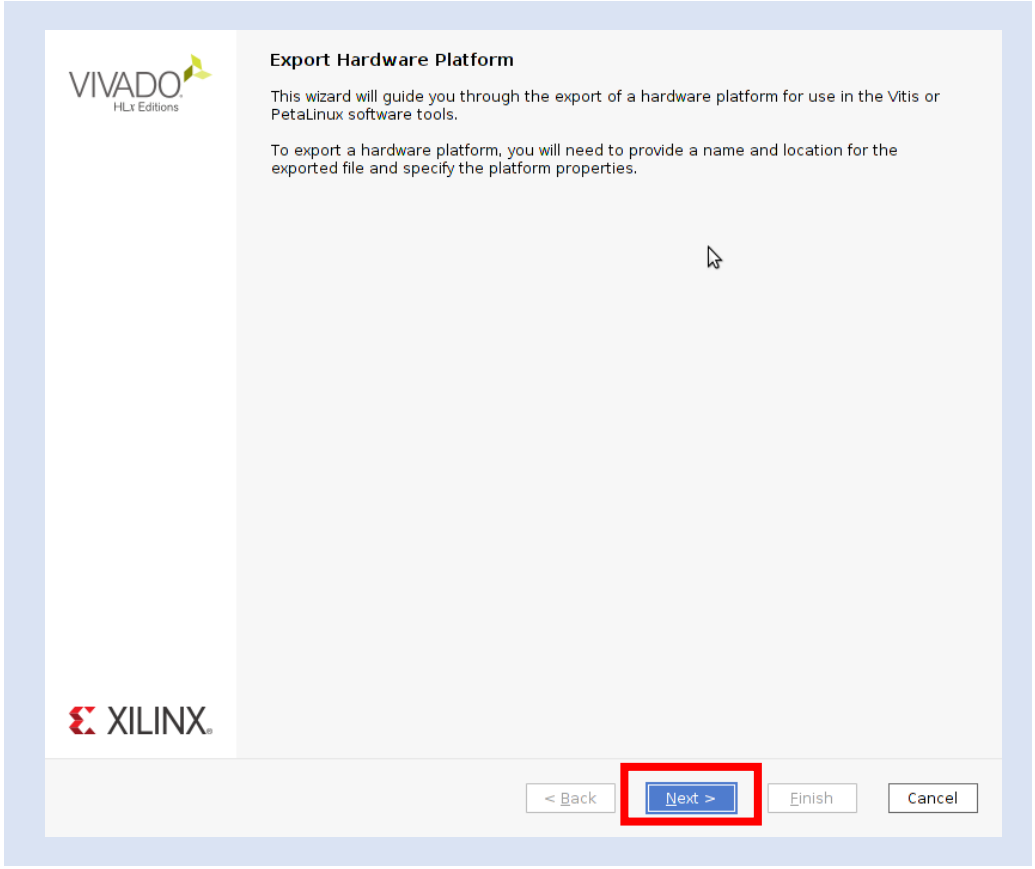
Lab
Creating Pong on the Basys3

Part 1:

Running Hello World on Vitis

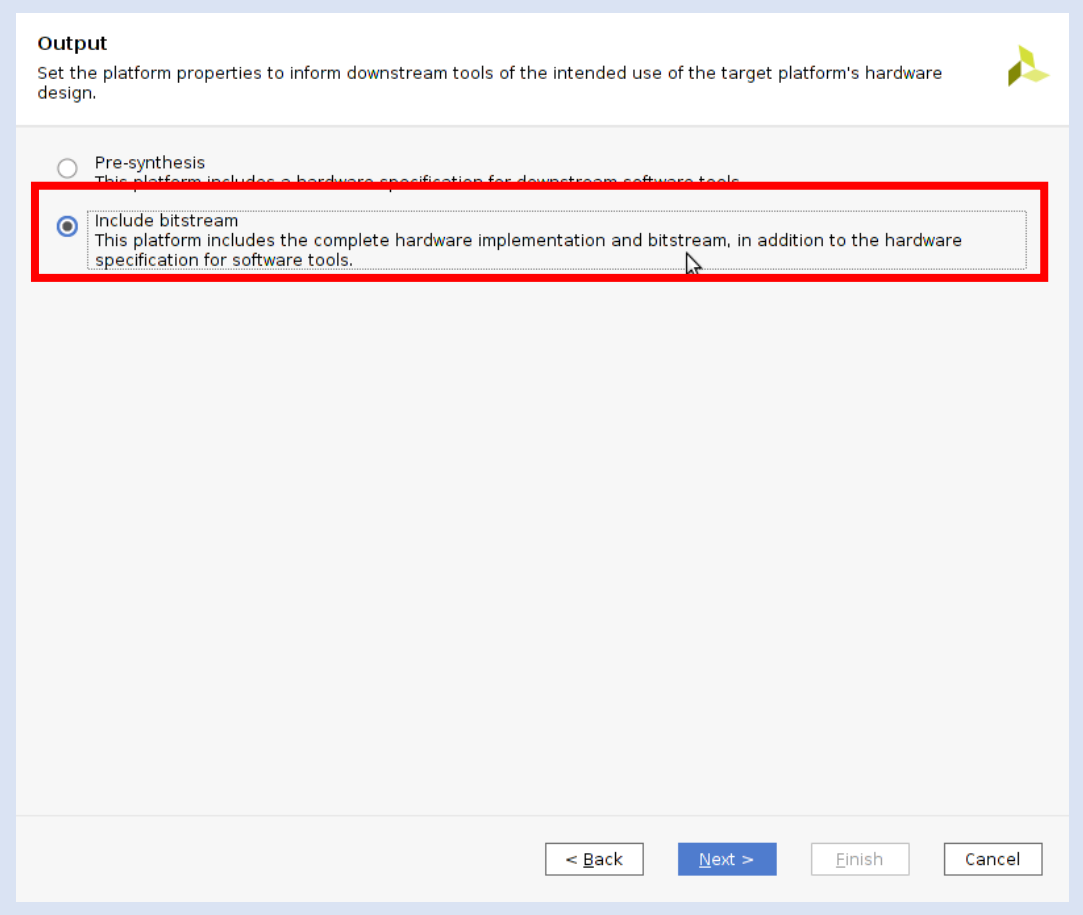
Crowd Supply: Lab Two

Step 1 – At the end of the first lab, we generated our bitstream. Now we need to export it. Using Vivado, open the project created in the last lab. Export to hardware by navigating: File > Export > Export Hardware.



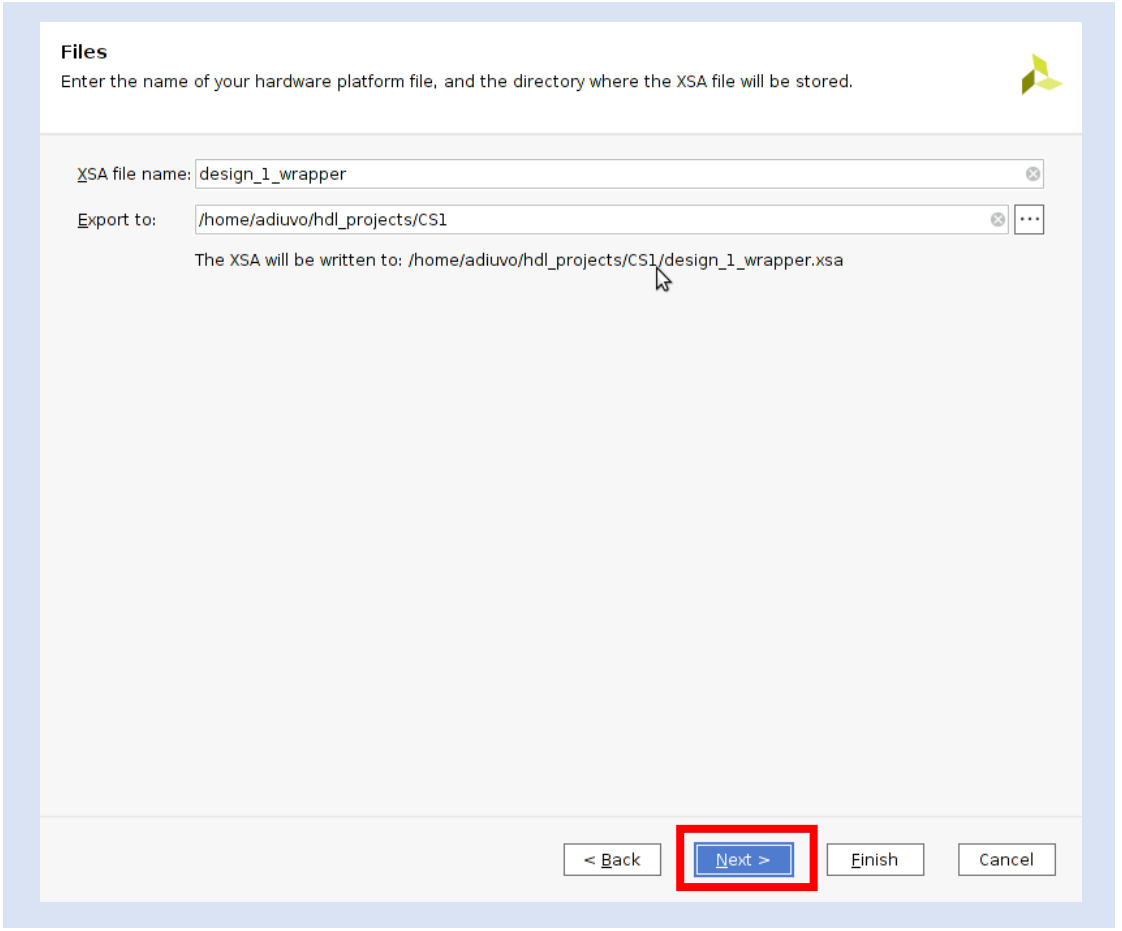
Crowd Supply: Lab Two

Step 2 – Select “Include bitstream”. Click “Next”.



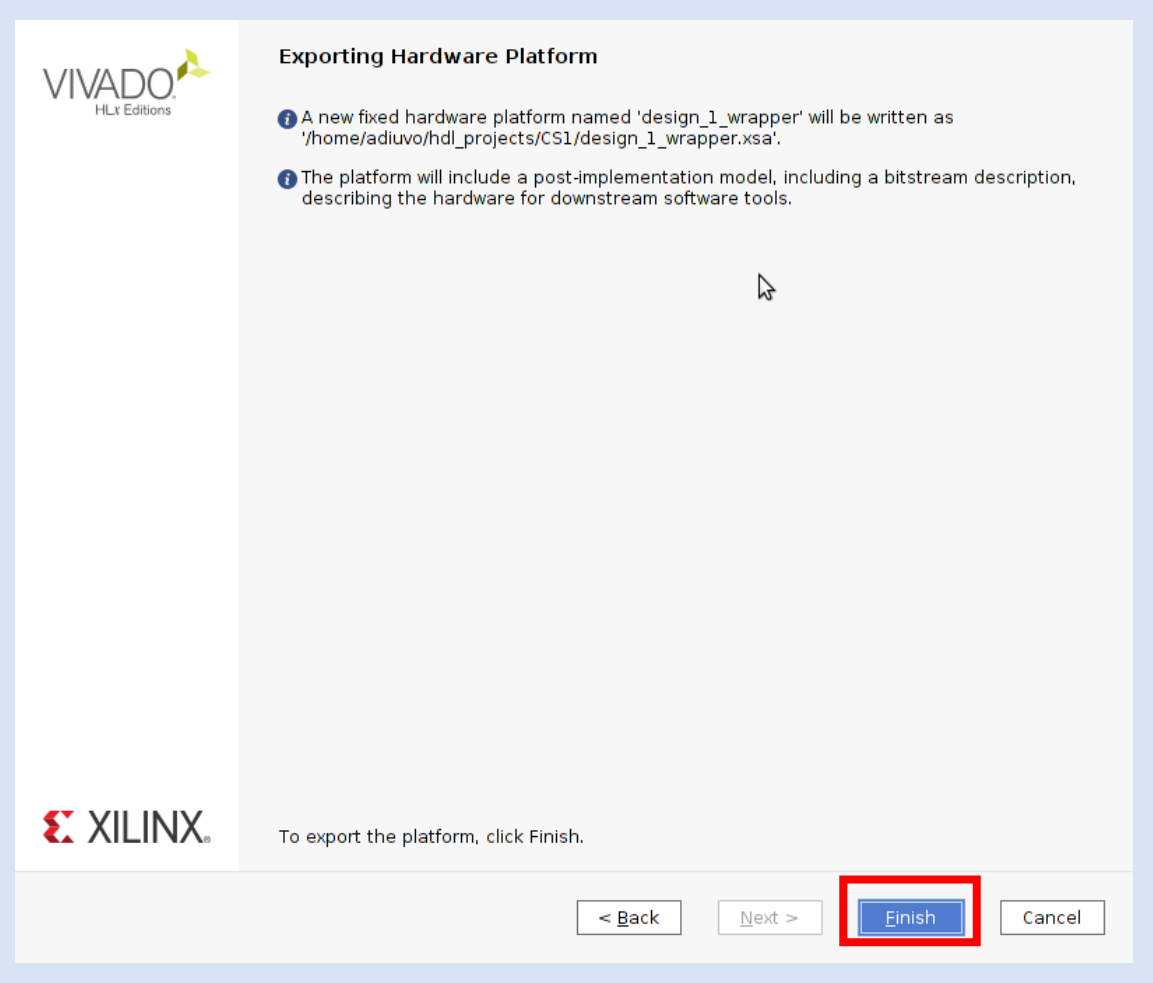
Crowd Supply: Lab Two

Step 3 – Leave the defaults for your project. Click “Next”.



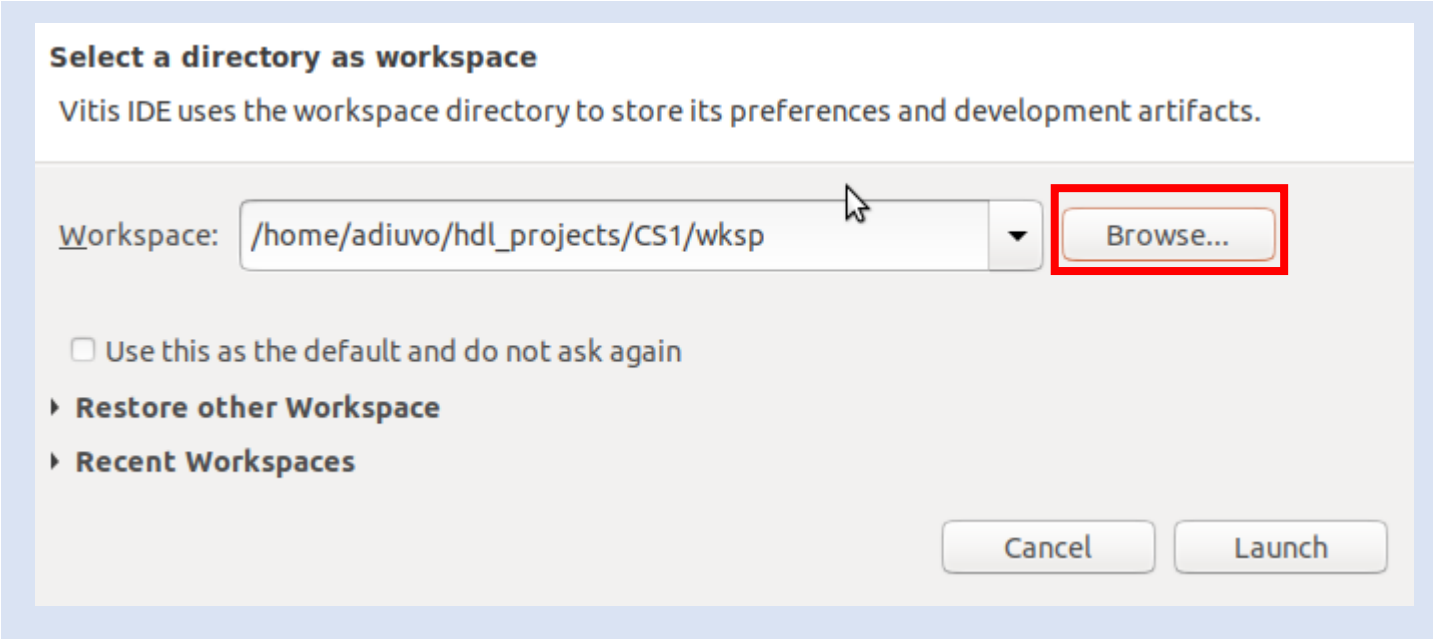
Crowd Supply: Lab Two

Step 4 – Click “Finish” to export the hardware definition.



