

# Getting to Know AMD Vivado™

## Course Workbook

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# About this Workbook

This workbook is designed to be used in conjunction with the Getting to Know AMD Vivado™ course.

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](mailto:adam@adiuvoengineering.com).

# Pre-Lab

## Workshop Pre-requisites

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# Required Hardware

There is no required hardware for this course.

# 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.

AMD Vitis™ 2021.2	<a href="#">Download</a>
Source Project Files	<a href="#">Download</a>

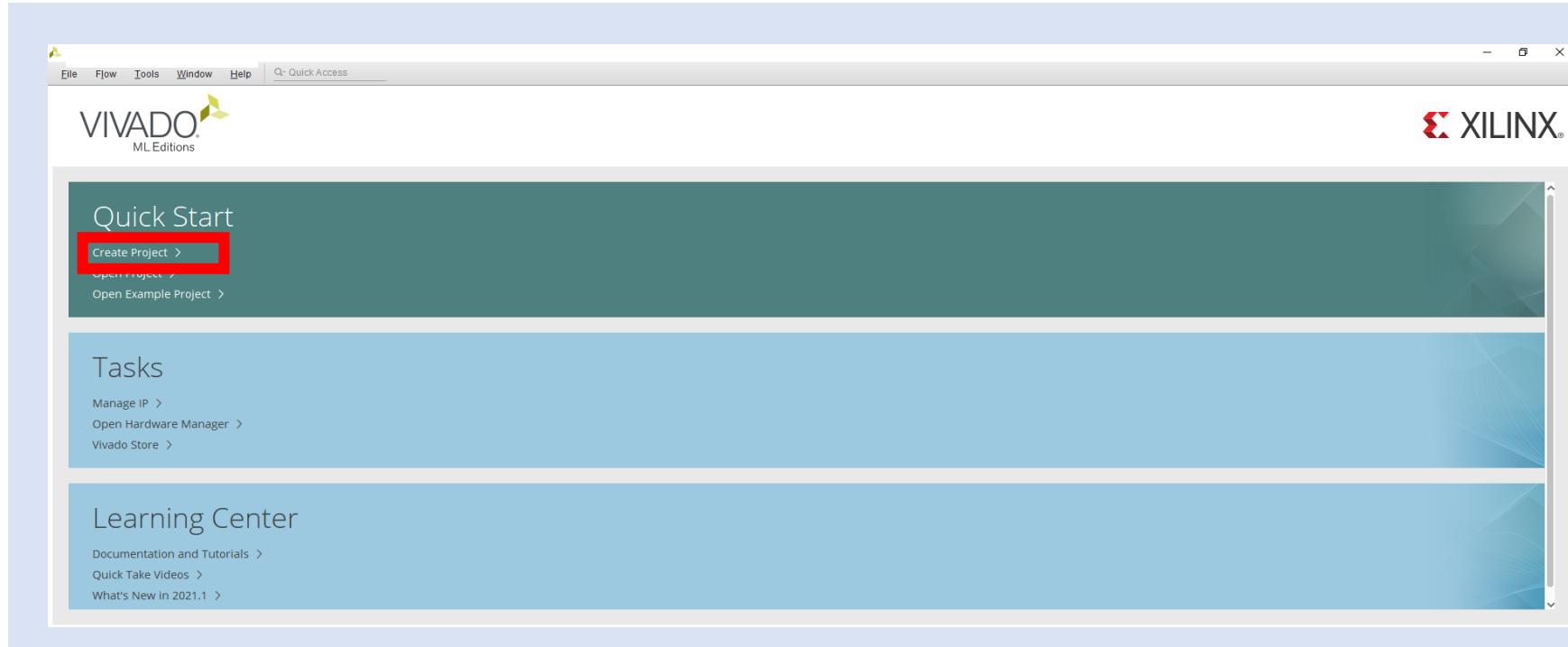
# Lab

## Overview and Introduction to AMD Vivado™

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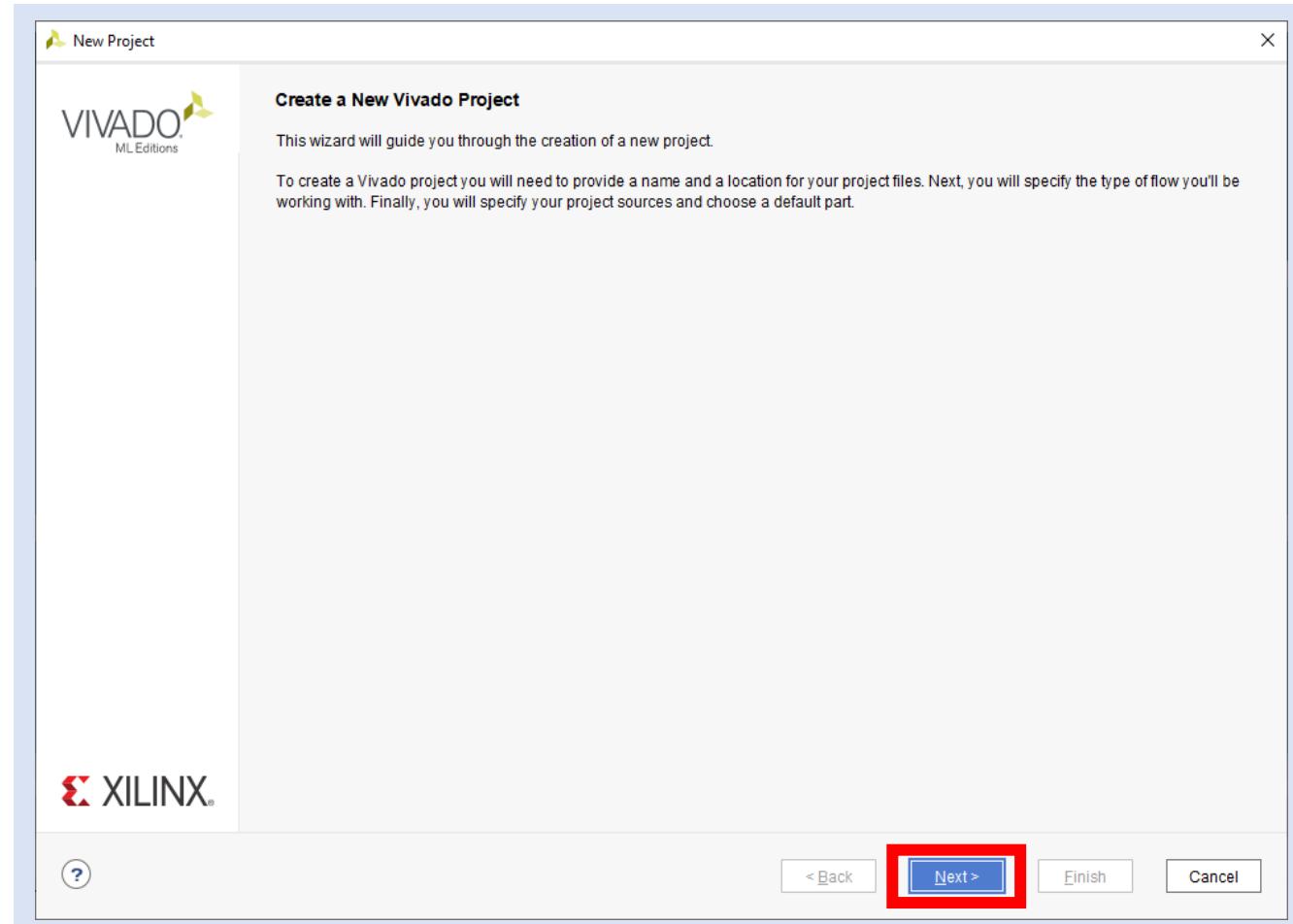
## Step 1 – Open Vivado 2022.2



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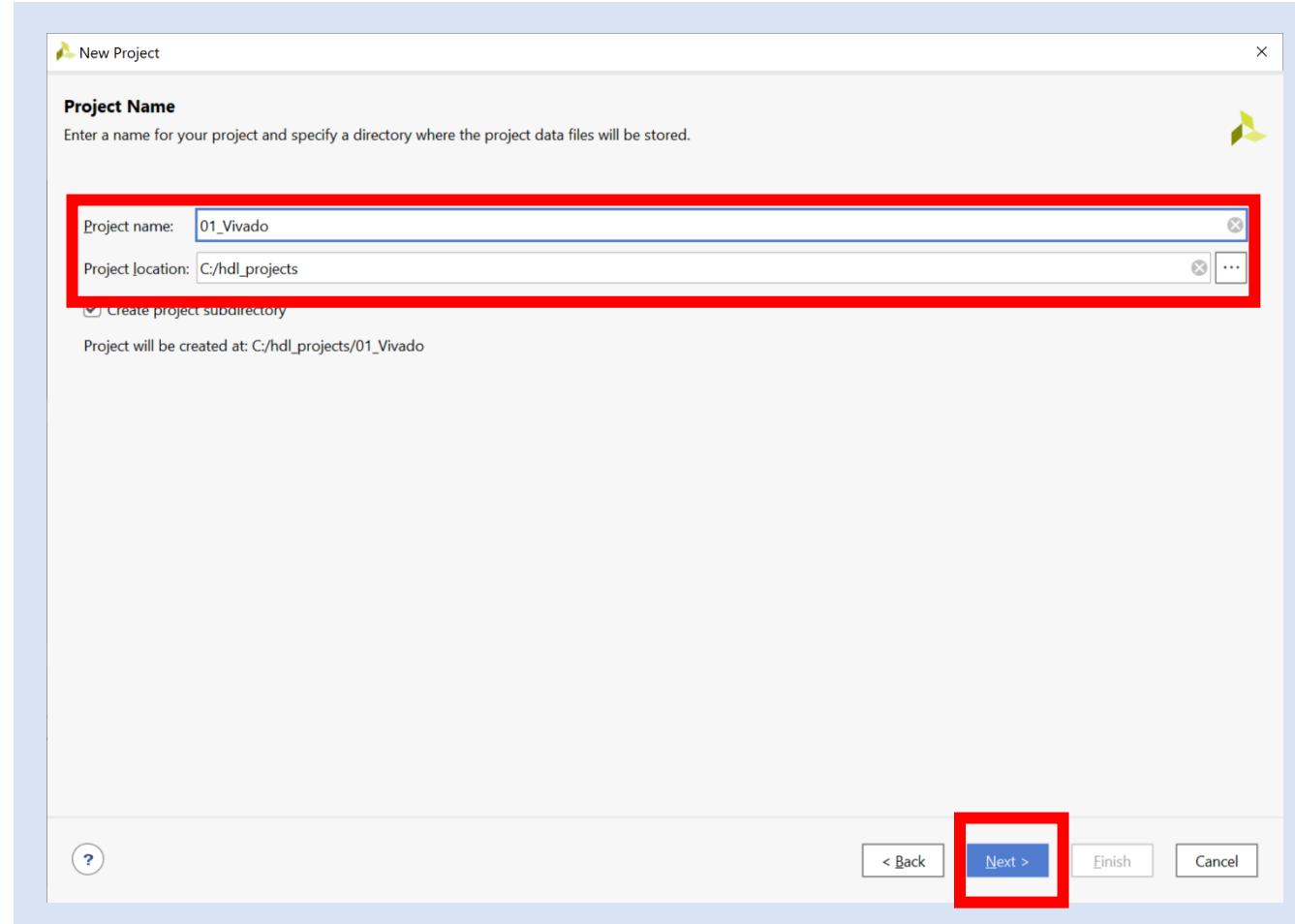
**Step 2 – Click on Create Project.** This will open the New Project Wizard. Click **Next**.



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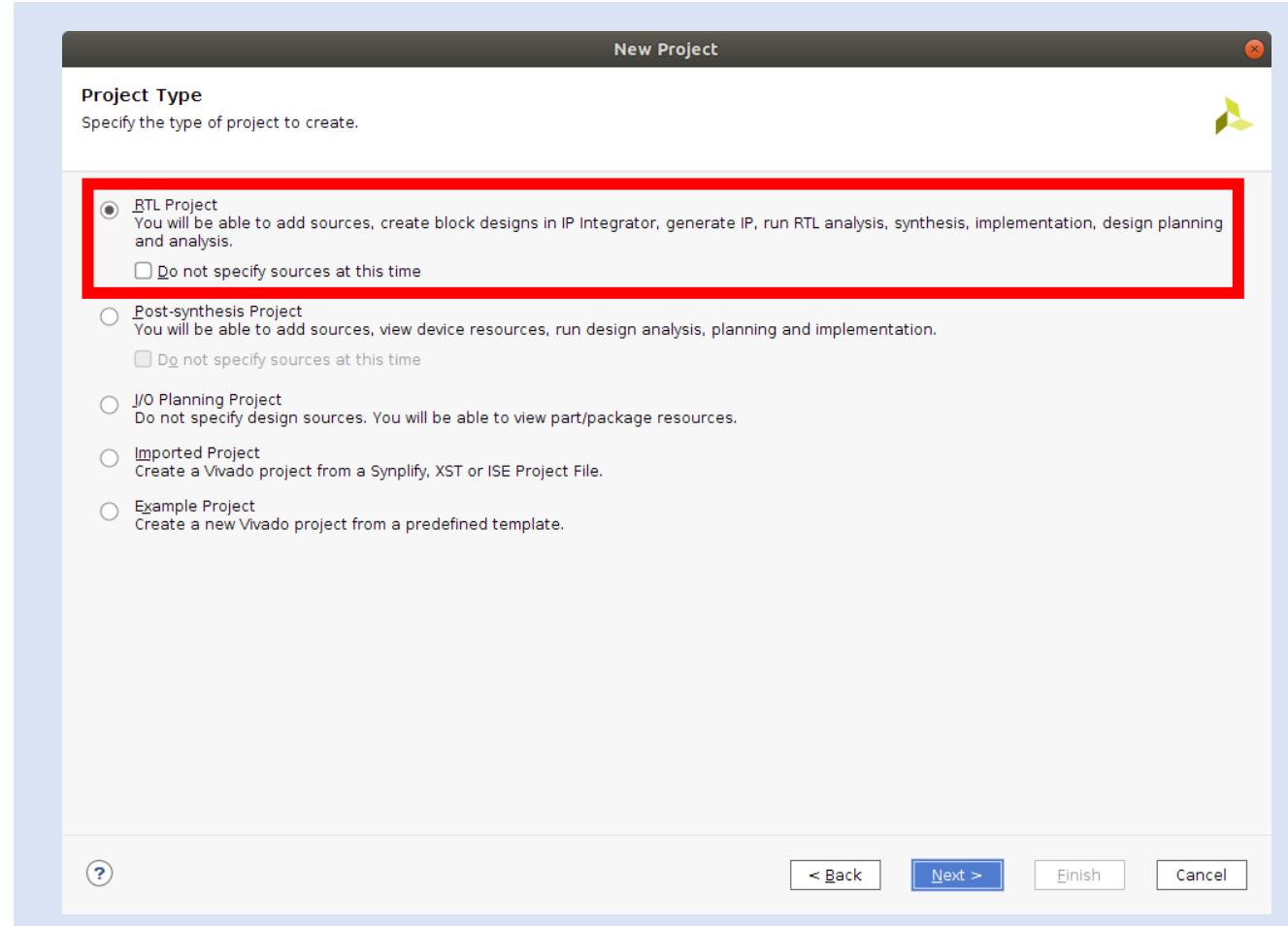
**Step 3 – Enter the project name of “01\_Vivado” and select the location you want to save the project. Click **Next**.**



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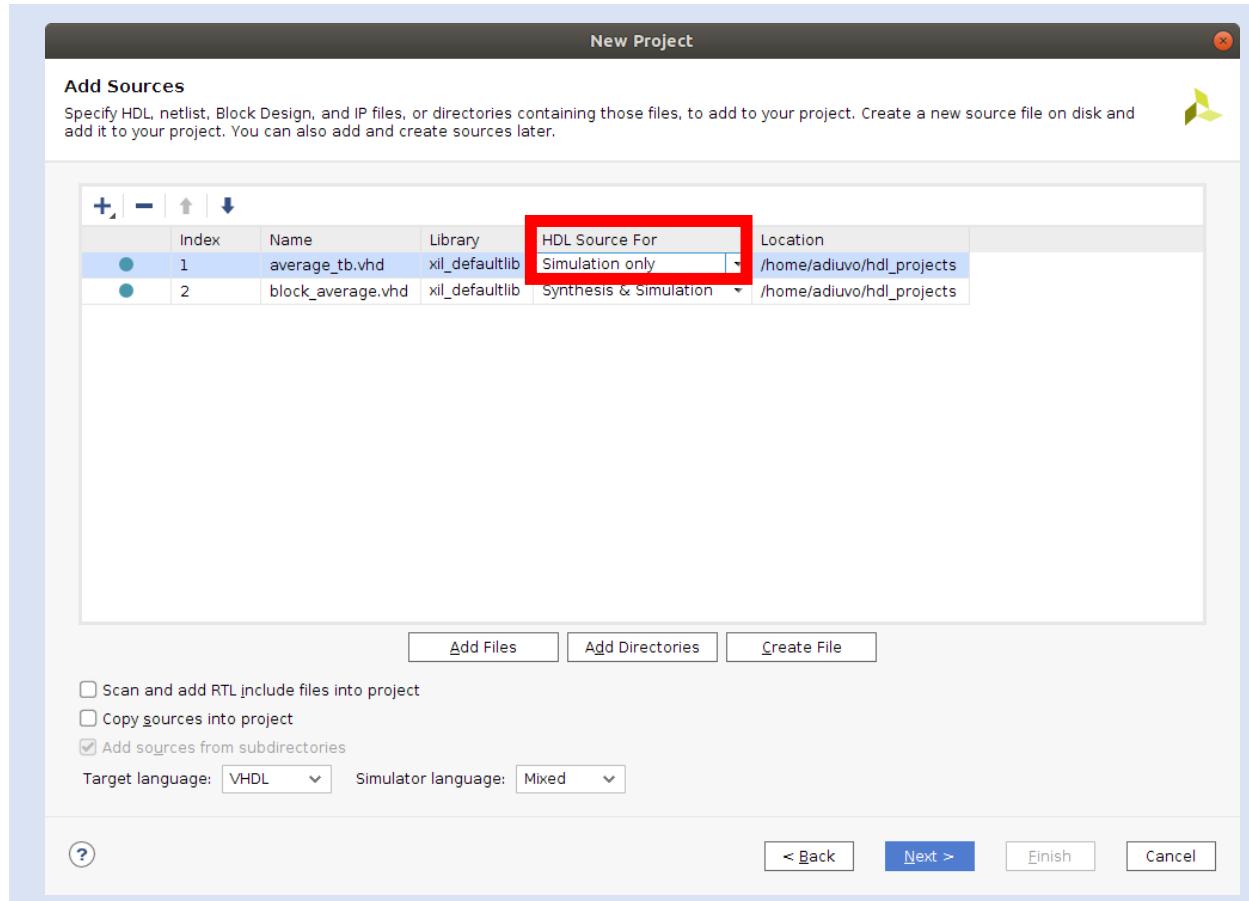
**Step 4 – Select RTL Project.** Check that “Do not specify sources” is unticked.