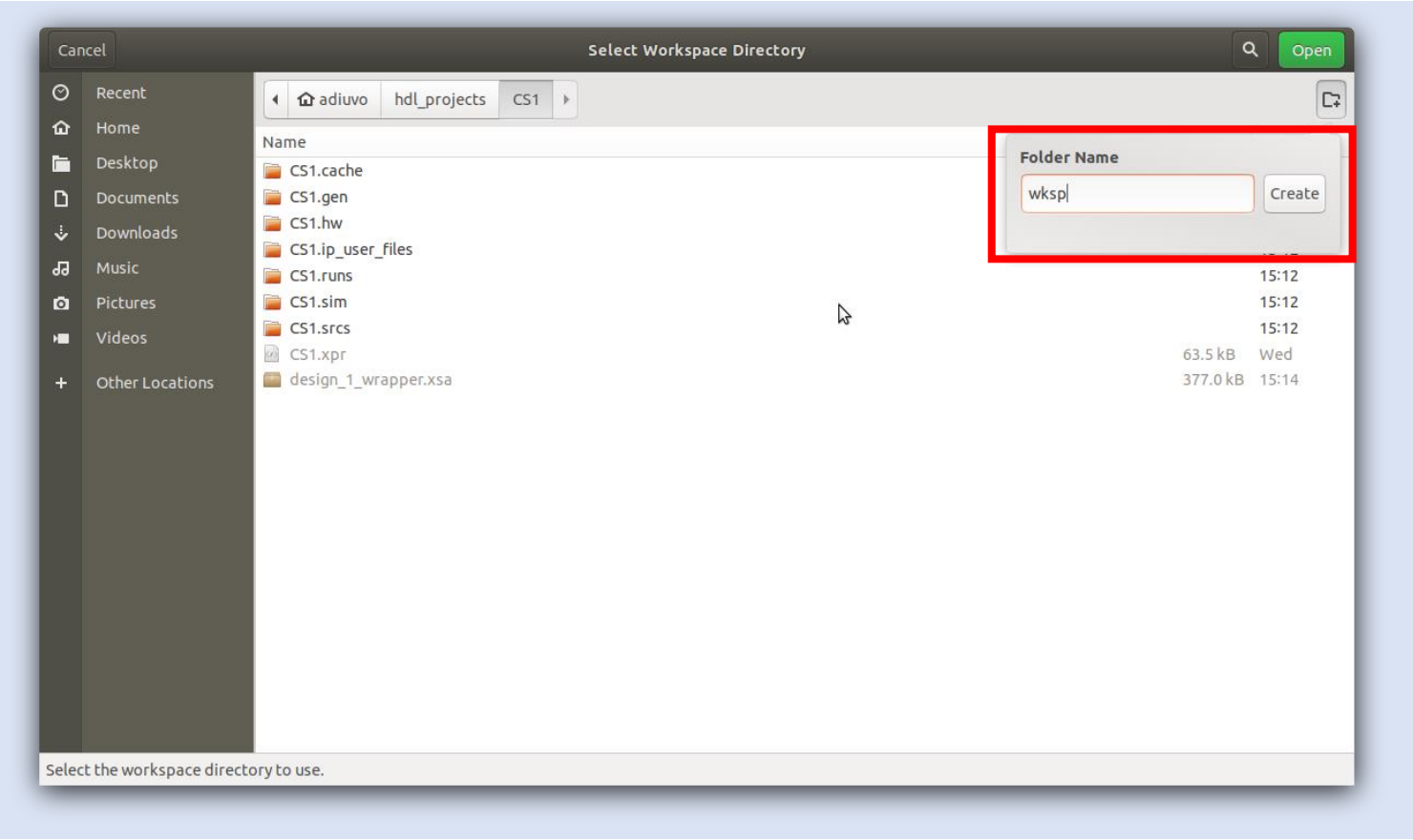
Crowd Supply: Lab Two

Step 5 – Launch Vitis from the Vivado Tools Menu. Select “Browse…”



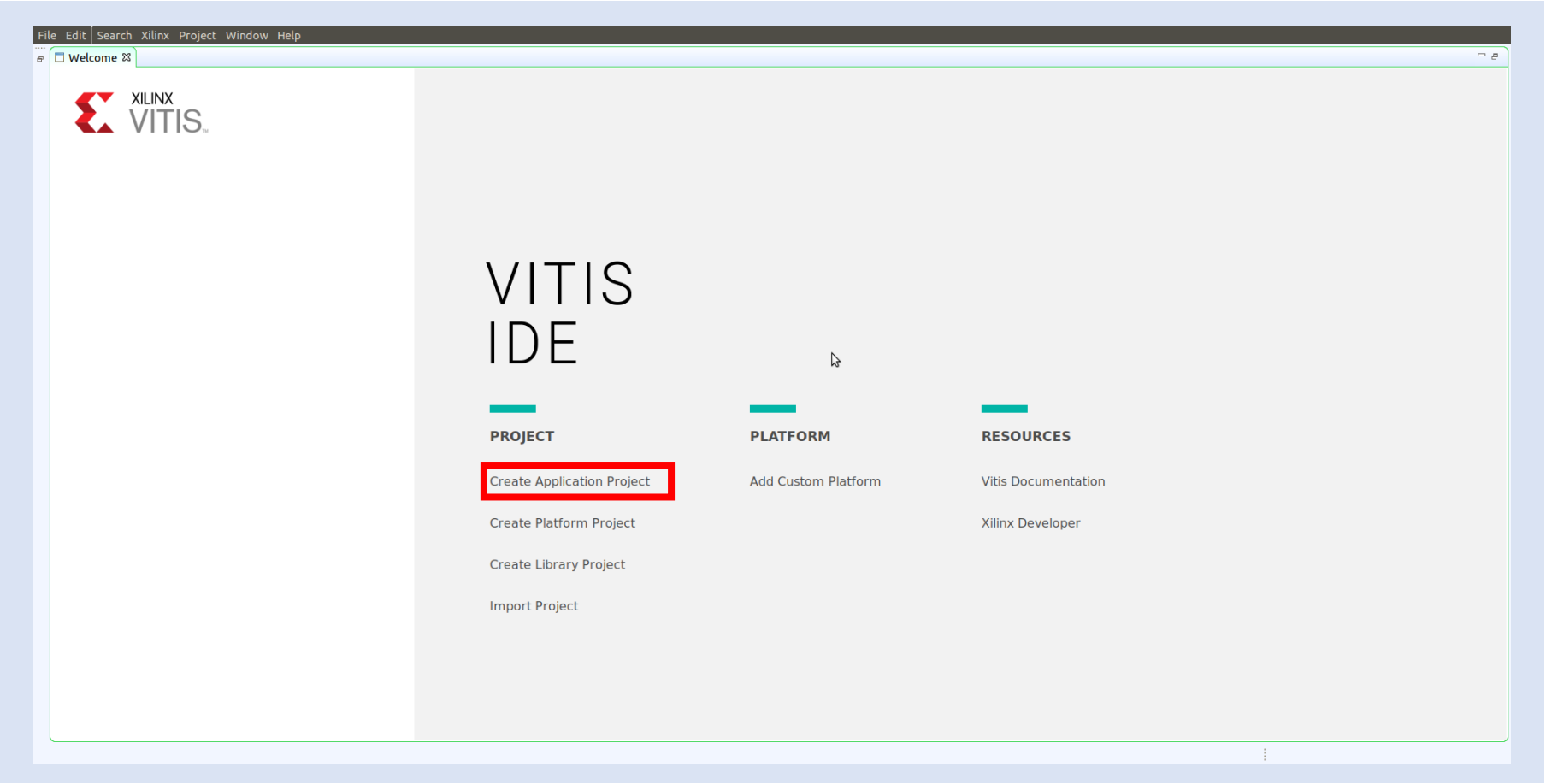
Crowd Supply: Lab Two

Step 6 – Navigate to your Vivado project folder and click the folder icon to create a new “wksp” folder.



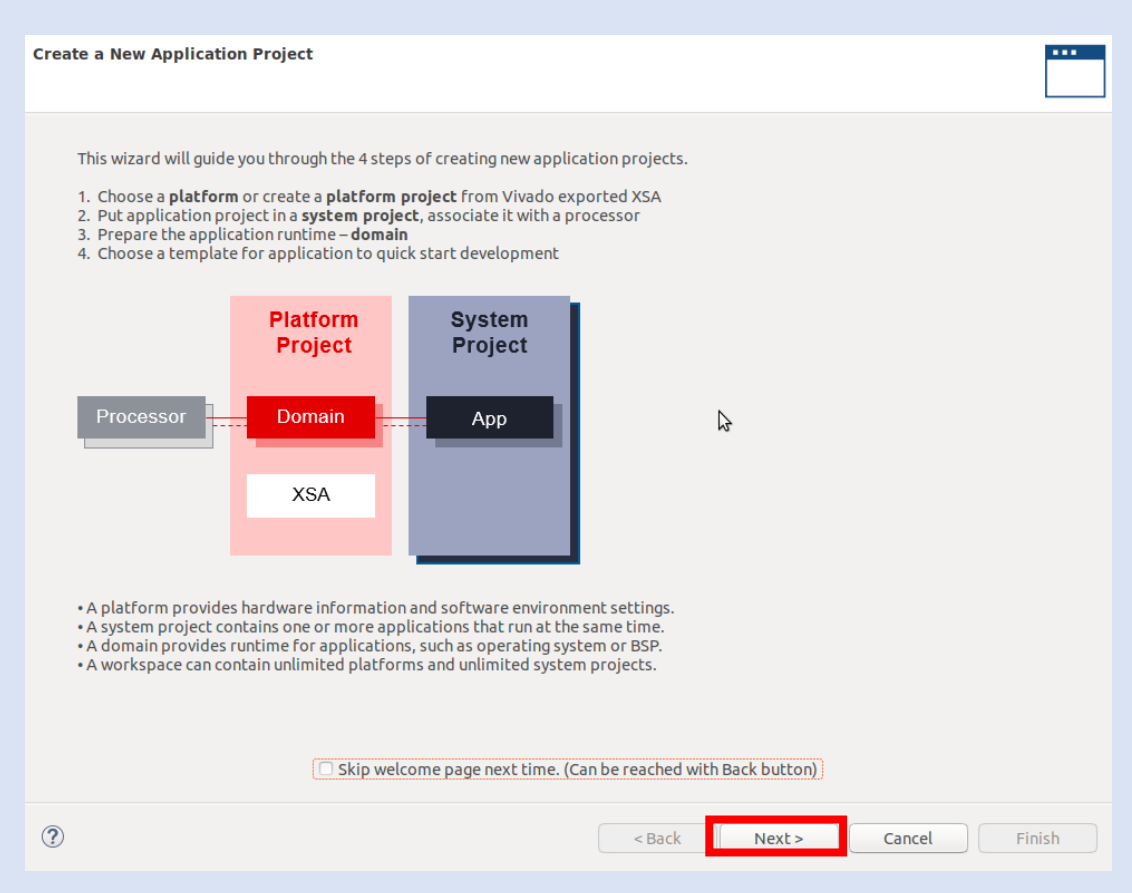
Crowd Supply: Lab Two

Step 7 – Select “Create Application Project”.



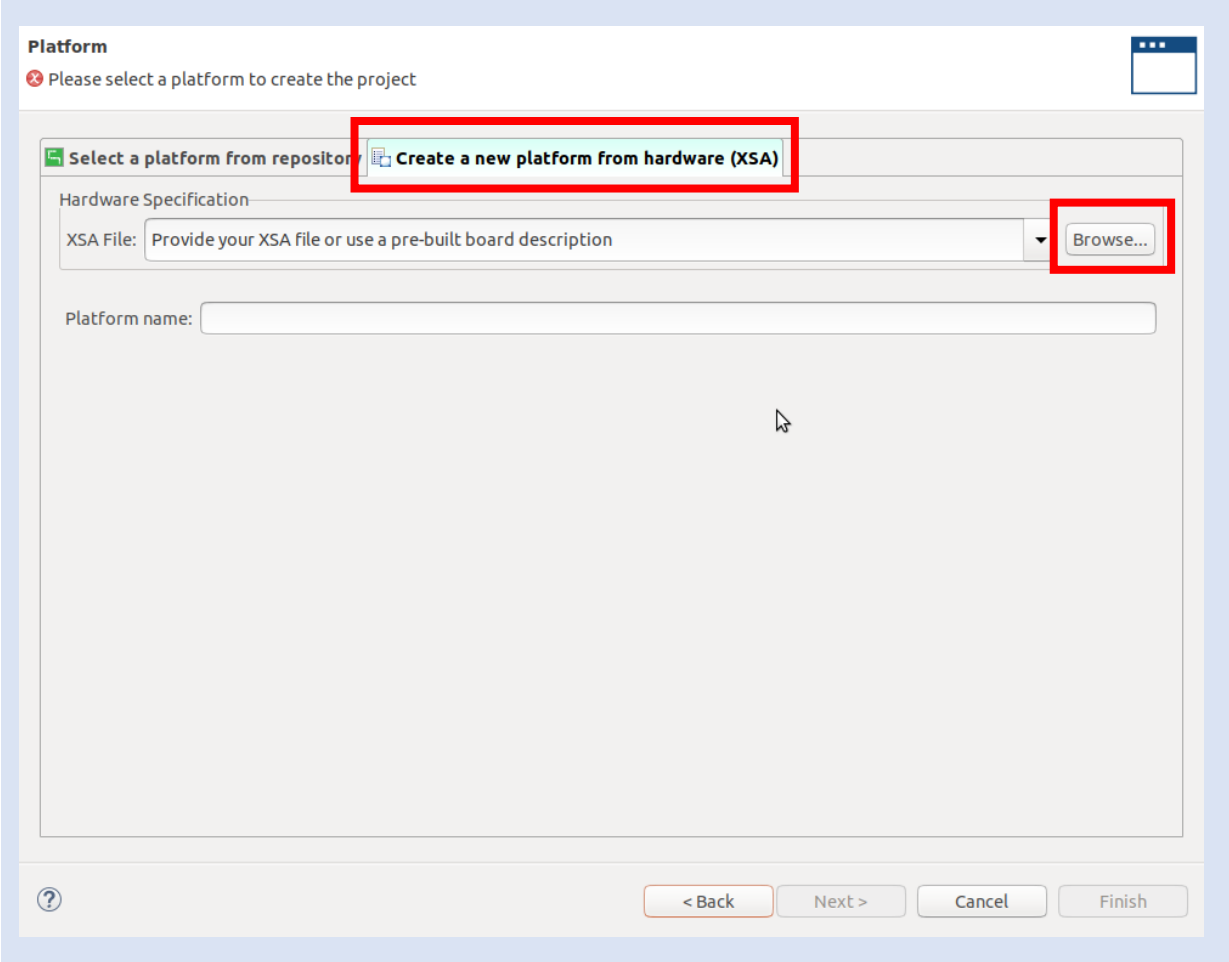
Crowd Supply: Lab Two

Step 8 – Click “Next”.



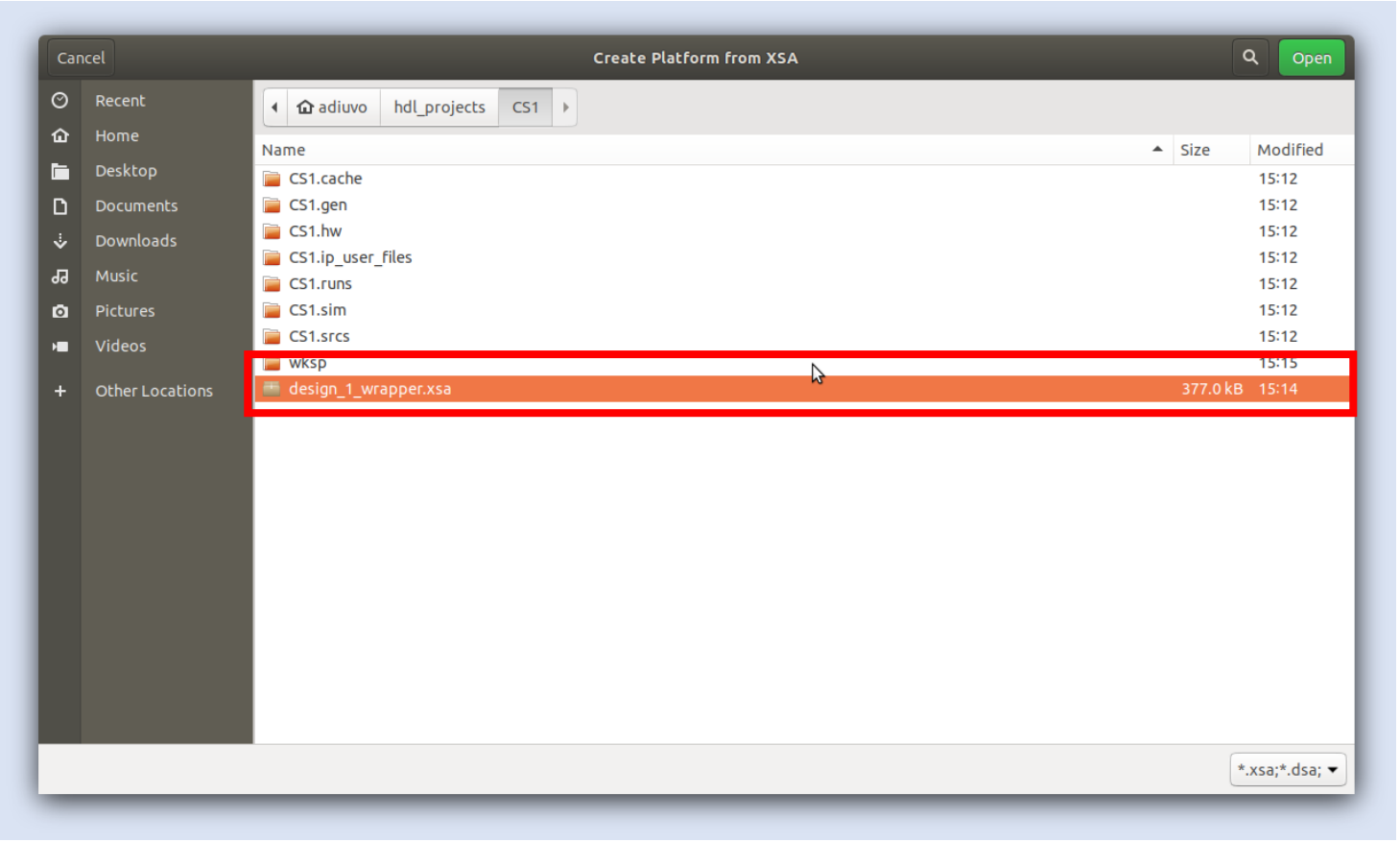
Crowd Supply: Lab Two

Step 9 – At the platform selection dialogue, open the “Create a new platform from hardware (XSA)” tab and select “Browse…”



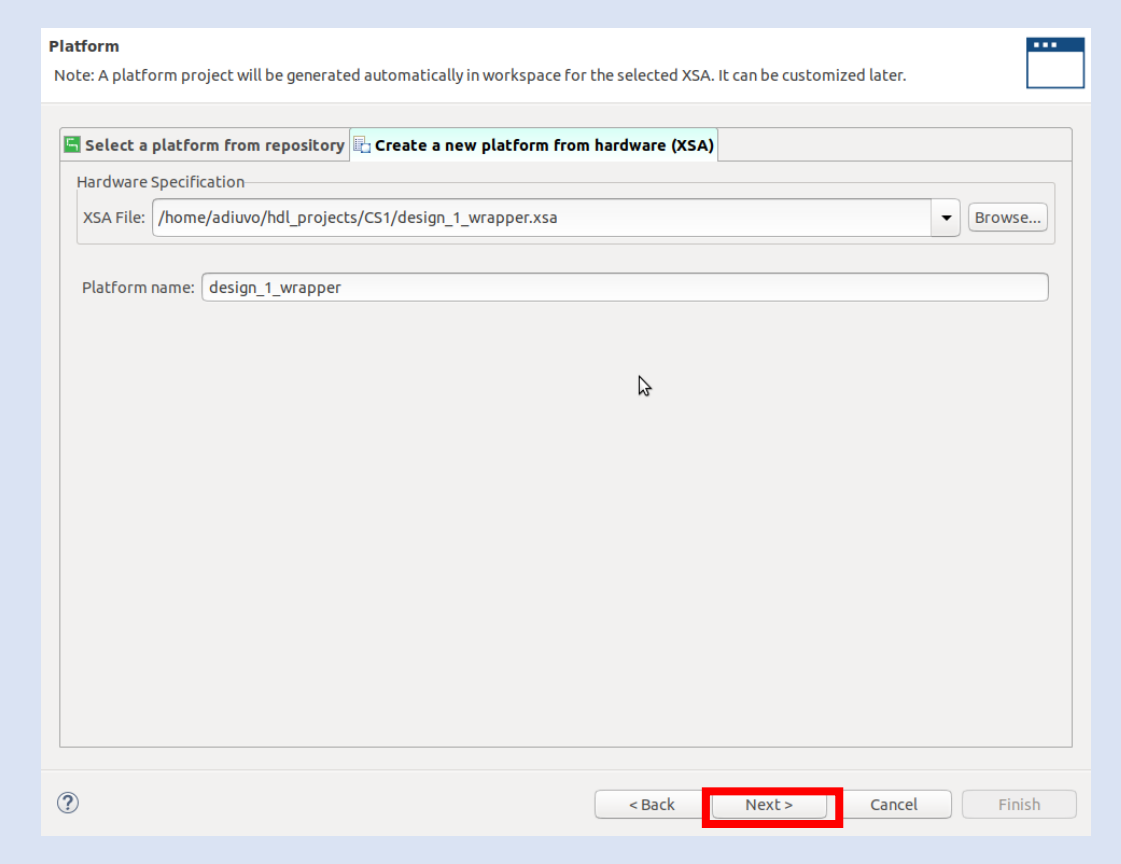
Crowd Supply: Lab Two

Step 10 – Navigate to your Vivado project folder and select the .xsa file you generated. Select “Open”.



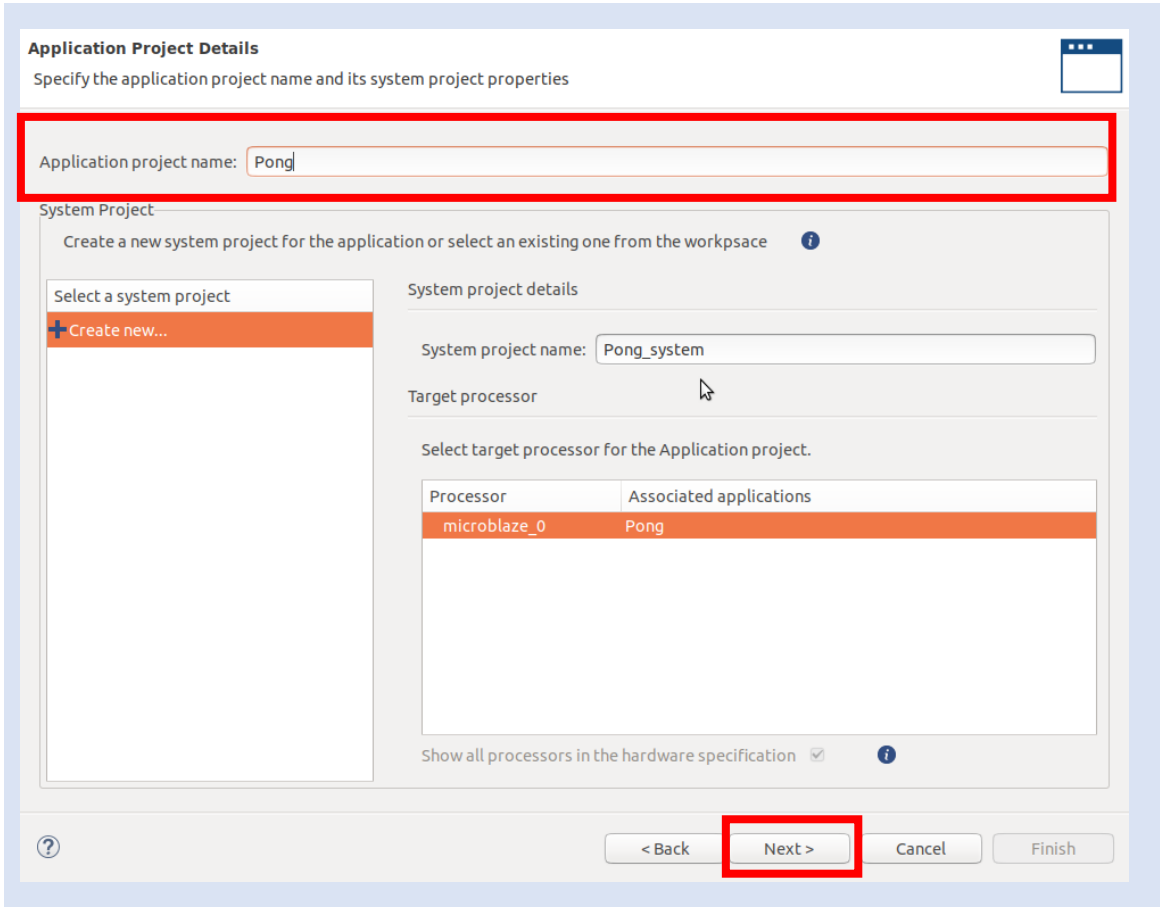
Crowd Supply: Lab Two

Step 11 – Click “Next” to use this as the platform.



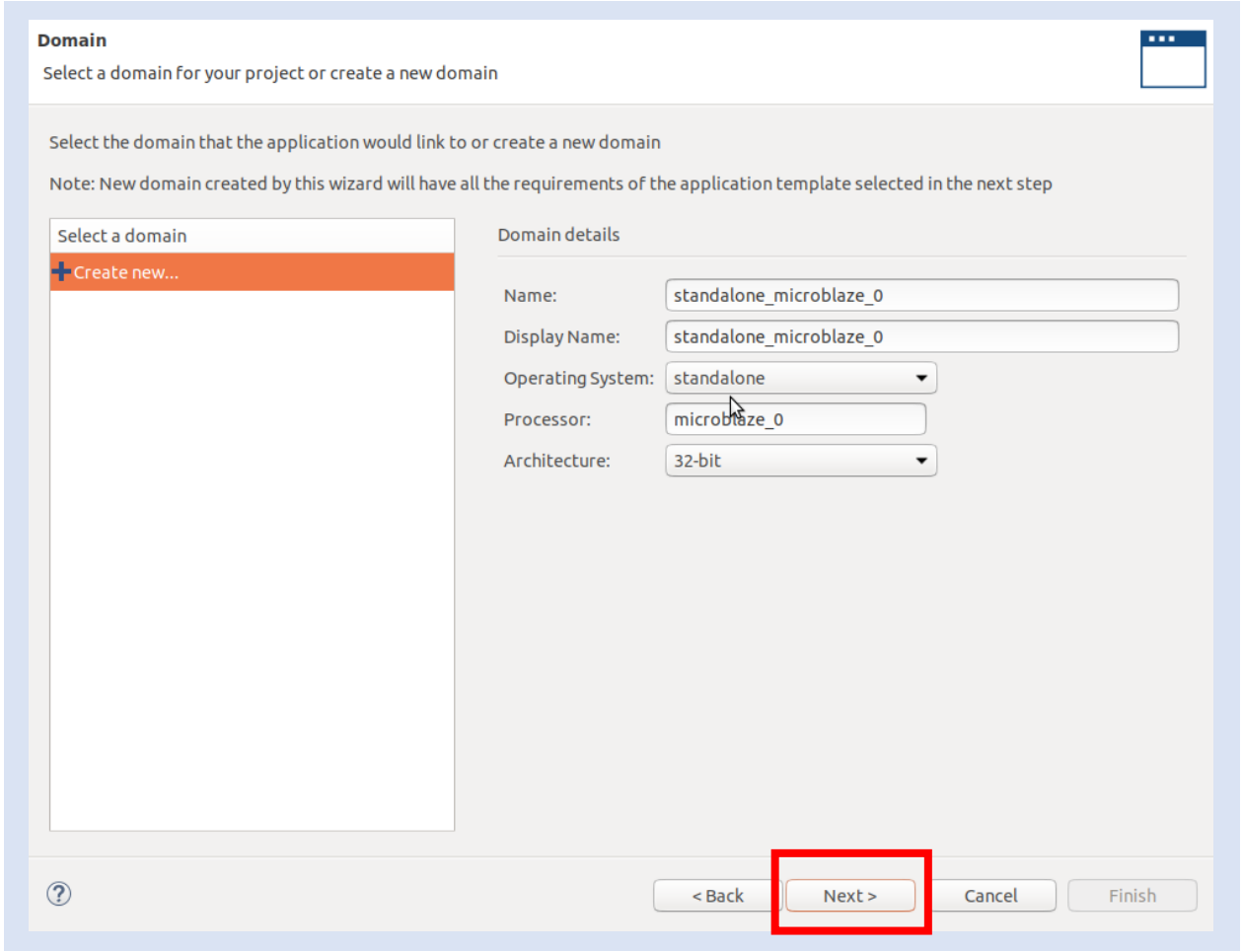
Crowd Supply: Lab Two

Step 12 – Enter a project name and click “Next”.



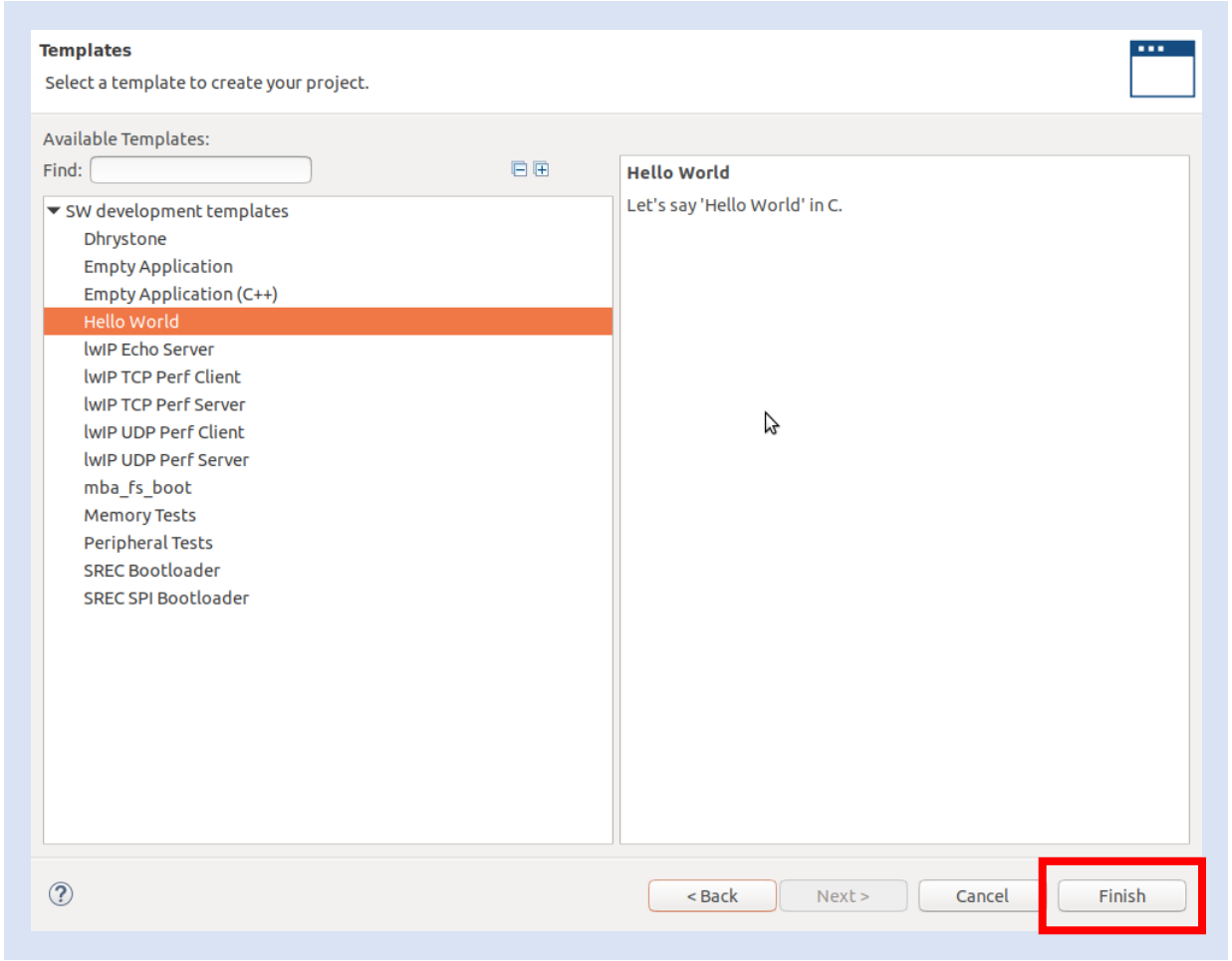
Crowd Supply: Lab Two

Step 13 – Leave the domains unchanged. Click “Next”.



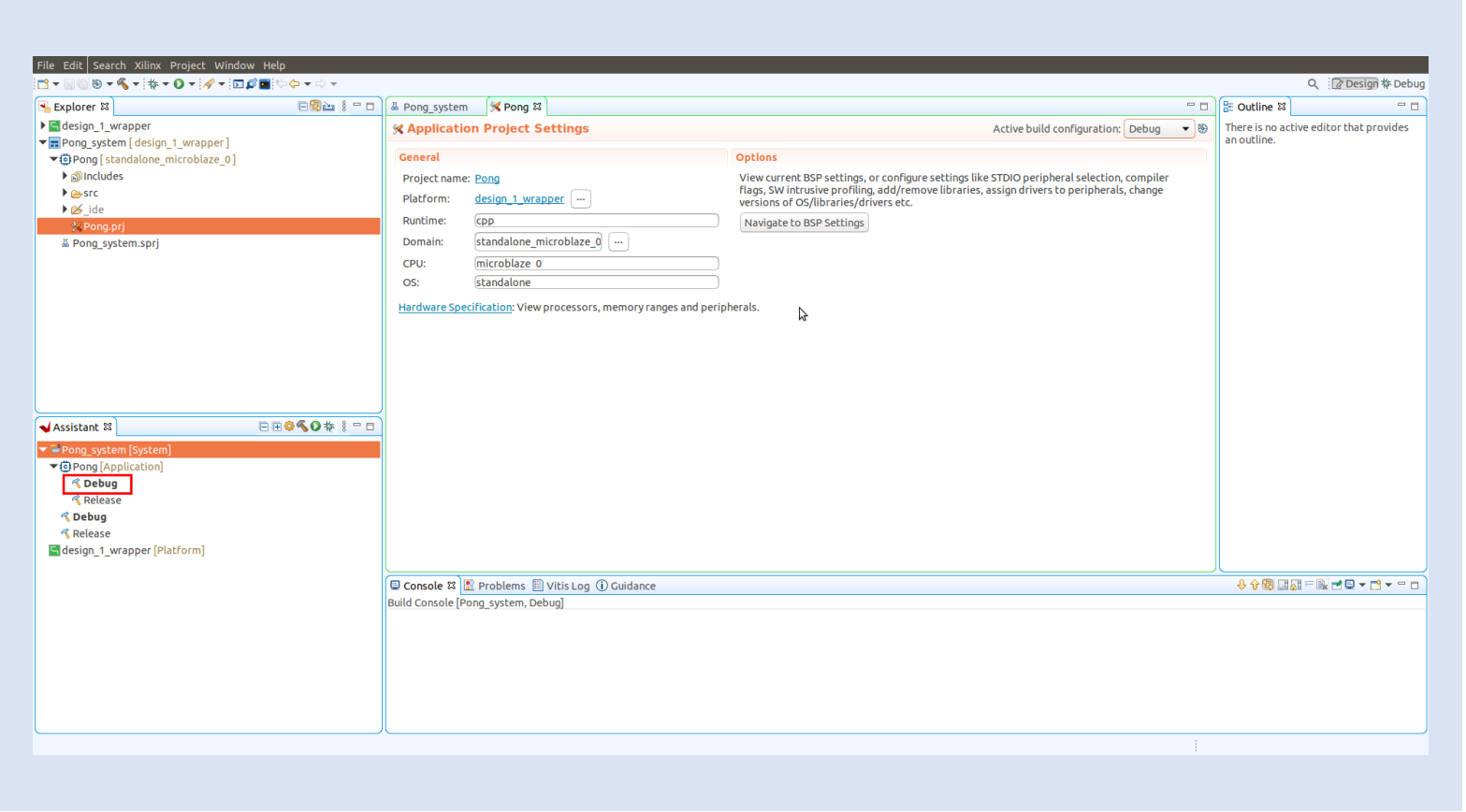
Crowd Supply: Lab Two

Step 14 – Select “Hello World” project template. Click “Finish”.