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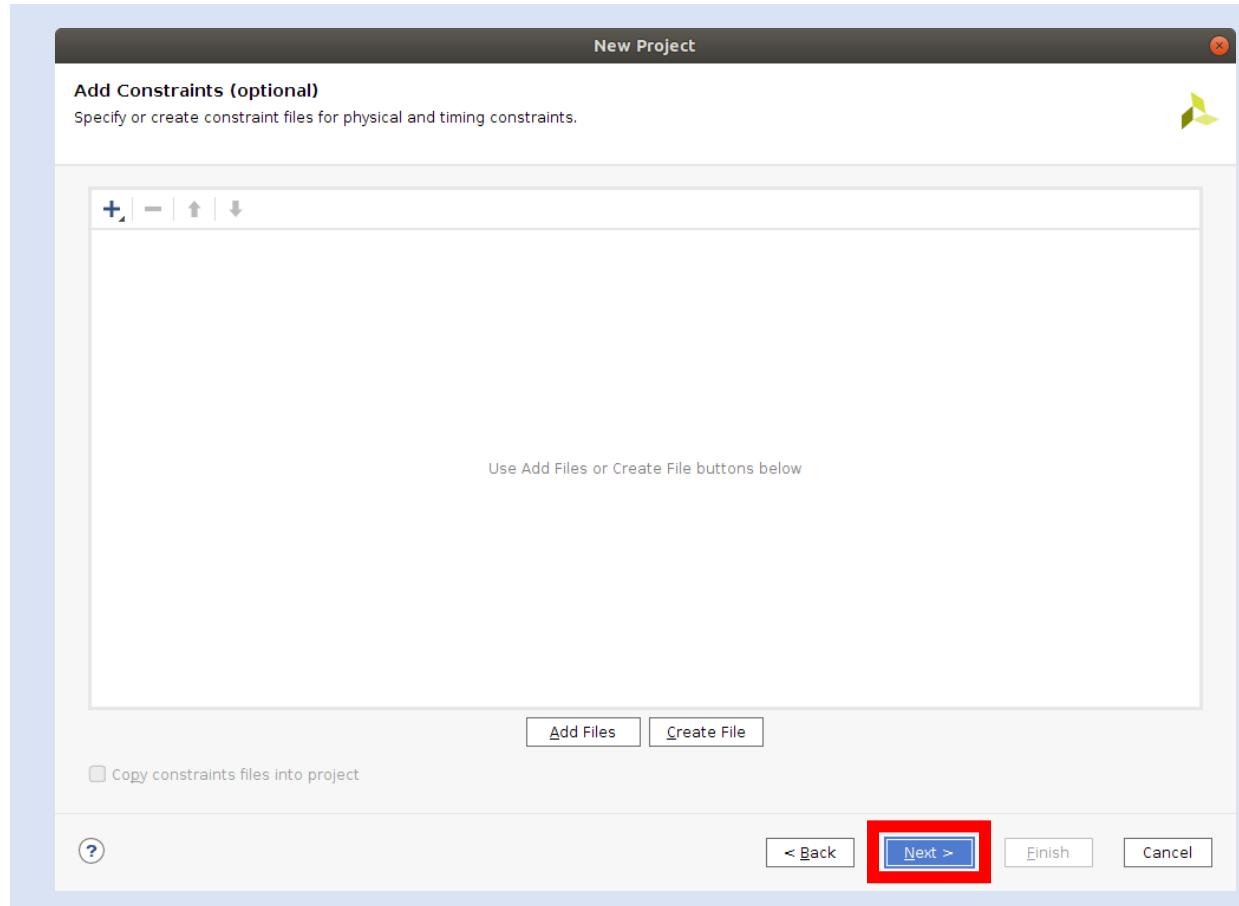
**Step 5 – Click ADD FILES and select the two files downloaded from Github. For the file average\_tb.vhd, change the HDL source to **Simulation Only**. Click **Next**.**



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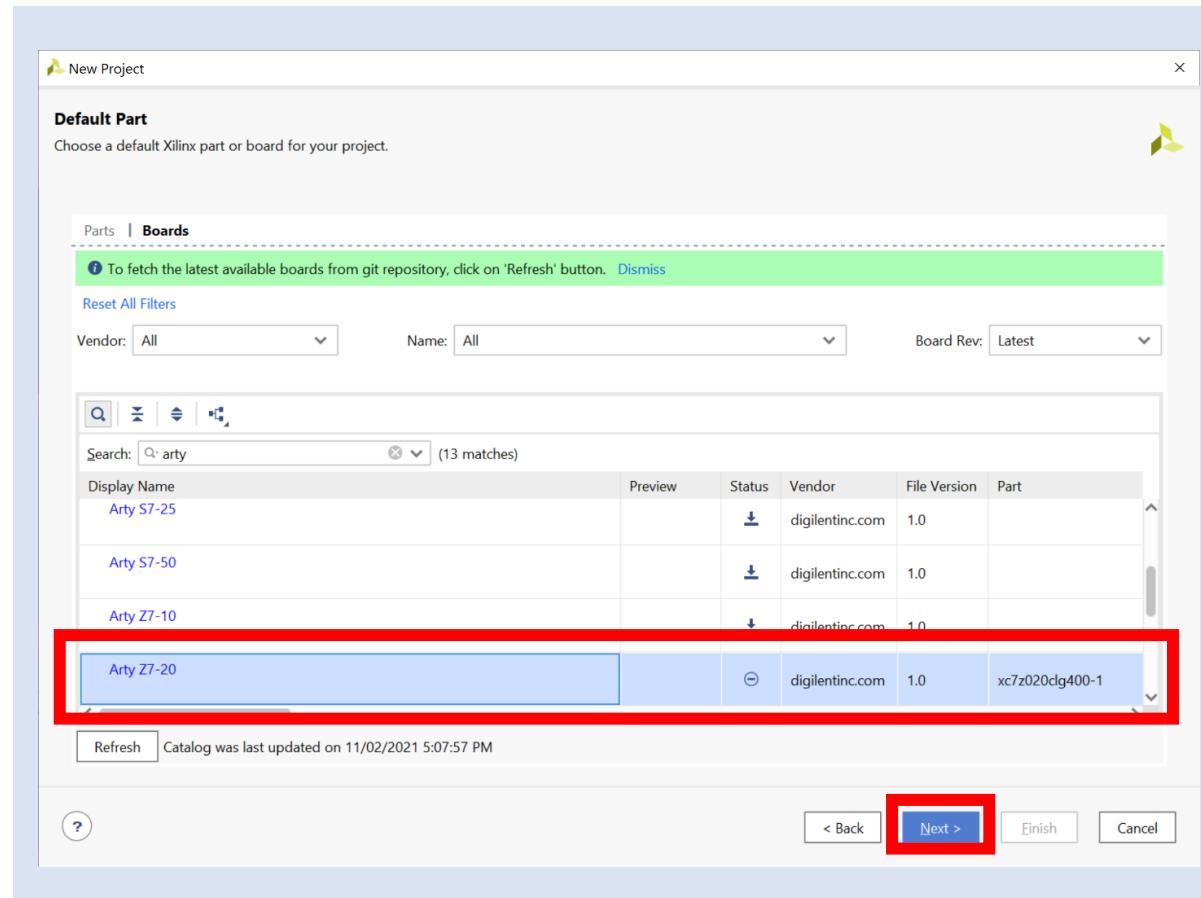
**Step 6 –** At this time we do not want to add any constraints files. Click **Next**.