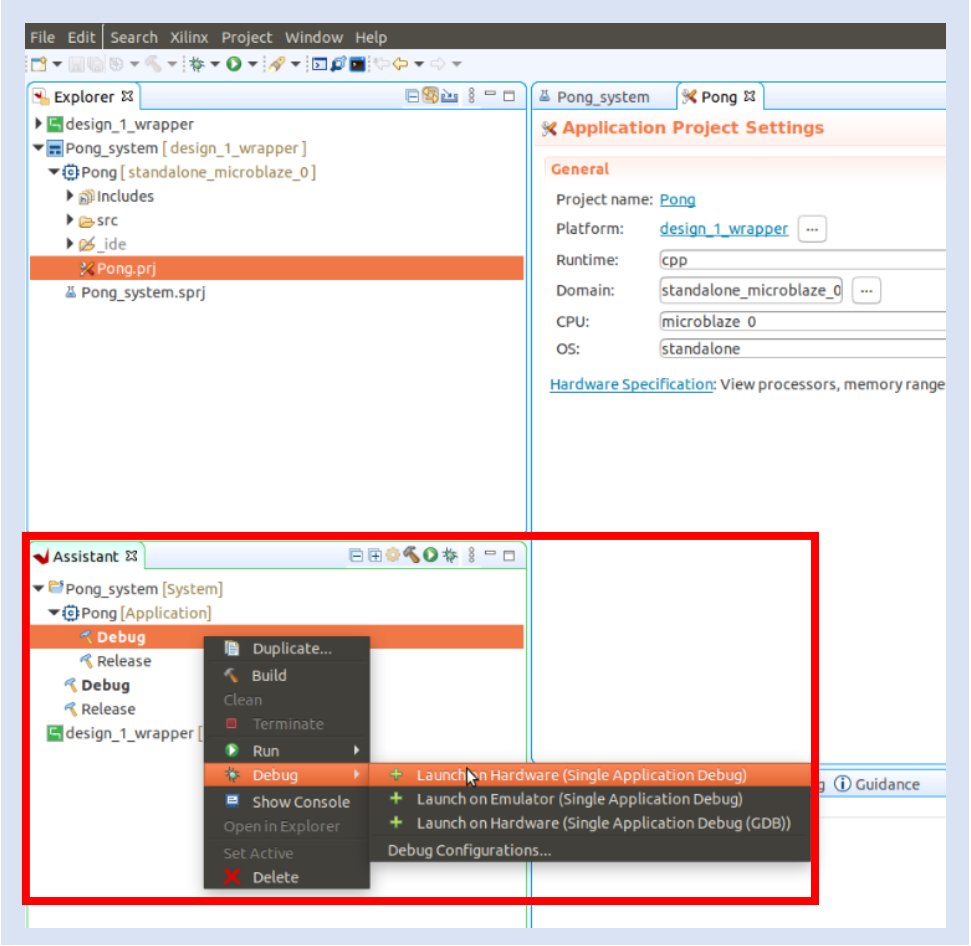
Crowd Supply: Lab Two

Step 15 – You will see your project open as shown below. **Under your application name** in the “Assistant” window, select the hammer next to “Debug” to build the application. Connect the Basys3 to the development system using the USB cable and turn on the board. Also, open and connect your terminal program to the board.



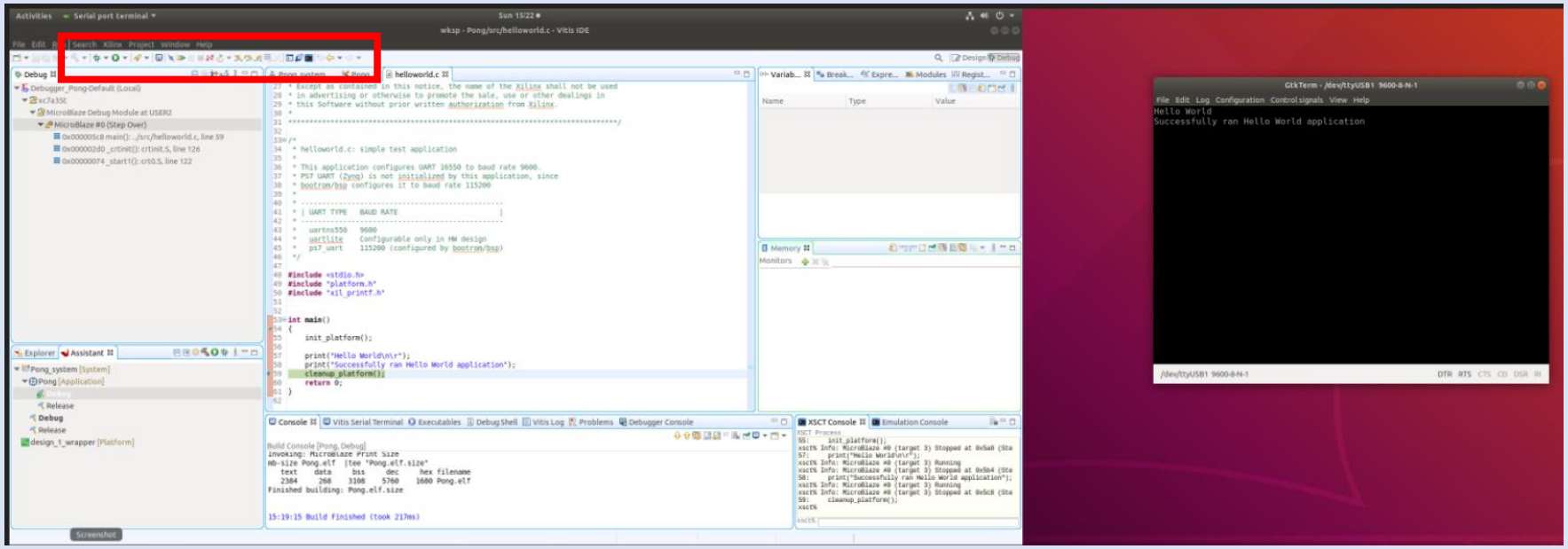
Crowd Supply: Lab Two

Step 16 – In the “Assistant” window underneath your project name, right click on “Debug,” and from the Debug menu, select “Launch on Hardware (Single Application Debug)”.



Crowd Supply: Lab Two

Step 17 – After running the application on hardware, you should be able to see that Hello World has run successfully in your terminal window. This confirms that MicroBlaze is working correctly, and we can begin application development.



Part 2:

Launching Pong with Vitis

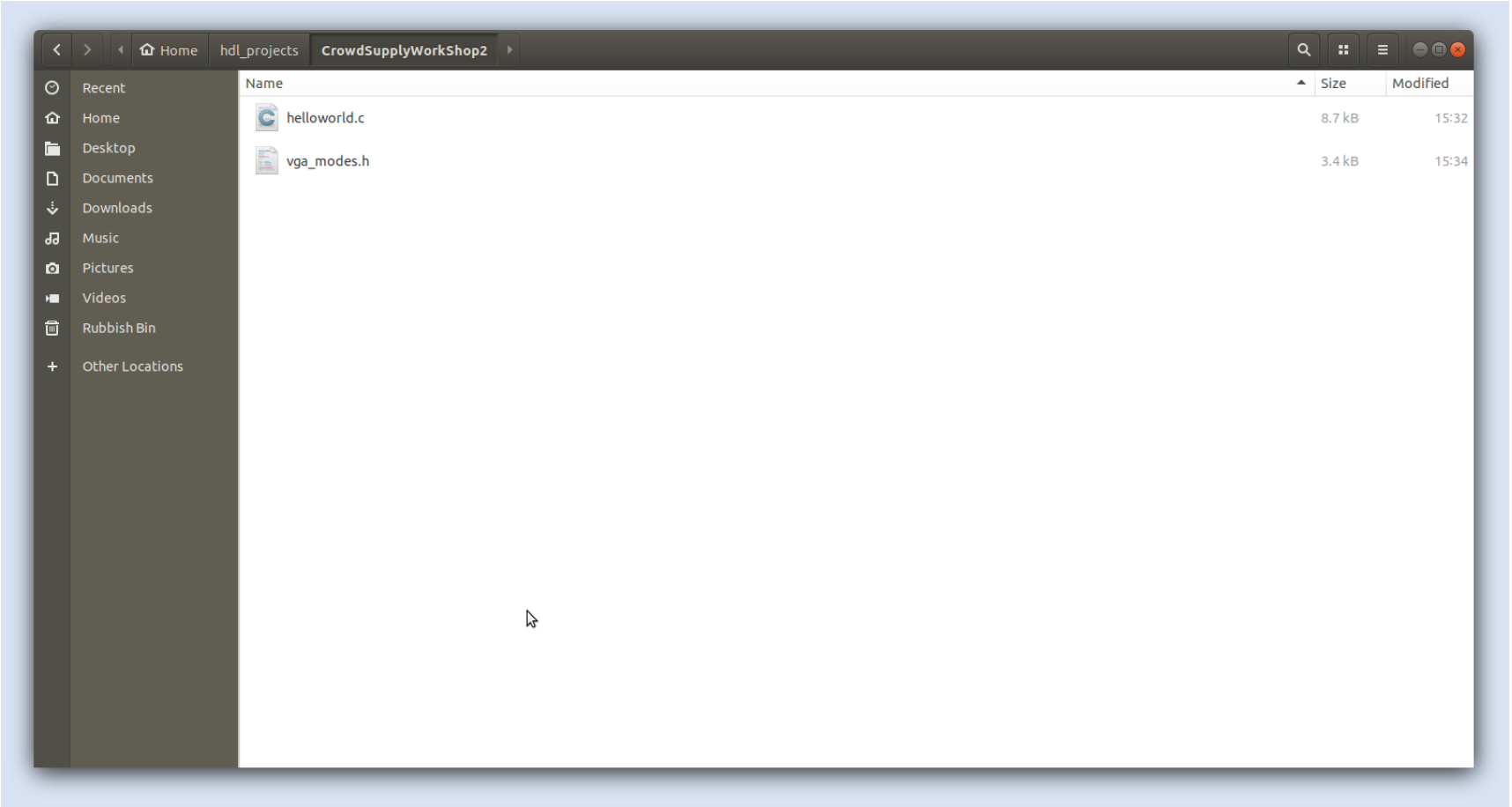
Crowd Supply: Lab Two

Step 18 – Clone the repository for this lab with the command
git clone https://github.com/ATaylorCEngFIET/CrowdSupplyWorkShop2, or download the files from that URL.

```
File  Edit  View  Search  Terminal  Help
adiuvo@Adiuvo:~$ cd hdl_projects/
adiuvo@Adiuvo:~/hdl_projects$ ls
01_vivado                                    basys3_calc
01_vivado_lab1.xpr.zip                       block_average.vhd
01_vivado_lab2.xpr.zip                       CrowdSupplyWorkShop1
01_vivado_rebuild                            CS1
adiuvoengineering.com_user_Average_Fifo_1.0.zip  cs1_repo
average                                      rfsoc_vitis
Average_sources                              U96_Breakout_P1
average_tb.vhd                               vivado-library-master
adiuvo@Adiuvo:~/hdl_projects$ git clone https://github.com/ATaylorCEngFIET/CrowdSupplyWorkShop2
Cloning into 'CrowdSupplyWorkShop2'...
Username for 'https://github.com': adam@adiuvoengineering.com
Password for 'https://adam@adiuvoengineering.com@github.com':
remote: Enumerating objects: 3, done.
remote: Counting objects: 100% (3/3), done.
remote: Compressing objects: 100% (2/2), done.
remote: Total 3 (delta 0), reused 3 (delta 0), pack-reused 0
Unpacking objects: 100% (3/3), done.
adiuvo@Adiuvo:~/hdl_projects$
```

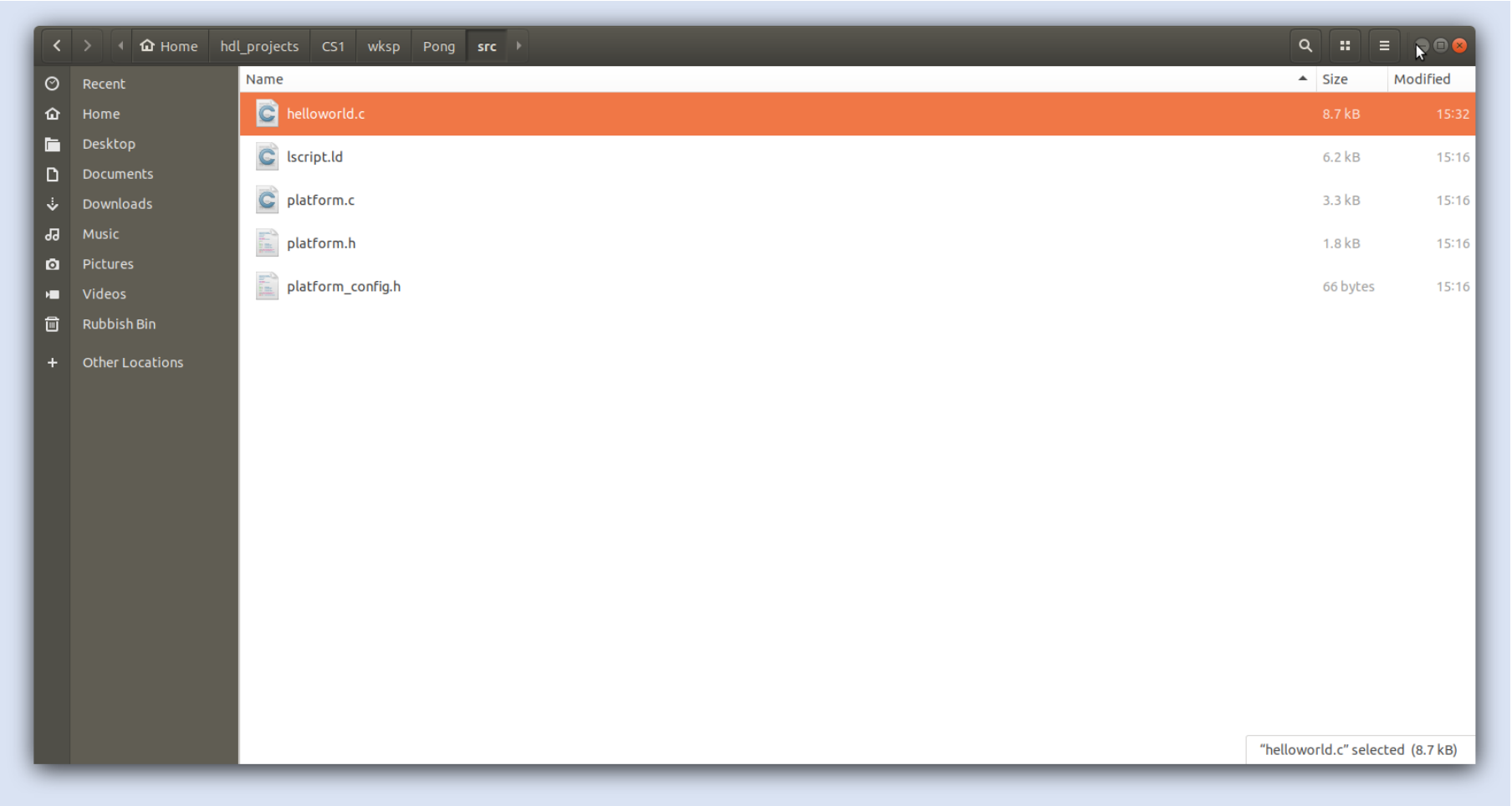
Crowd Supply: Lab Two

Step 19 – This will clone two source files from the repo as shown below.



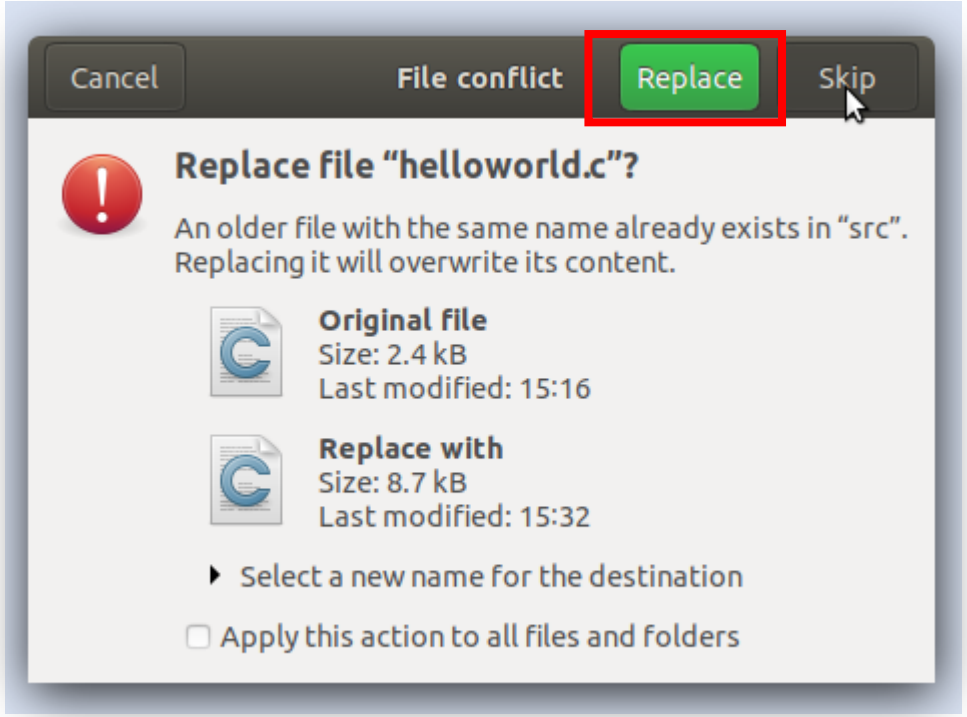
Crowd Supply: Lab Two

Step 20 – Copy the cloned .c and .h files into wksp > <Project Name> > src



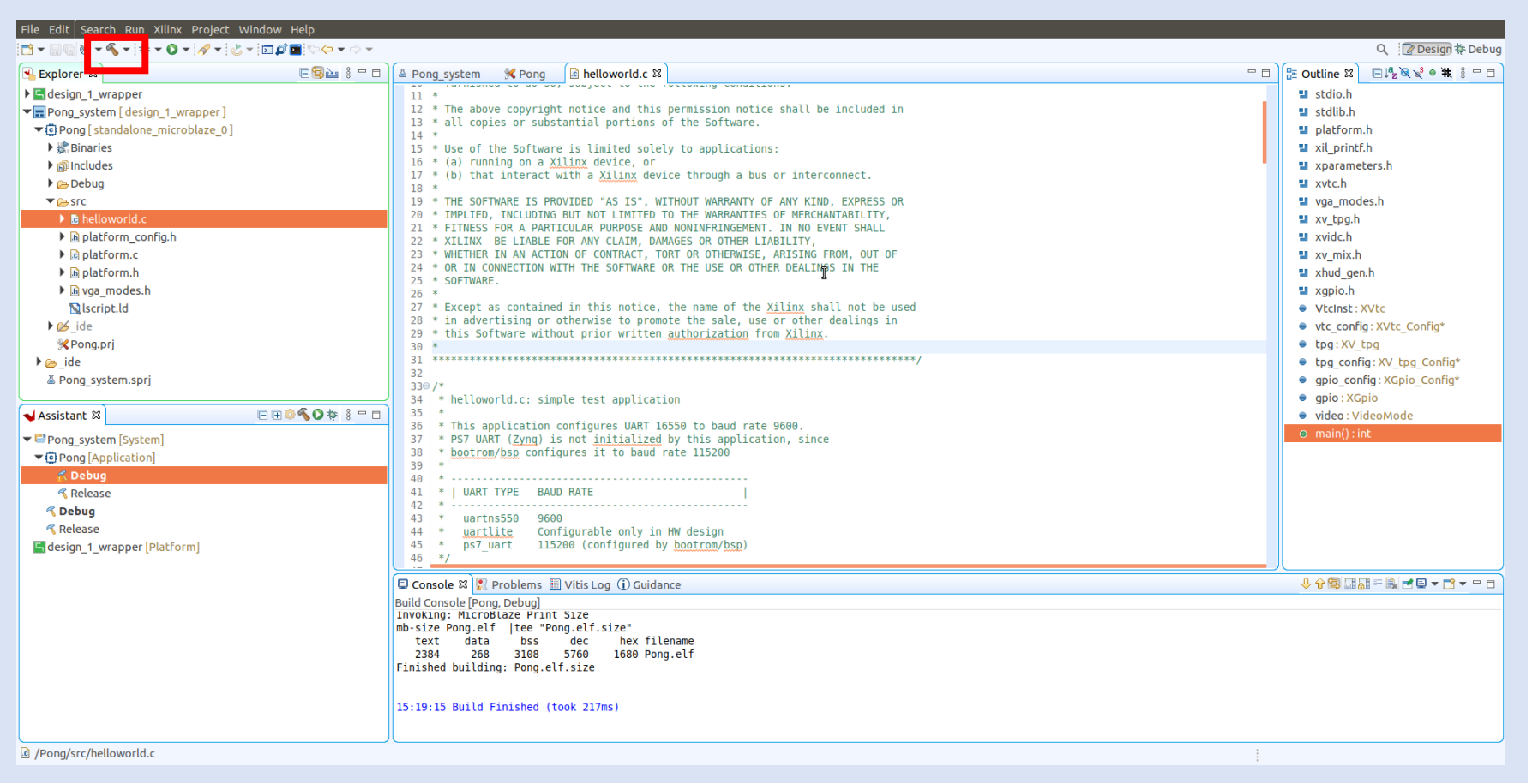
Crowd Supply: Lab Two

Step 21 – If prompted, allow the helloworld.c file to be replaced.



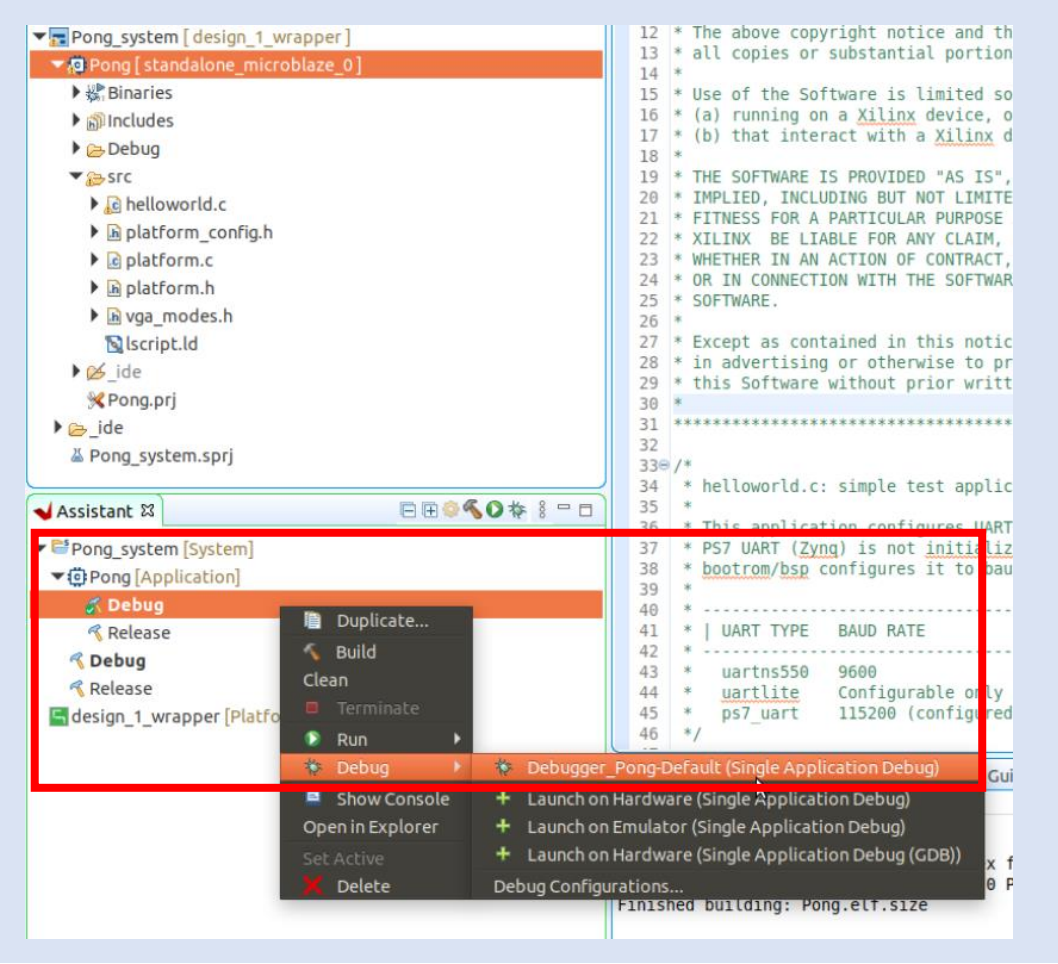
Crowd Supply: Lab Two

Step 22 – The Vitis project should now show the new files in the “Explorer” window. Open the build menu by clicking the arrow next to the hammer icon highlighted below. Click “Debug” to build the project again.



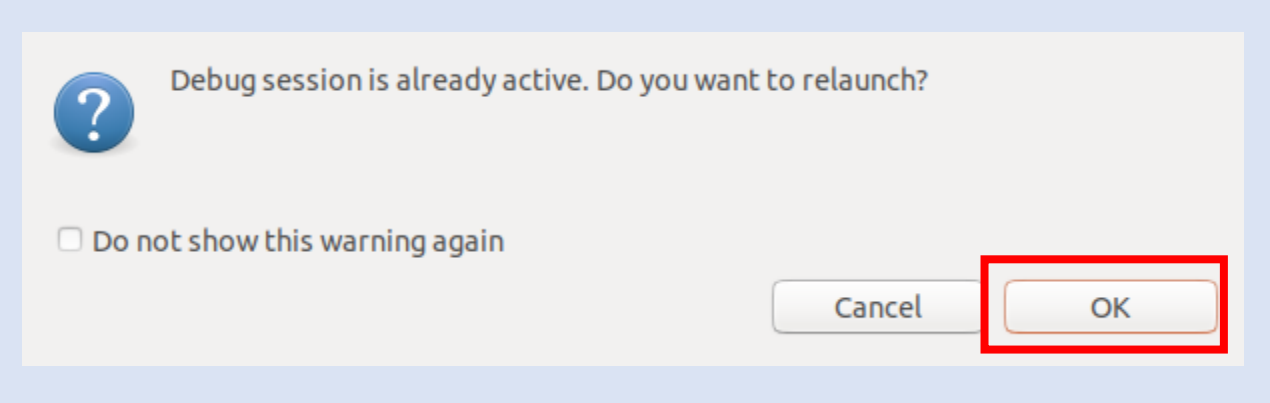
Crowd Supply: Lab Two

Step 23 – Once the build completes, relaunch the software debugger on the hardware as shown below. Note that we are **reusing** the previous debugger (not creating a new one) by selecting “Launch on Hardware”.



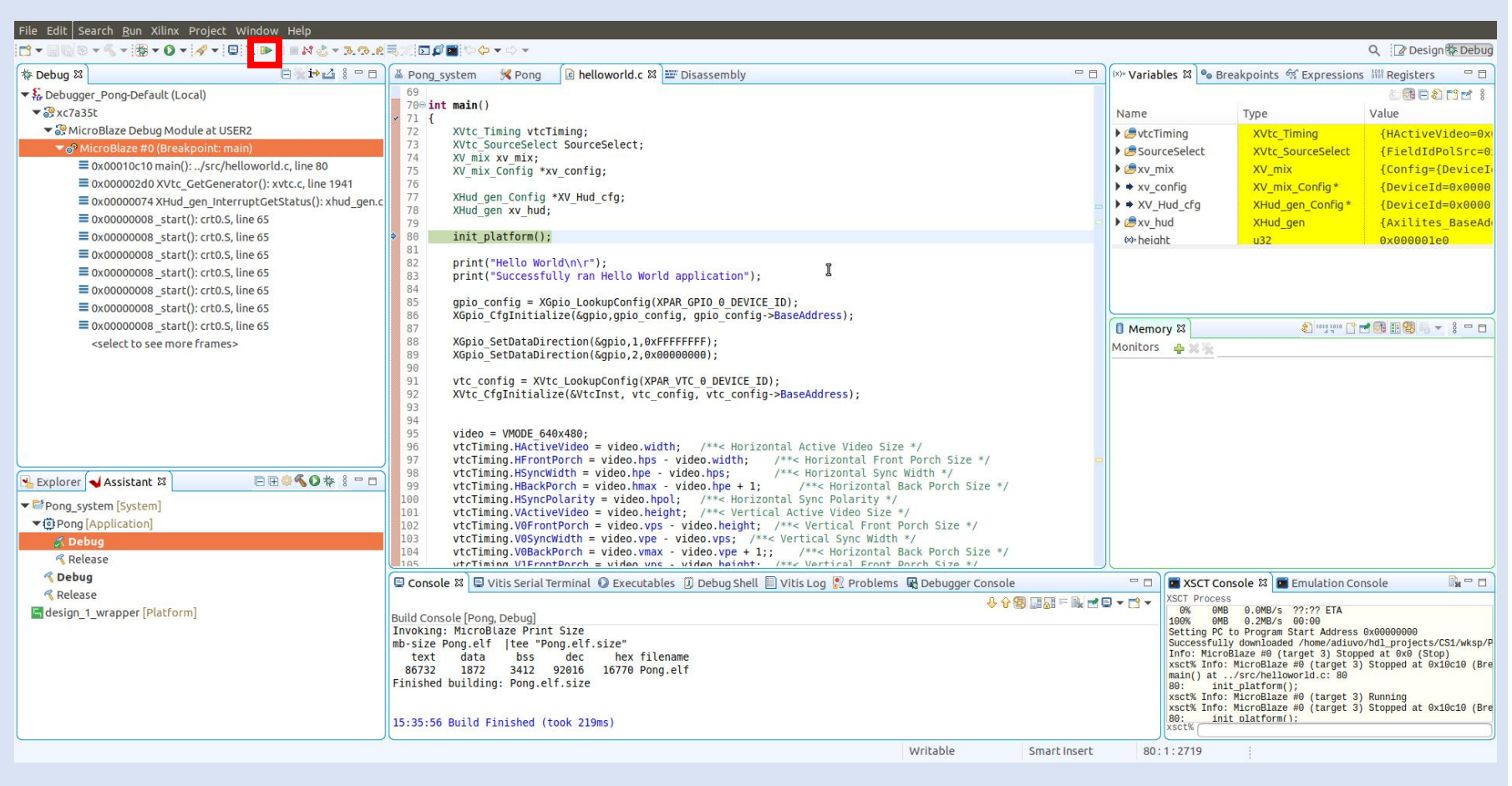
Crowd Supply: Lab Two

Step 24 – If you see a dialogue about an already active debug session, click “OK” to relaunch.



Crowd Supply: Lab Two

Step 25 – Once the first step of the application runs, verify your VGA monitor is attached and click on the icon highlighted below to continue the run. After a few seconds, you should see the game appear on the monitor attached to your VGA cable.

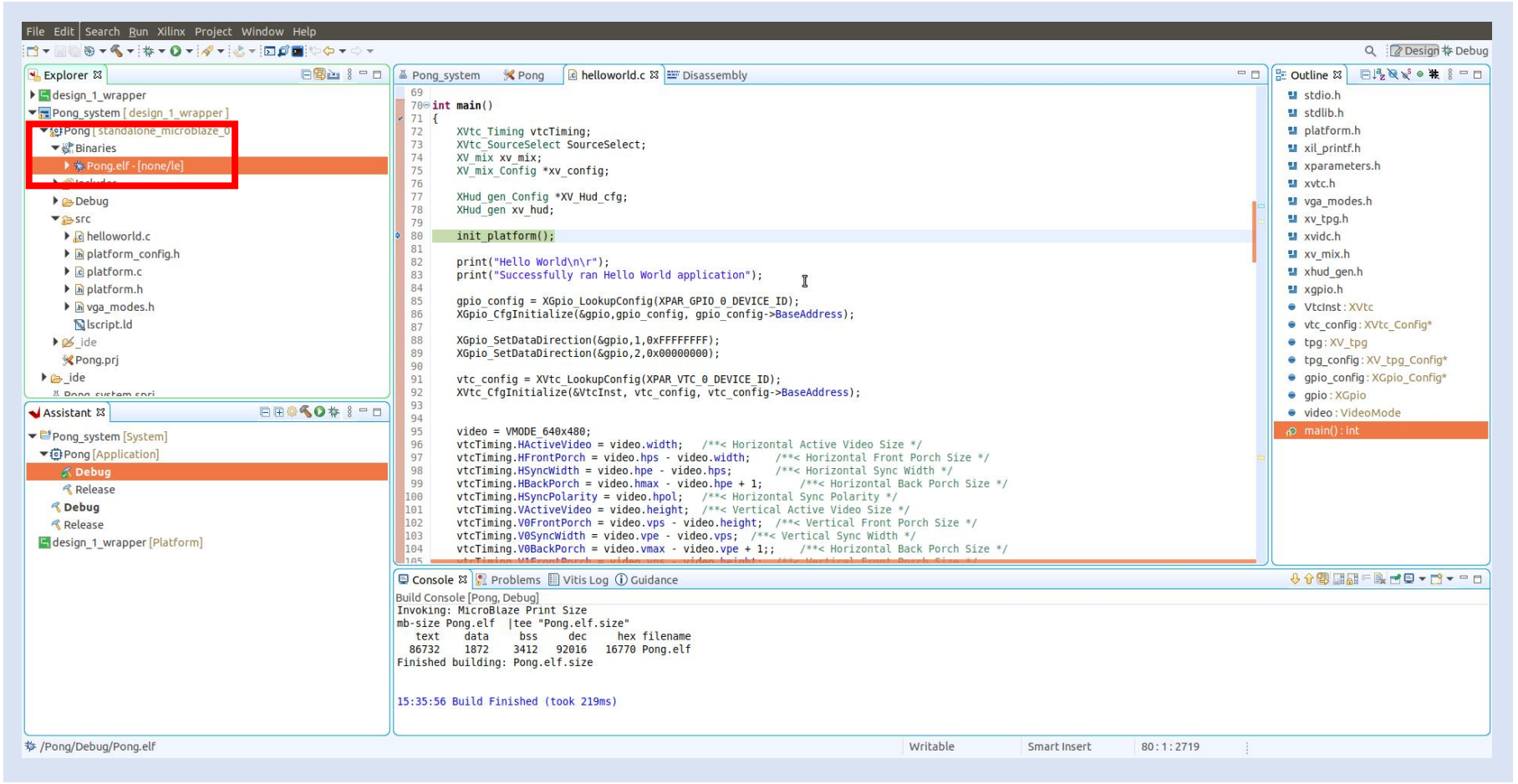


Part 3:

Running the Application From Board Power Up

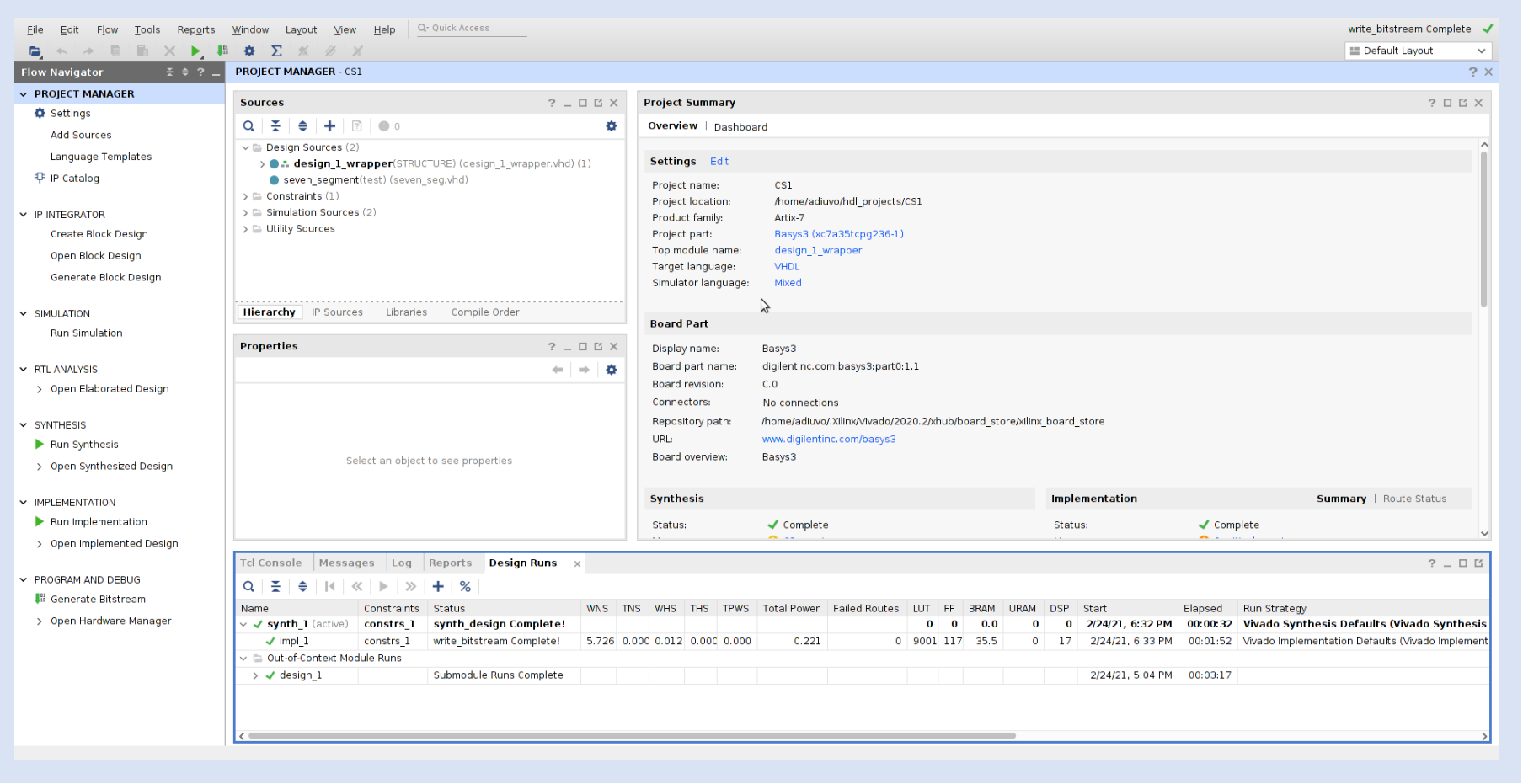
Crowd Supply: Lab Two

Step 26 – Expand “Binaries” in the “Explorer” window and you will see the ELF file that is running on the MicroBlaze. To use this on our board from power-up (without running the application through Vitis), we need to include it in our bitstream.



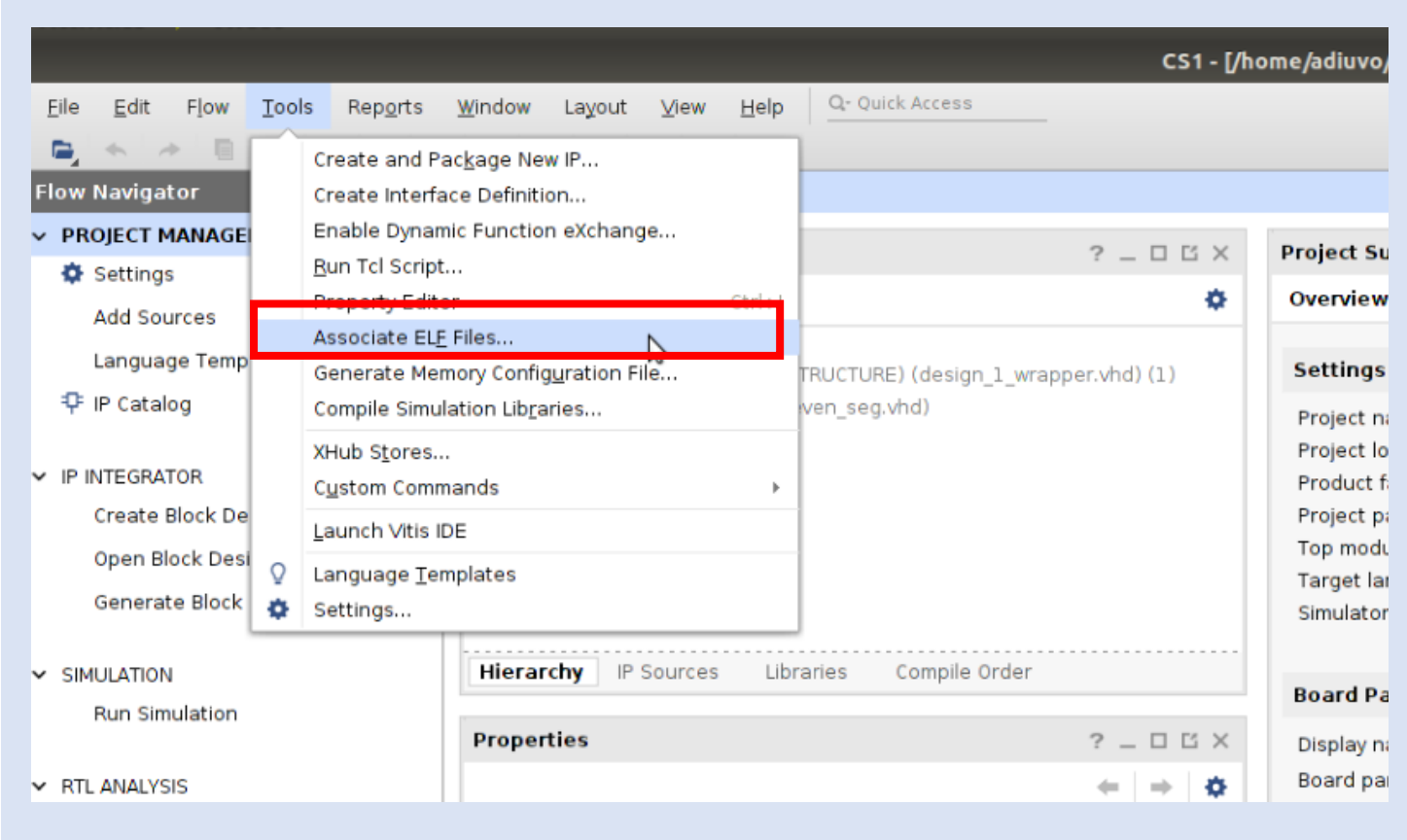
Crowd Supply: Lab Two

Step 27 – Switch back to your Vivado project.



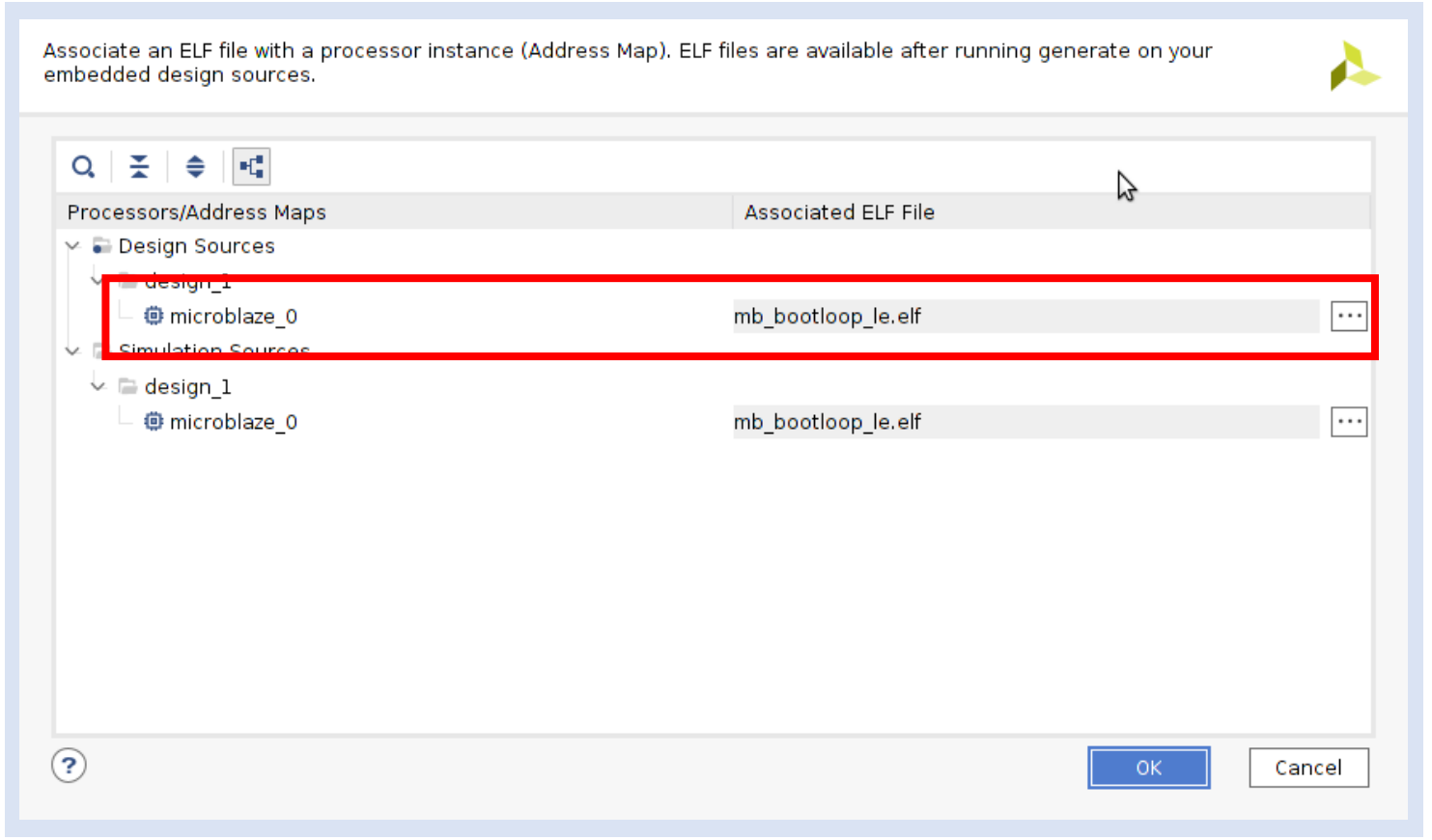
Crowd Supply: Lab Two

Step 28 – Navigate to the Tools menu and select “Associate ELF Files…”



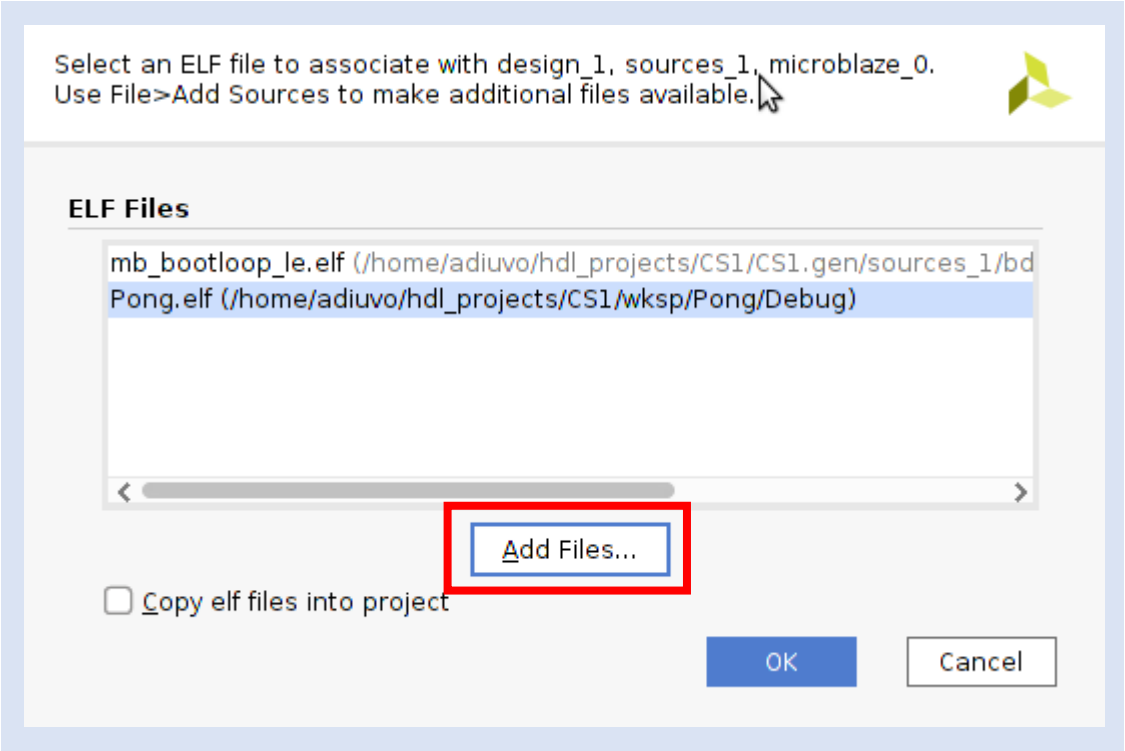
Crowd Supply: Lab Two

Step 29 – In the next window, under “Design Sources” > “design_1”, select “…” for the microblaze_0 design source.



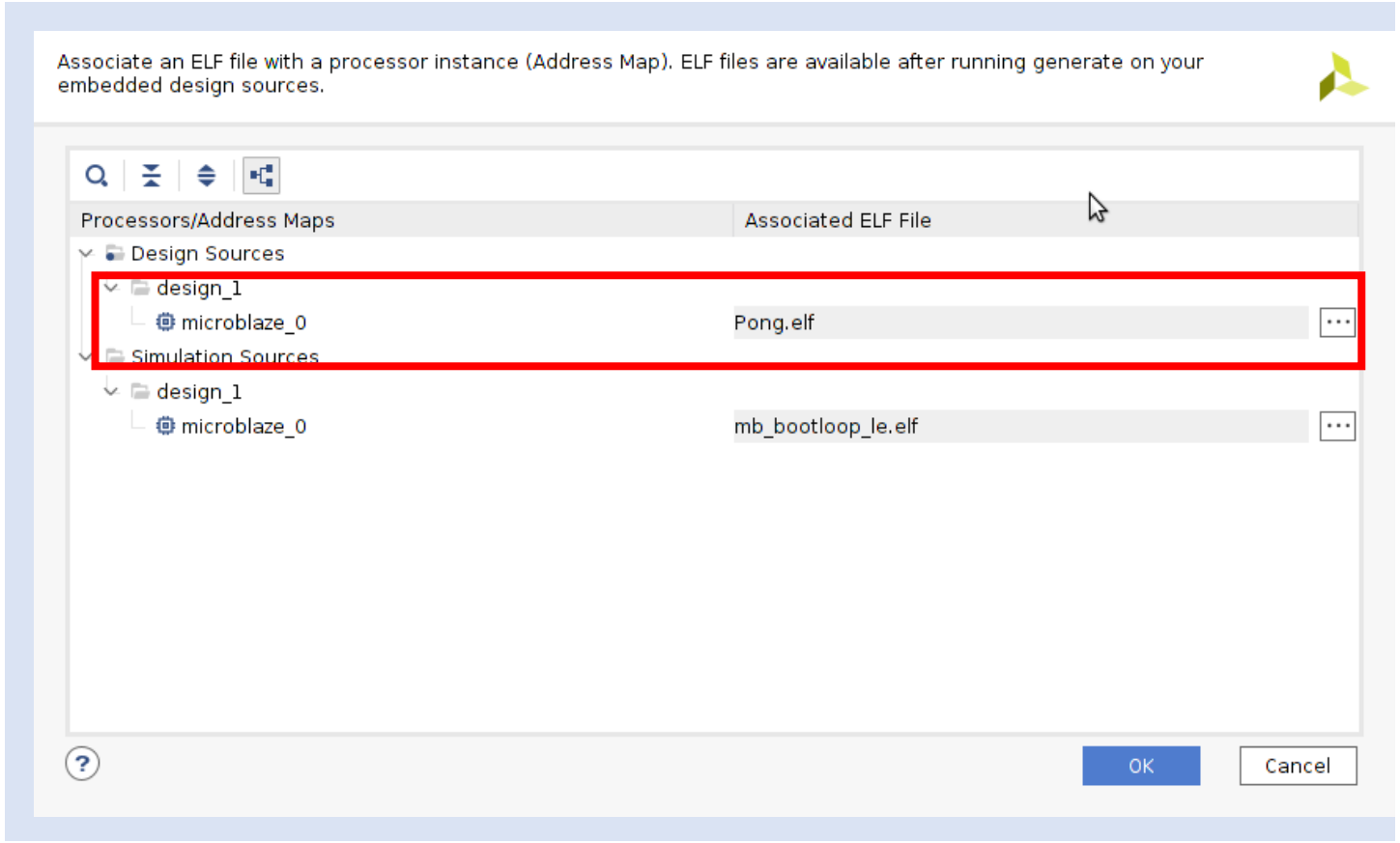
Crowd Supply: Lab Two

Step 30 – Click “Add Files…” and select the ELF file we created from our Vitis project. Click “OK”.