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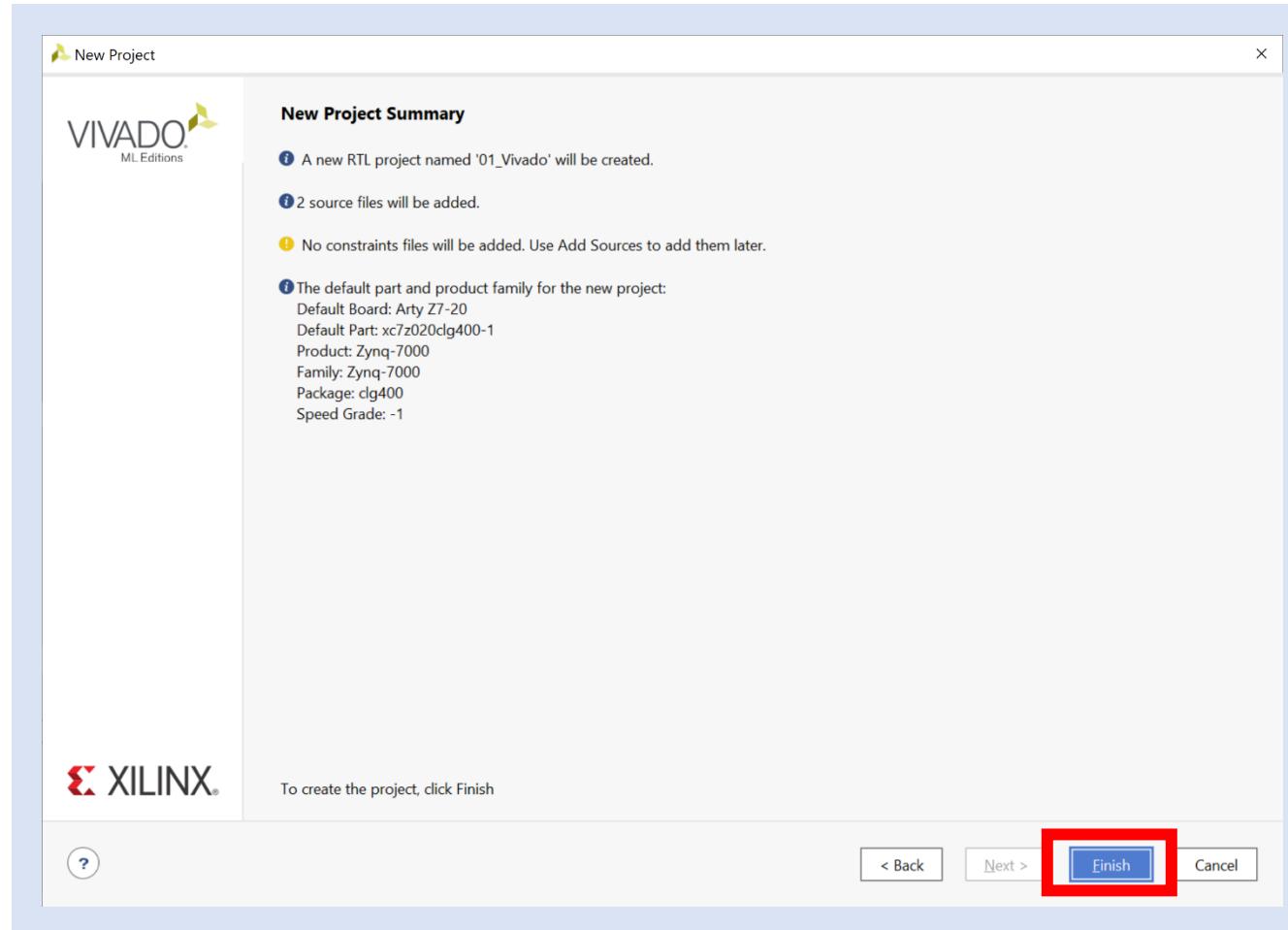
Step 7 – Select the Arty Z7-20 and click **Next**.



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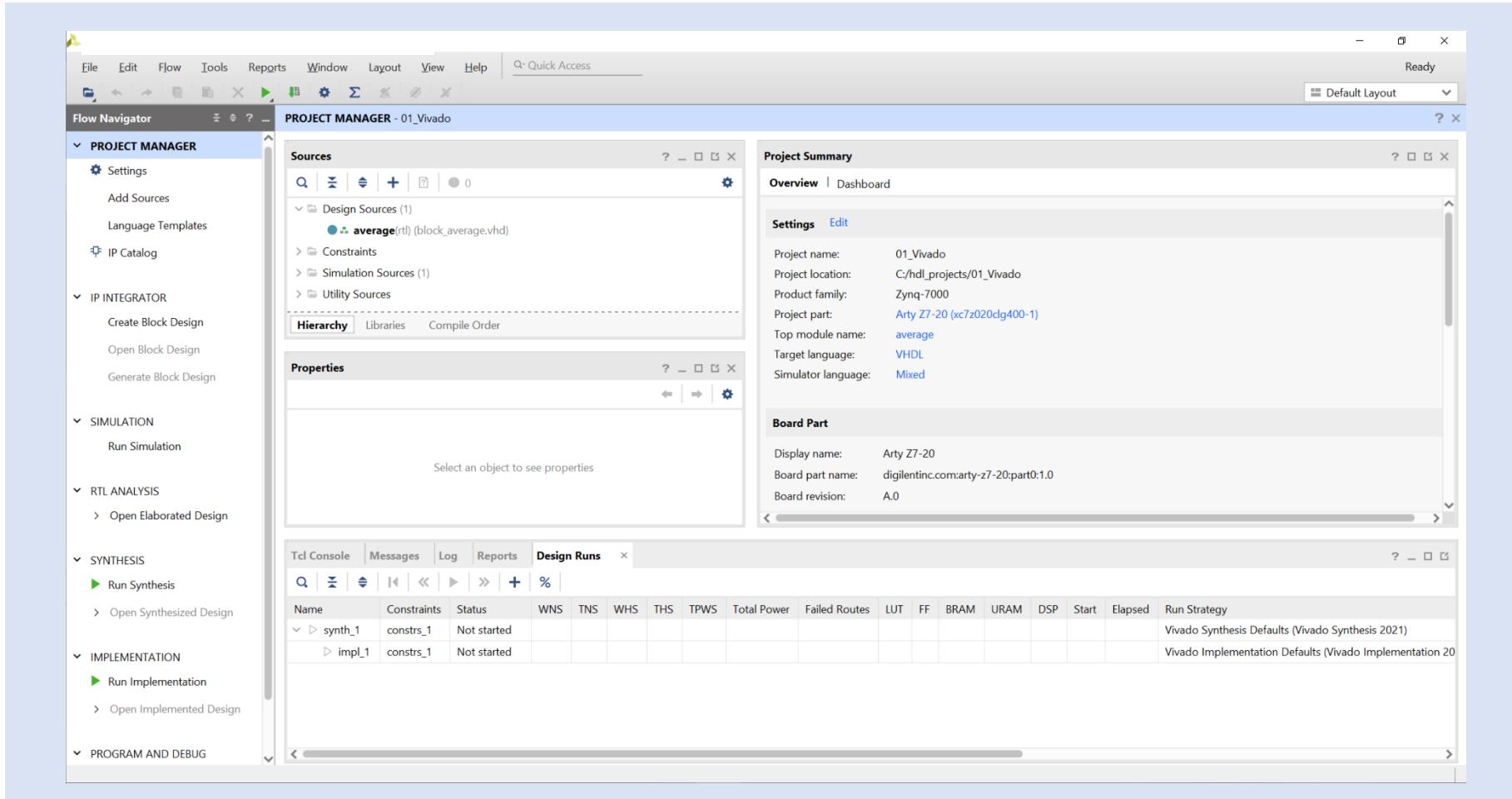
**Step 8 – On the project summary tab, select **Finish**.**



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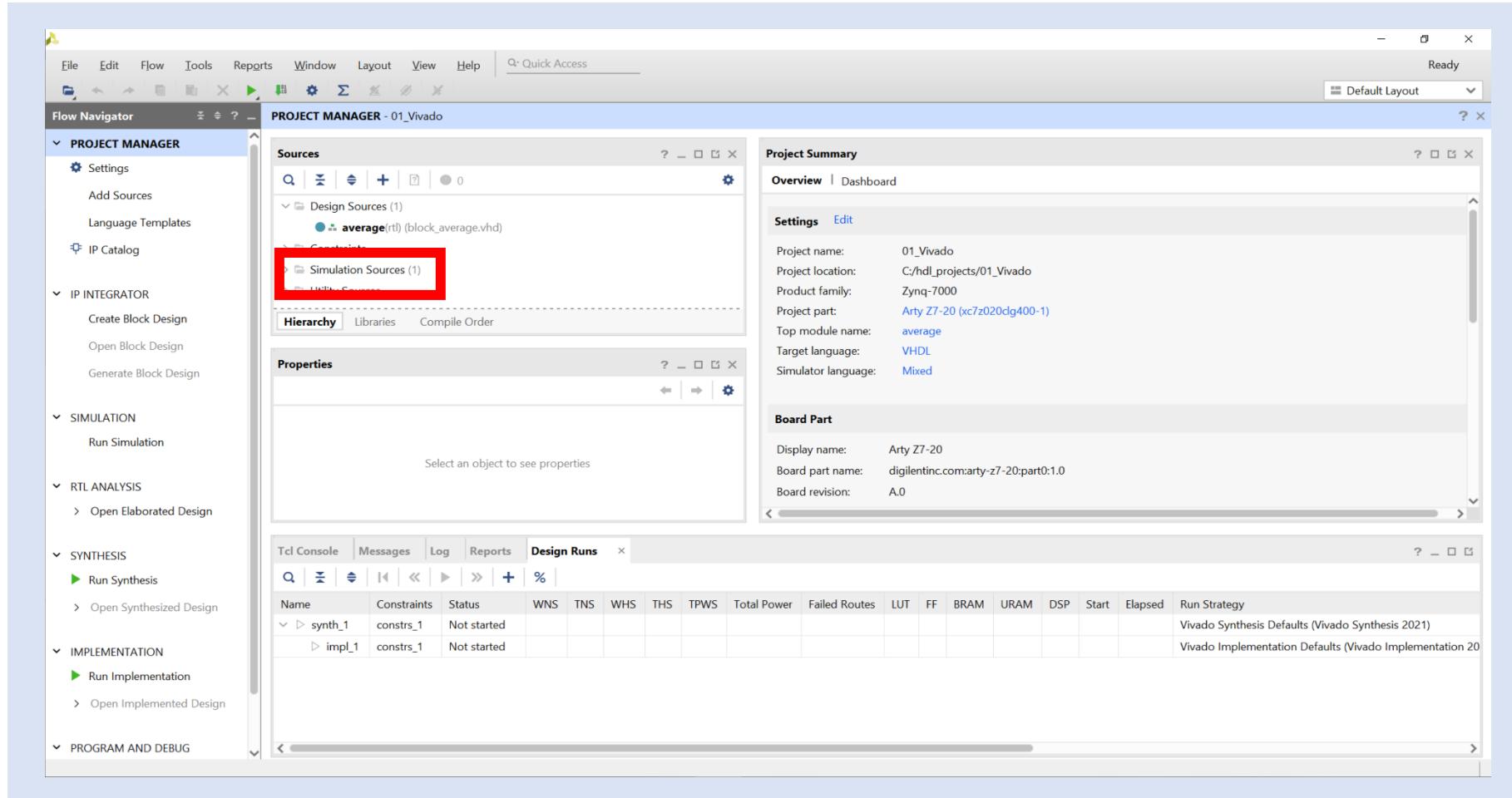
**Step 9 – This will open Vivado in the project manager view.**