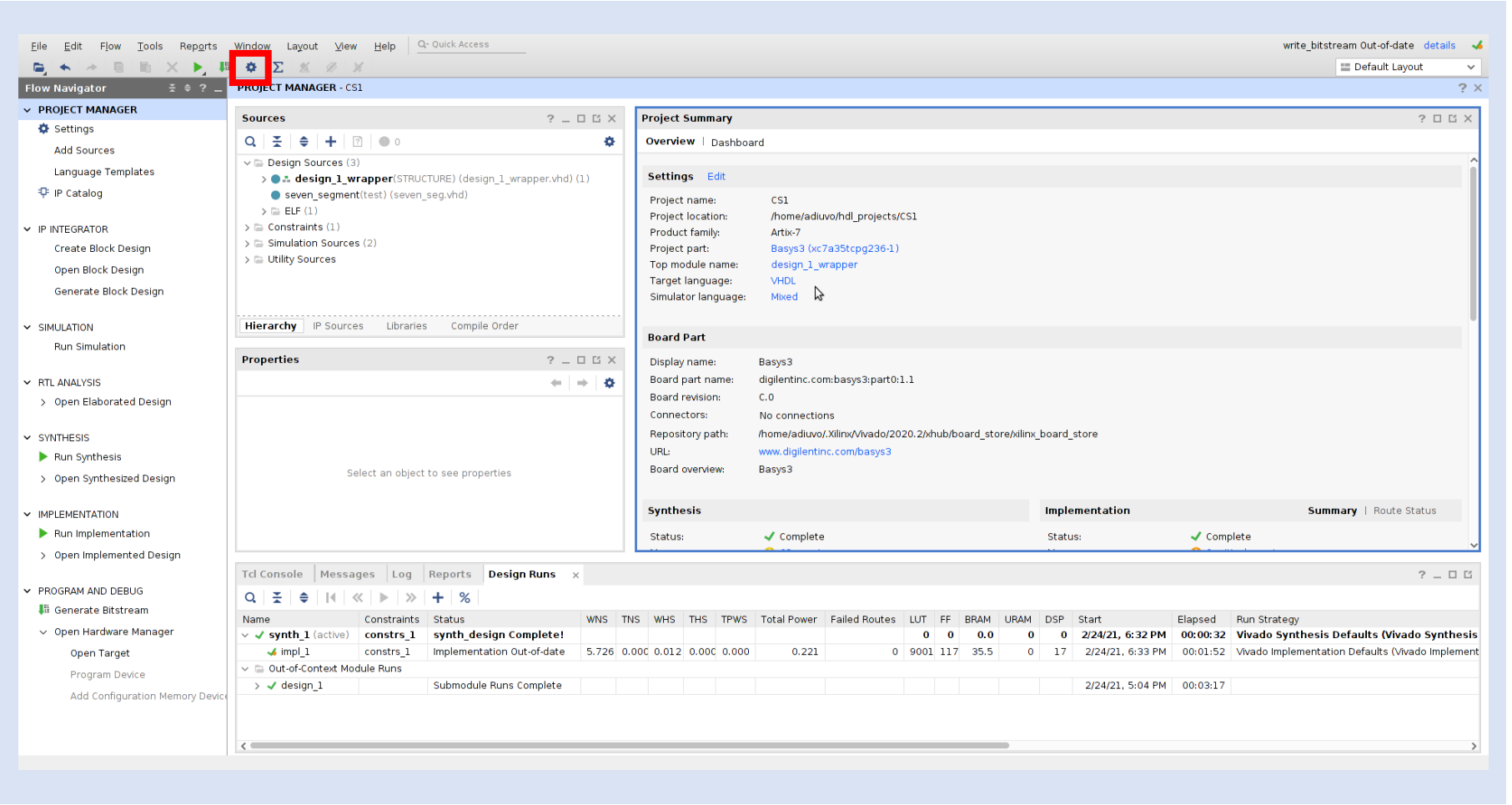
Crowd Supply: Lab Two

Step 31 – Select the <Application Name>.elf (e.g., Pong.elf) file and click “OK”.



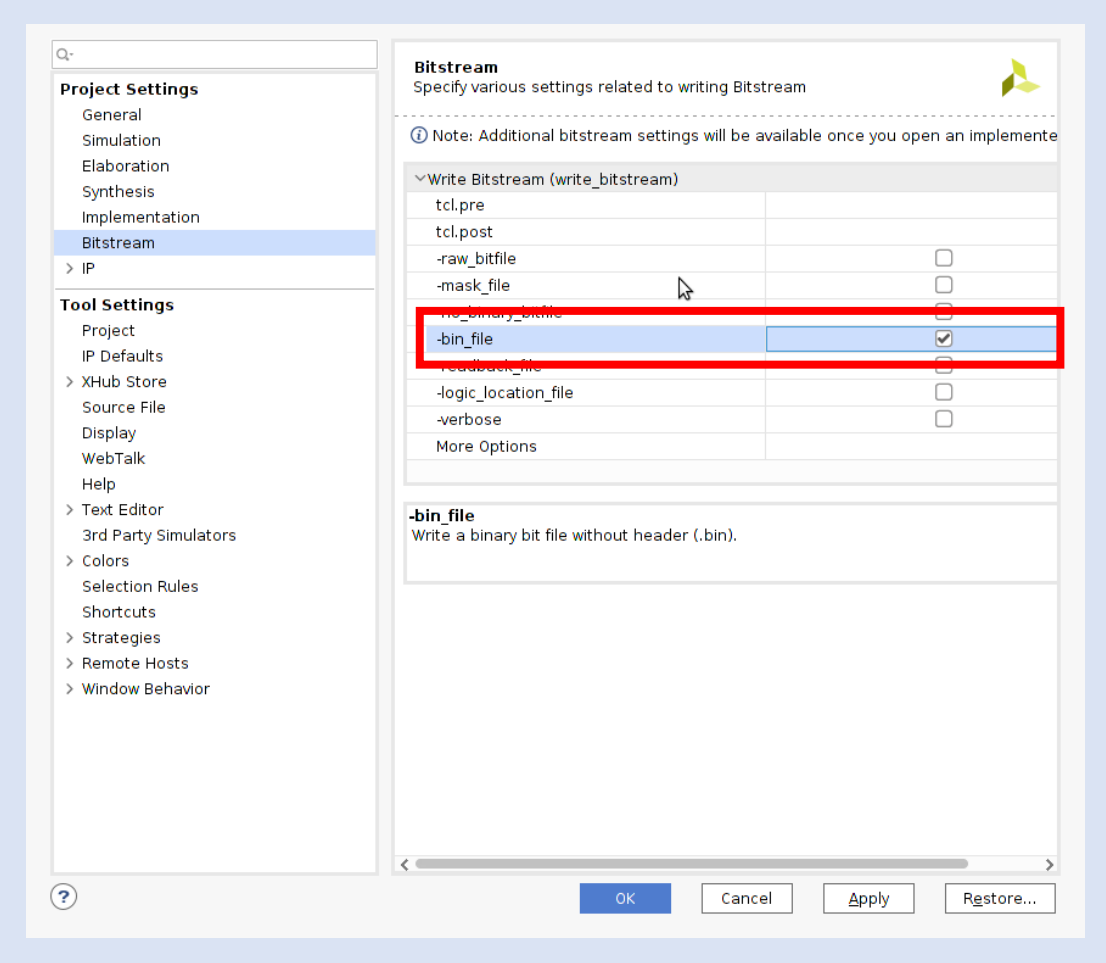
Crowd Supply: Lab Two

Step 32 – Select the gear icon at the top of the GUI to open the design settings.



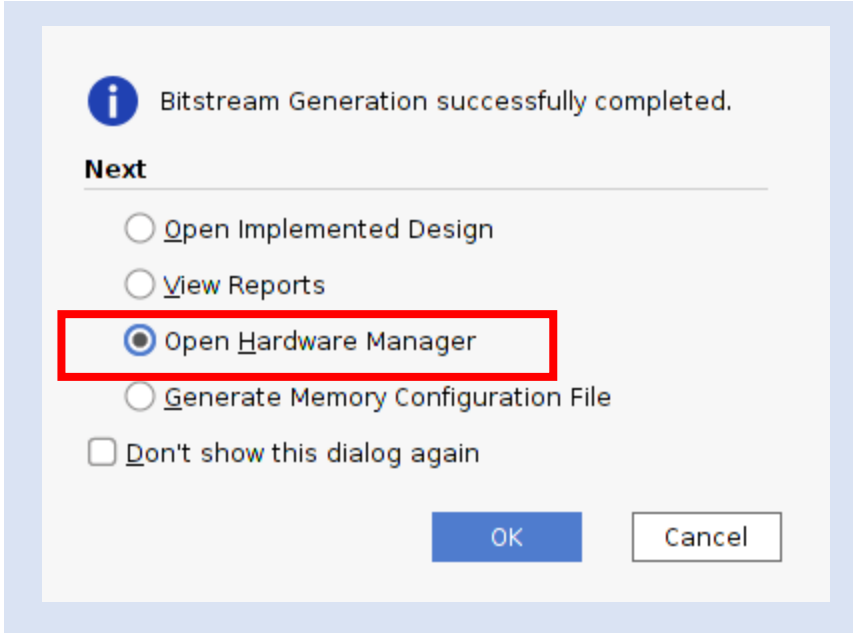
Crowd Supply: Lab Two

Step 32 – Under “Project Settings” > “Bitstream”, select –bin_file. Click “Apply” and then “OK” to confirm settings.



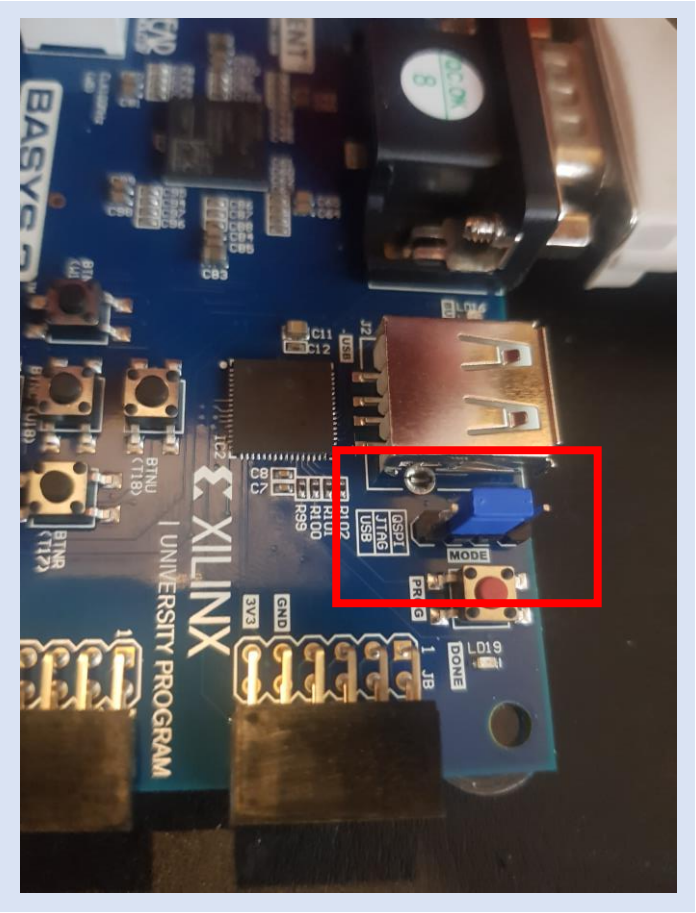
Crowd Supply: Lab Two

Step 33 – Rerun the bitstream generation as we did in the previous lab. After the bitstream generation completes, select “Open Hardware Manager” and click “OK”.



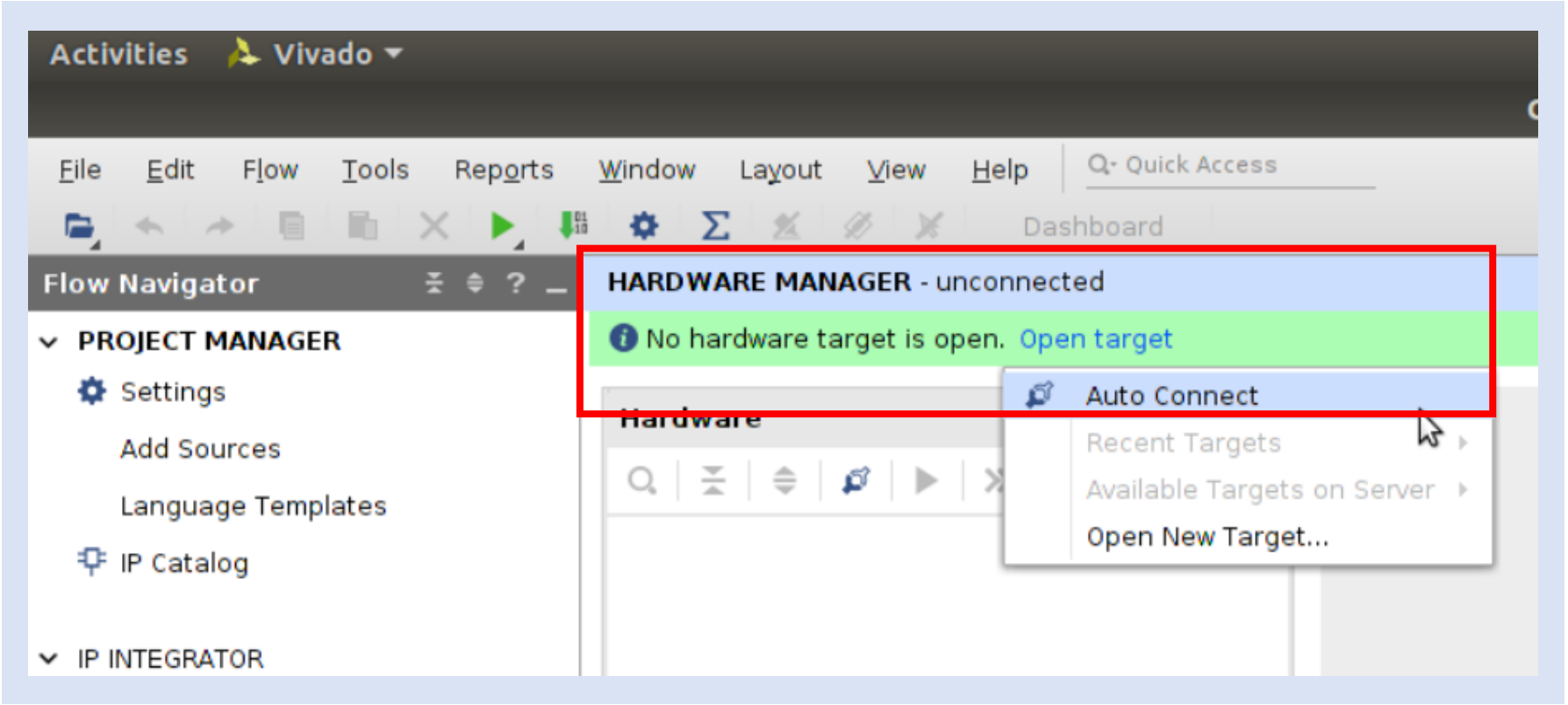
Crowd Supply: Lab Two

Step 34 – With the board powered off, set the configuration mode to JTAG. Remove the jumper at JP1 and set it to JTAG as shown below. Then power on the board.



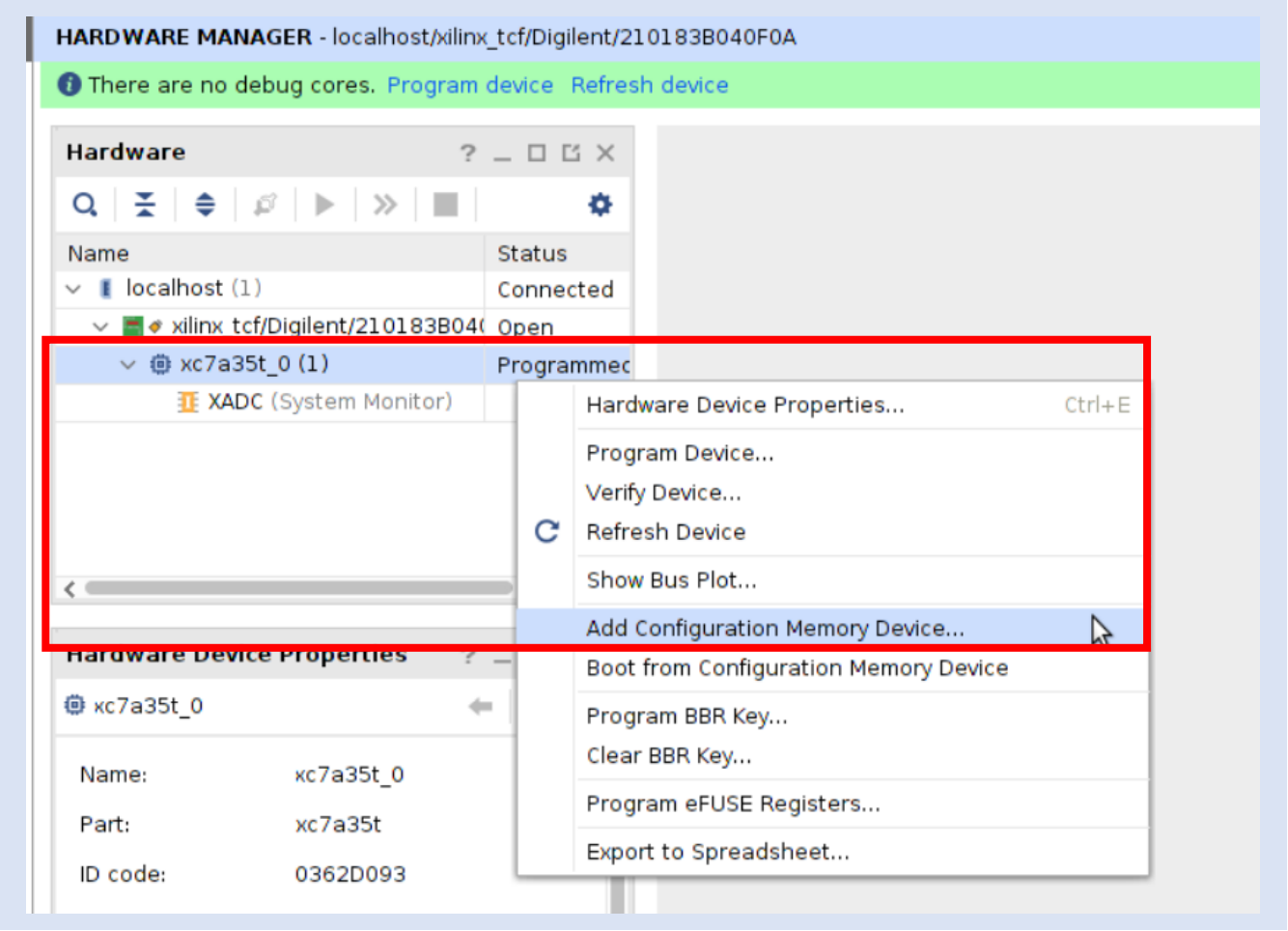
Crowd Supply: Lab Two

Step 35 – When the Hardware Manager opens, select “Open target” and then “Auto Connect”.



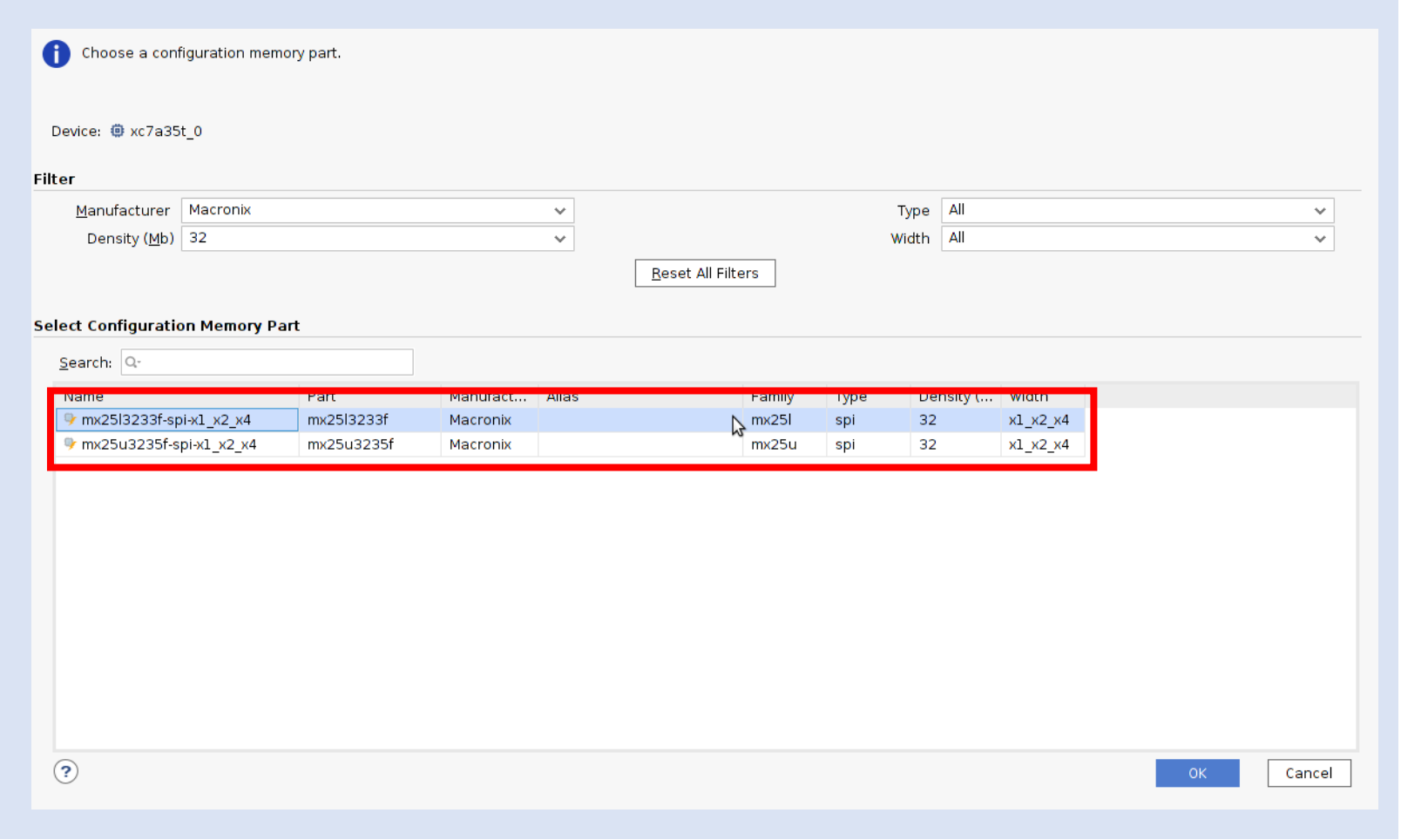
Crowd Supply: Lab Two

Step 36 – After the target is opened, right-click your board in the Hardware window and select “Add Configuration Memory Device…”



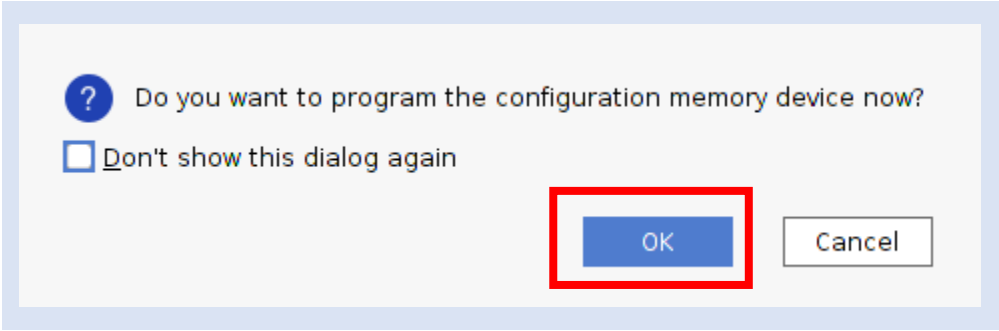
Crowd Supply: Lab Two

Step 37 – Select the appropriate memory device (depending on the QSPI fitted) and click “OK” to confirm.



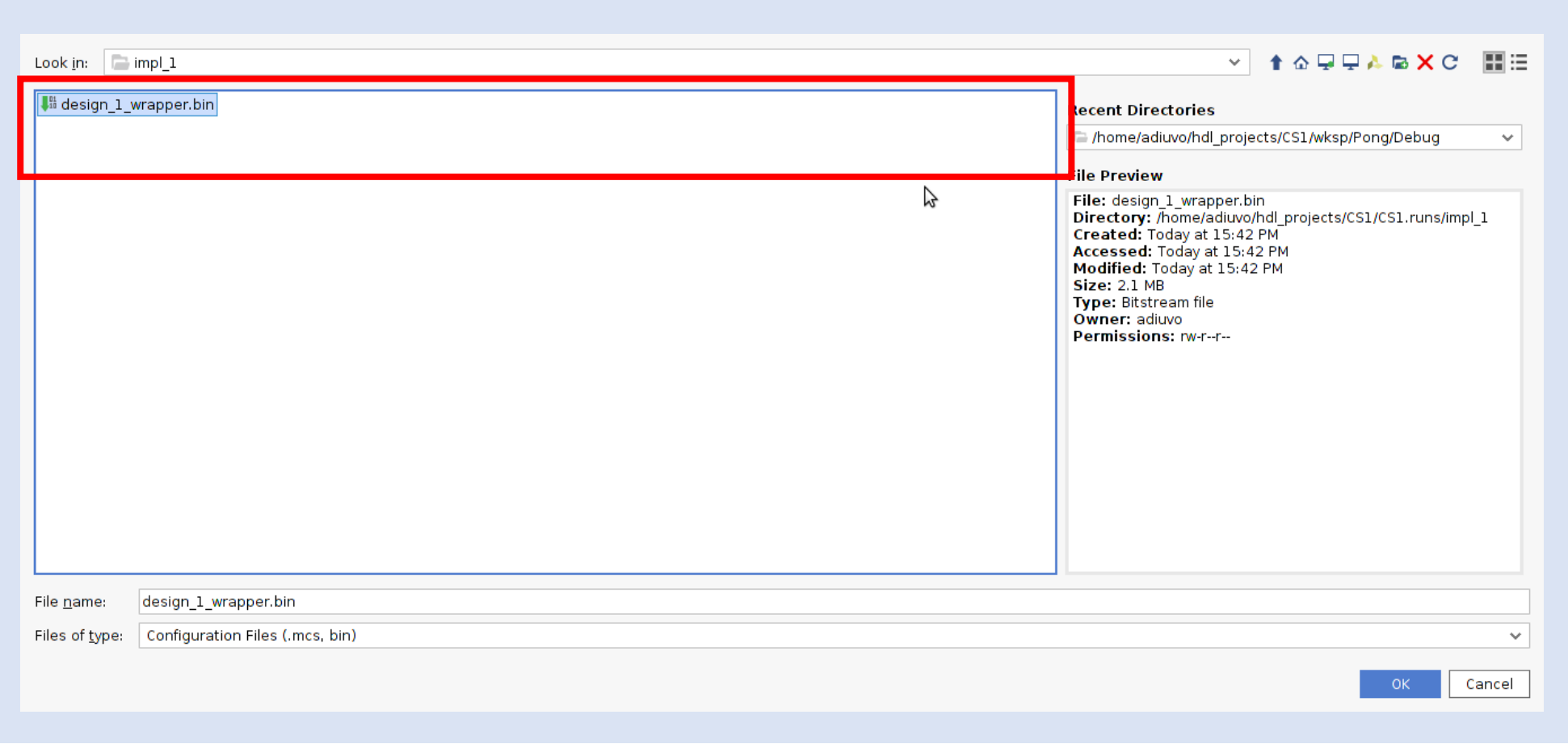
Crowd Supply: Lab Two

Step 38 – When prompted to configure the memory device, click “OK”.



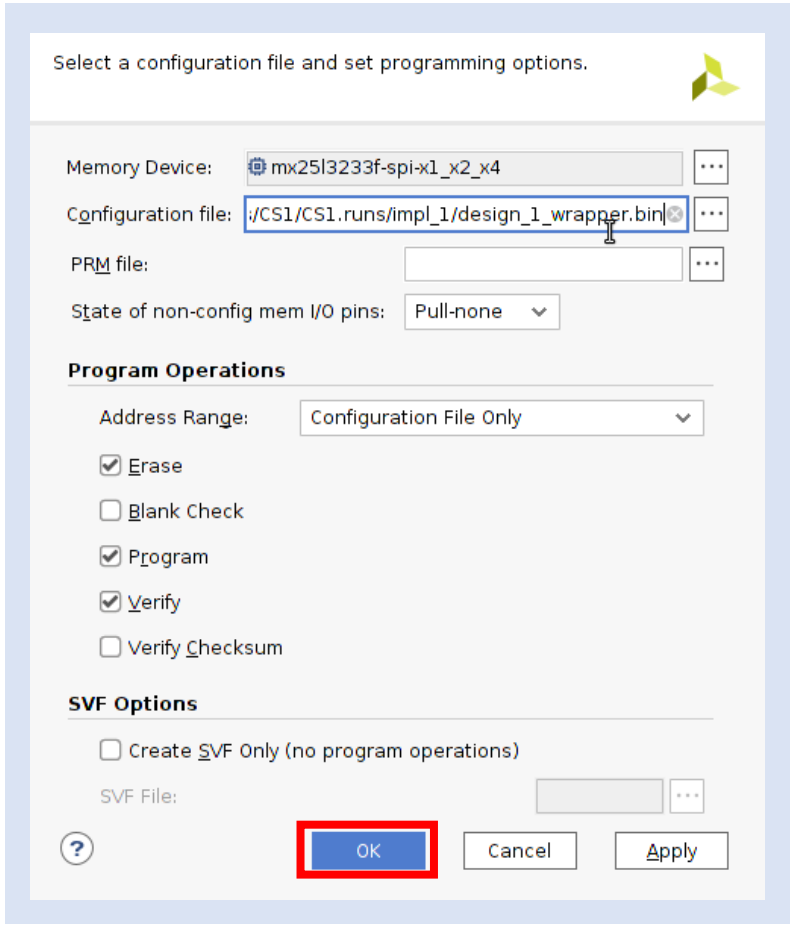
Crowd Supply: Lab Two

Step 39 – Select the BIN file you have just created after navigating to your Vivado project folder > <project>.runs > impl_1 . Click “OK” to confirm.



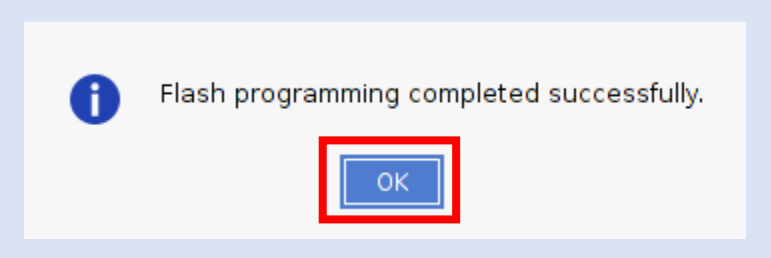
Crowd Supply: Lab Two

Step 40 – Keep the defaults in the following window and click “OK” to start the programming of the flash. Ensure power to the board is not disrupted while the write takes place.



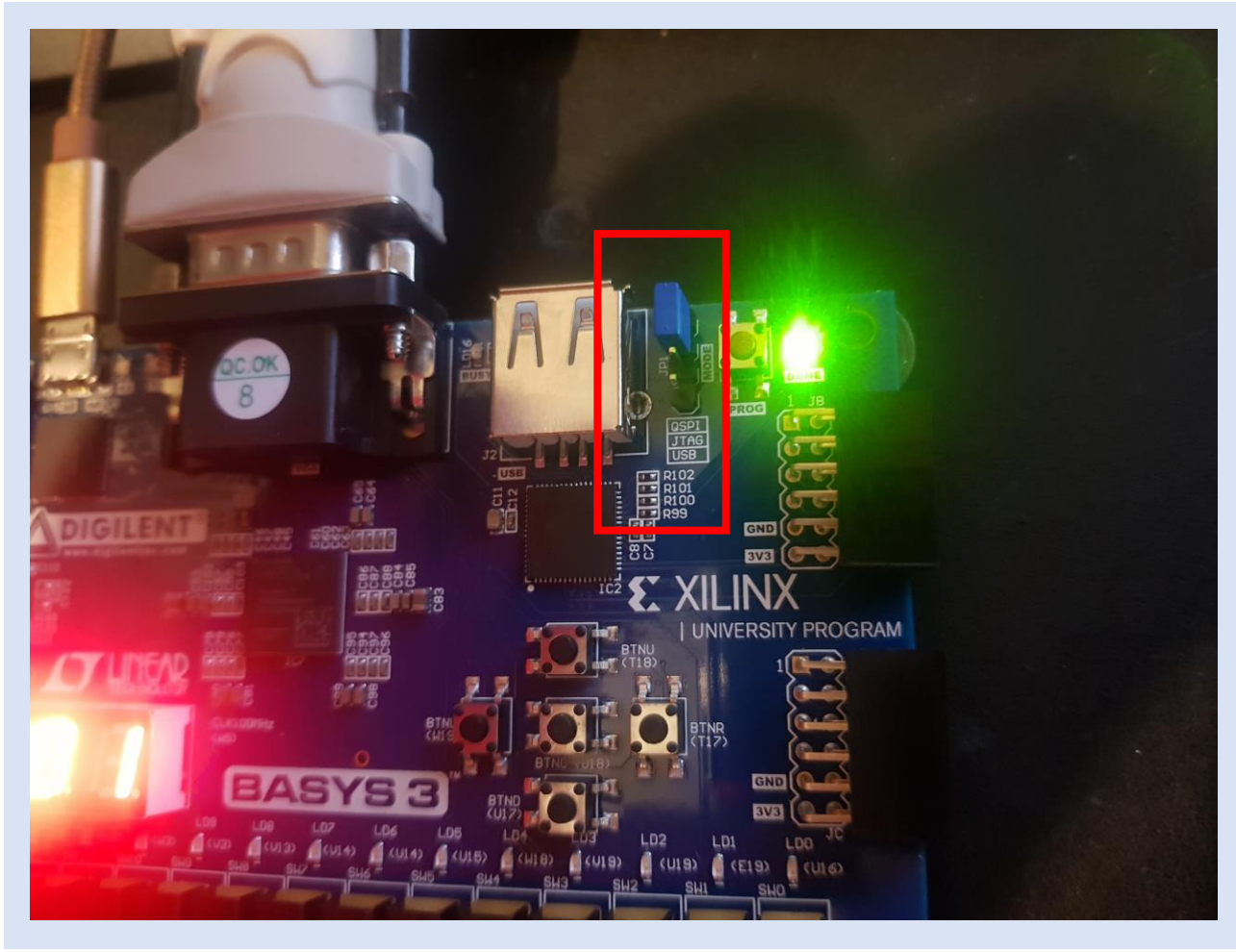
Crowd Supply: Lab Two

Step 41 – Once the flash is finished, click “OK”. Close the hardware manager and the Vivado project.



Crowd Supply: Lab Two

Step 42 – Power off the board and set JP1 to QSPI. Ensure your device is connected to your monitor via VGA and power on the board again.



Crowd Supply: Lab Two

Step 43 – After a few seconds, the game should start on the screen as shown below.

Commands:

BtnE/BtnW: Move the paddle left and right
BtnS: Increase paddle size
BtnN: Decrease paddle size
BtnC: Restart the game

A successful hit to the ball increases the score on the Seven Segment Display. Missing the ball will reset the score/game.