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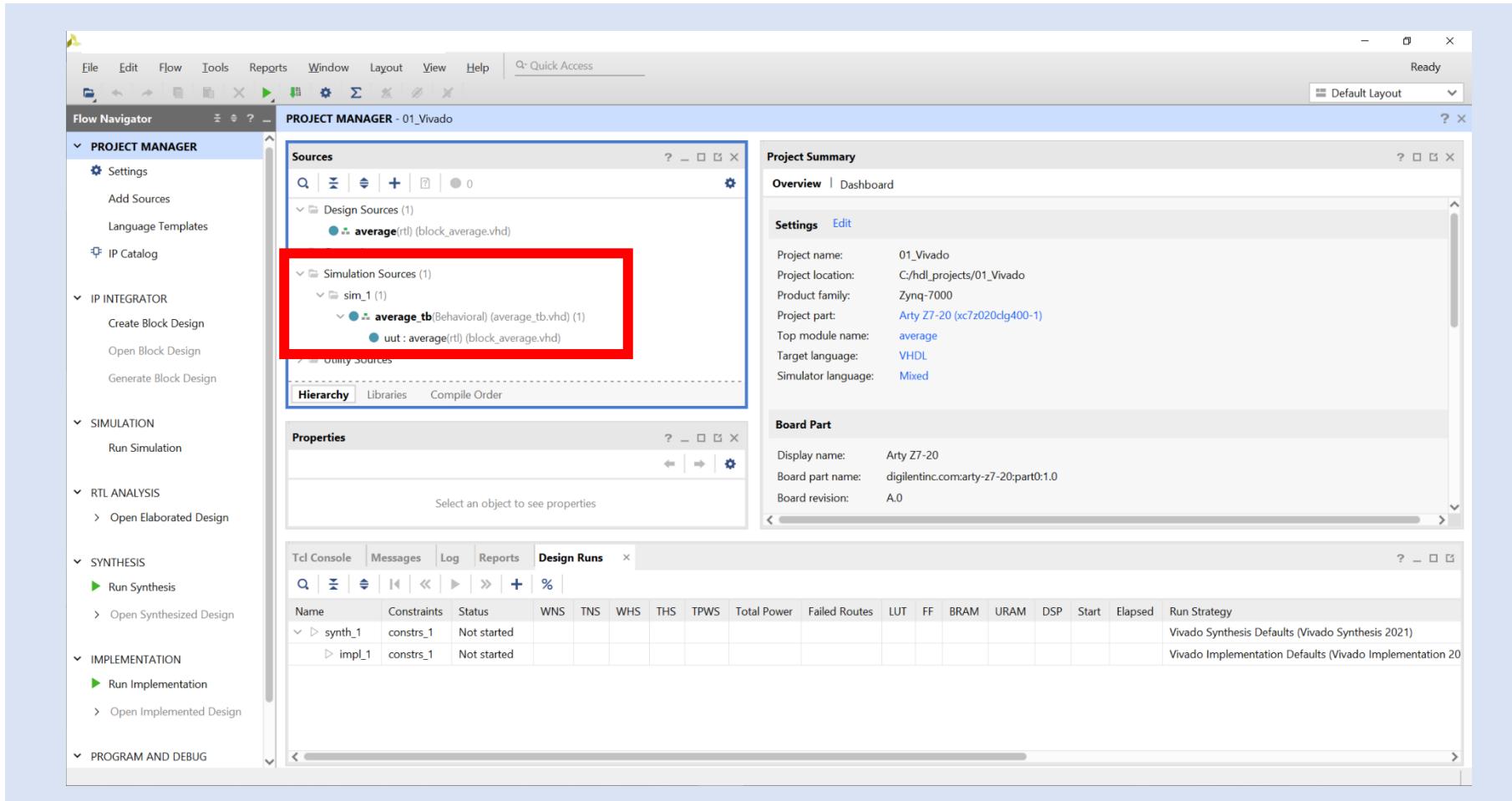
## Step 10 – Expand the Simulation Sources.



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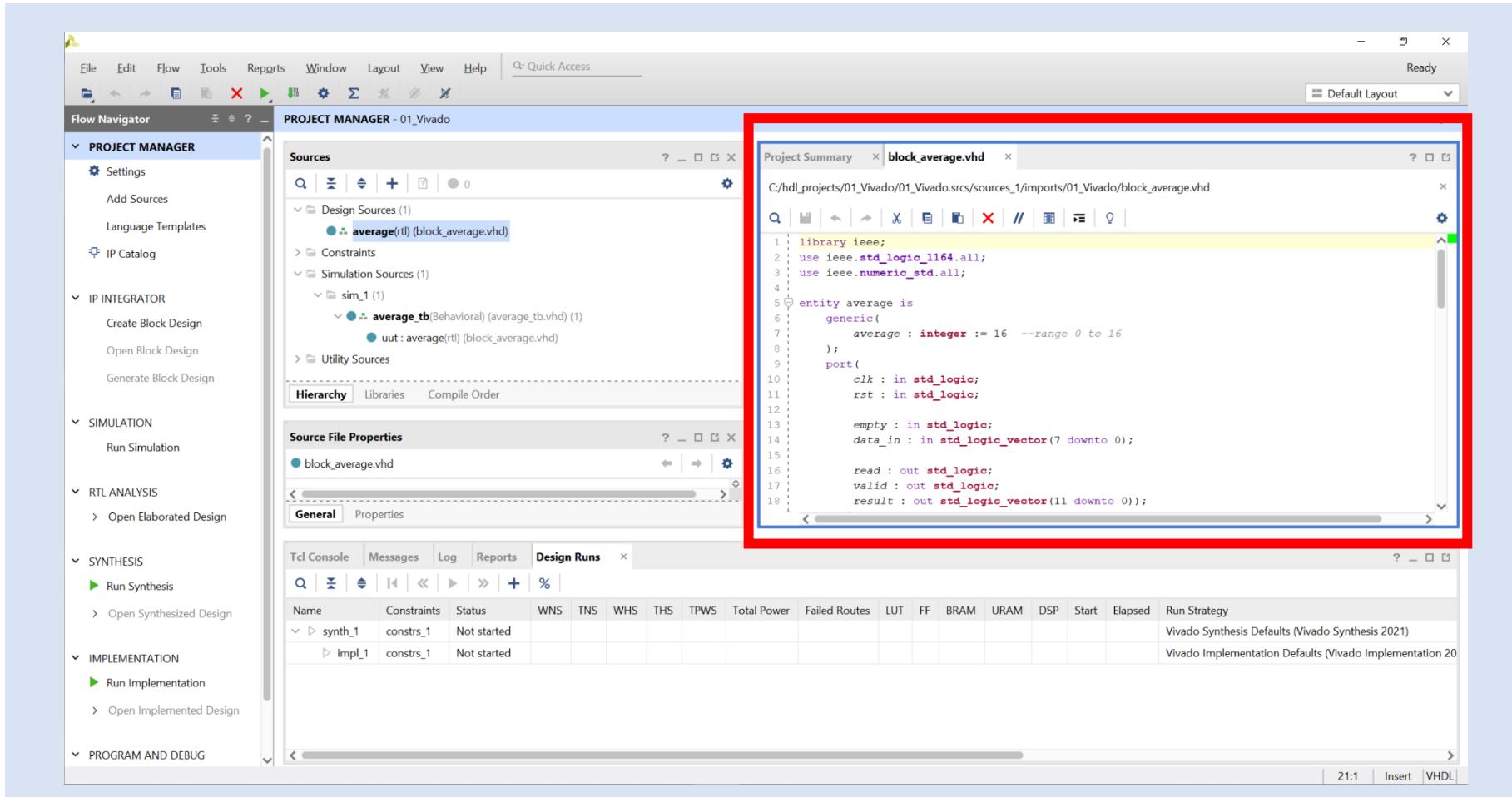
**Step 11** – This will show the test bench and the design source to be simulated.



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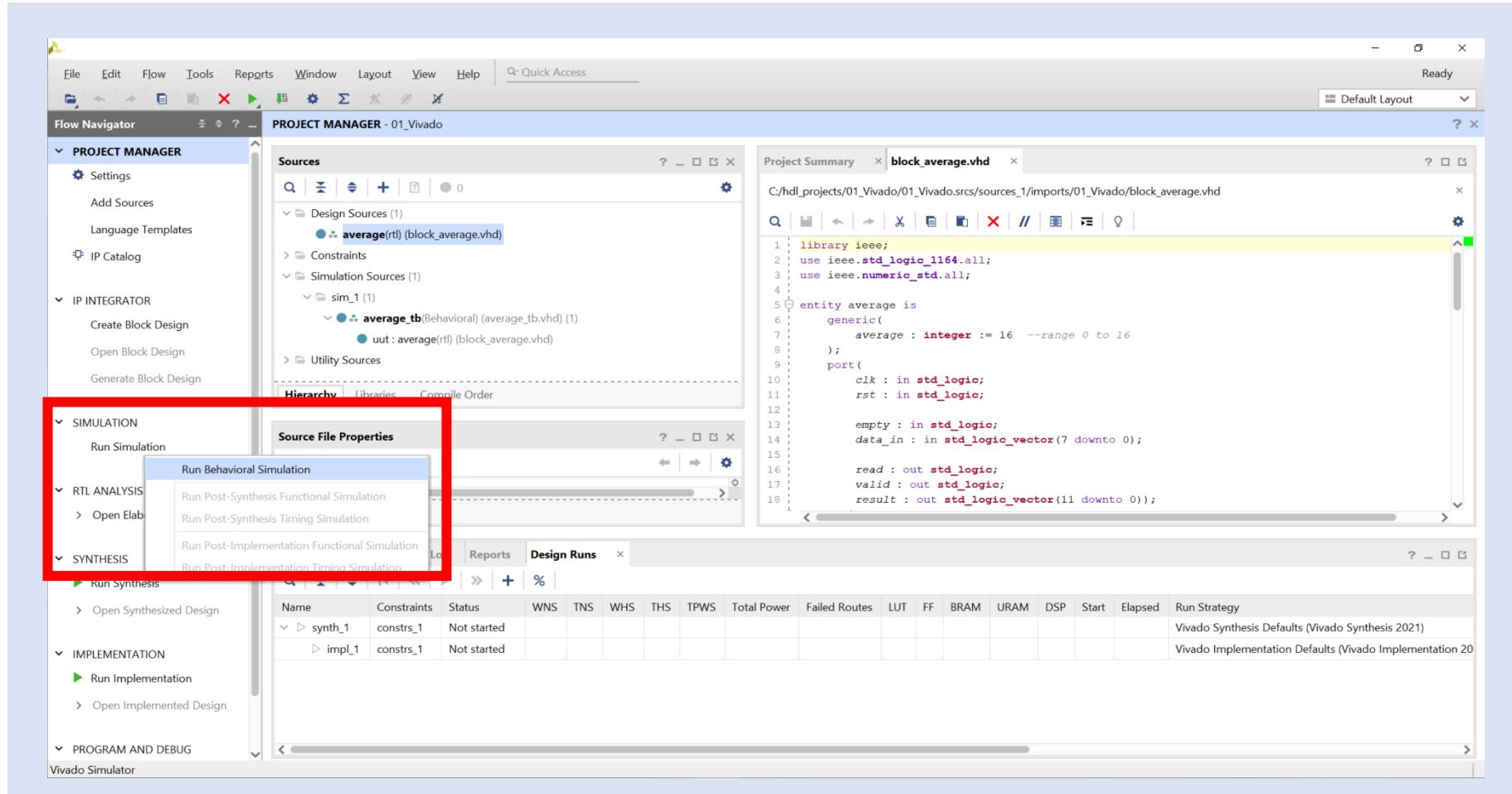
**Step 12 – Double clicking on the VHDL files will open the source for inspection.**



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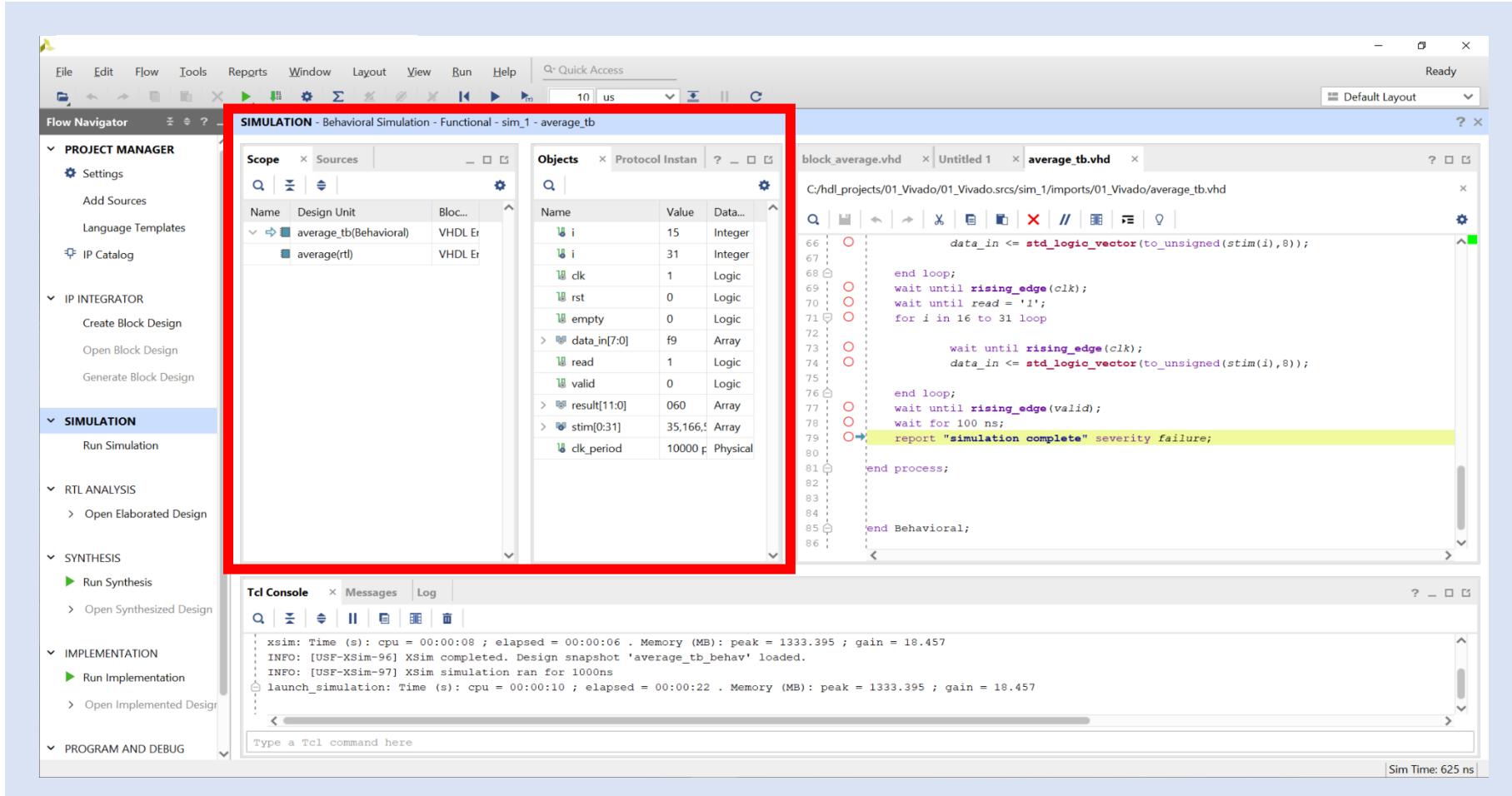
**Step 13 – To run a simulation, click on Run Simulation and select Run Behavioral Simulation.**



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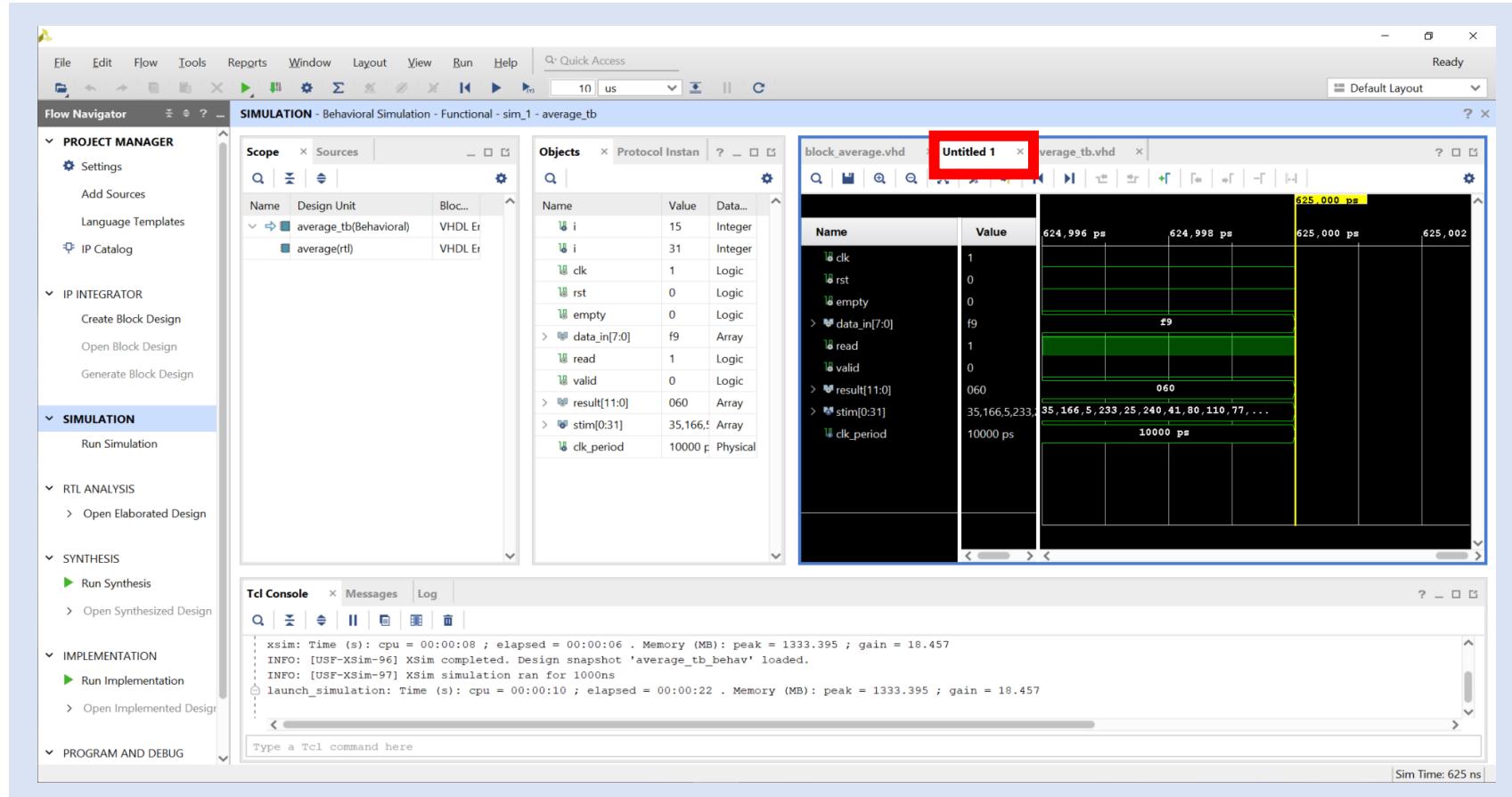
**Step 14 – This will open the behavioral simulation view. Note the scope and objects.**



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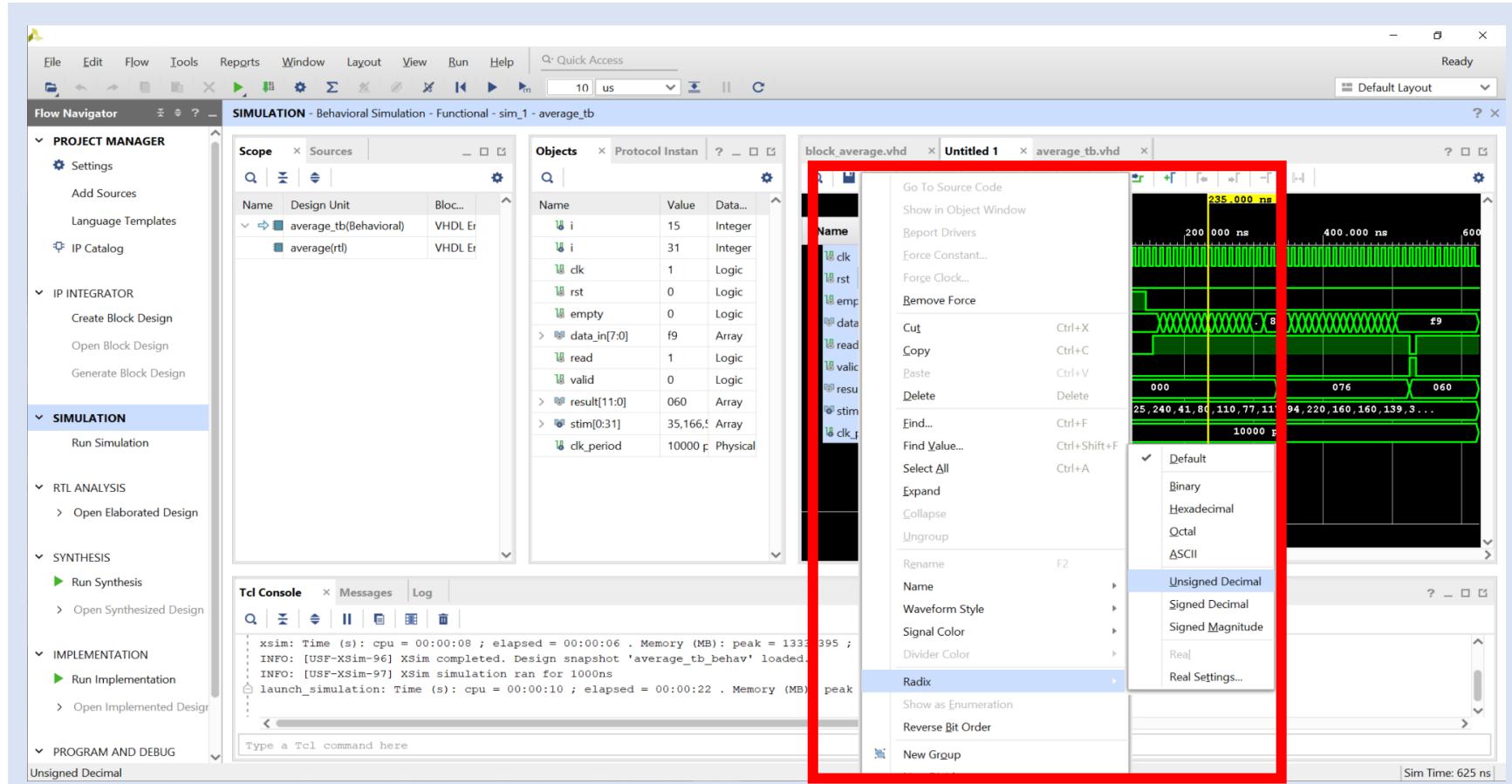
**Step 15 – Click on the Untitled\* tab to see the waveform of the simulation. Note this view shows the signals defined within the test bench only, not the Unit Under Test.**



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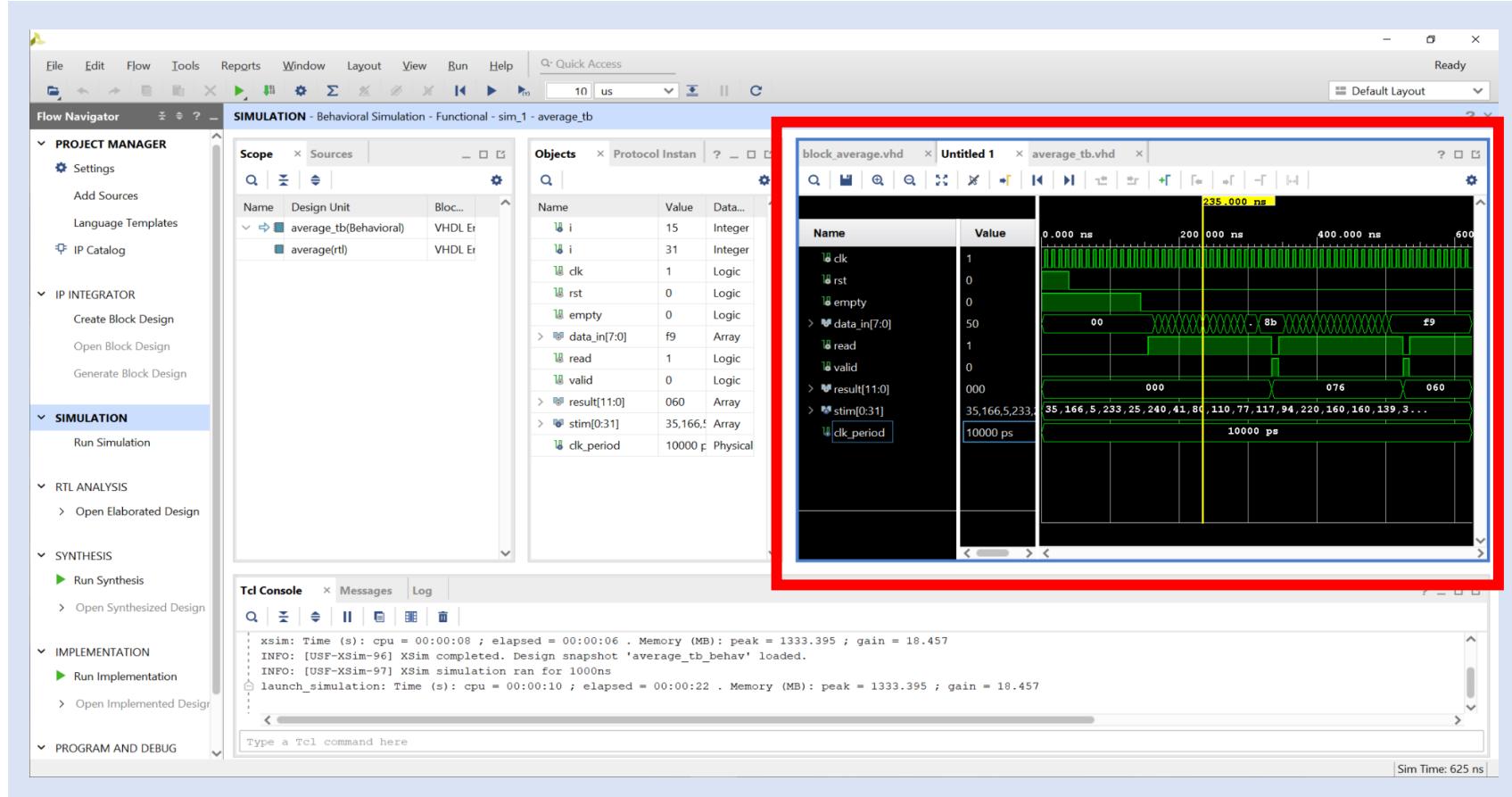
**Step 16 –** At the moment, the results are in hexadecimal but they make more sense in decimal. Select all the signals, right click, and select **unsigned decimal** from the **radix**.



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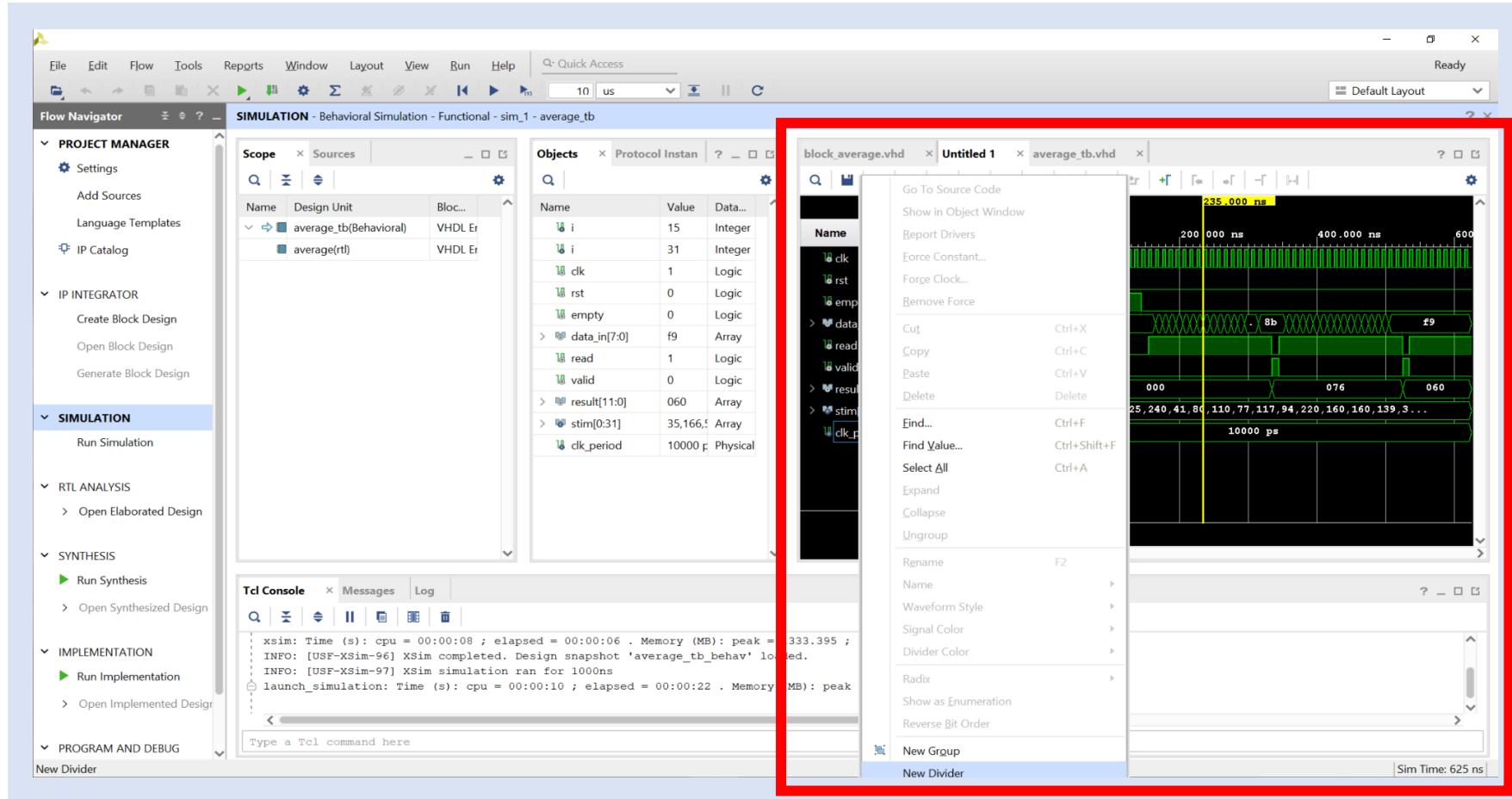
**Step 17 –** This will change the results to decimal. Correct operation has result showing 118 then 96. This is the block average of 16 input values.



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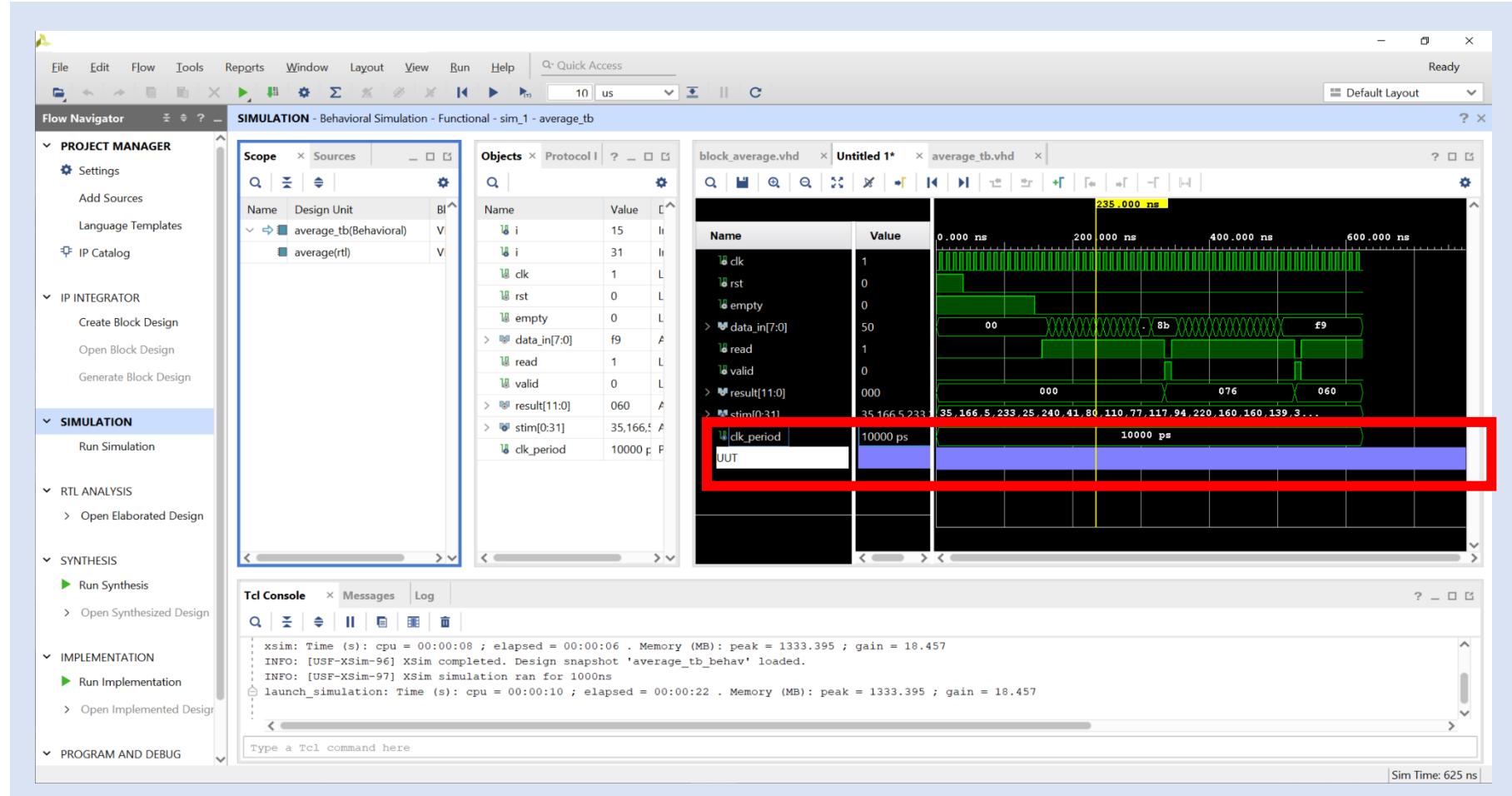
**Step 18 –** Often we want to be able to see the signals in the UUT. To do this, first let's insert a divider. Right click on the **bottom signal** and select **New Divider**.



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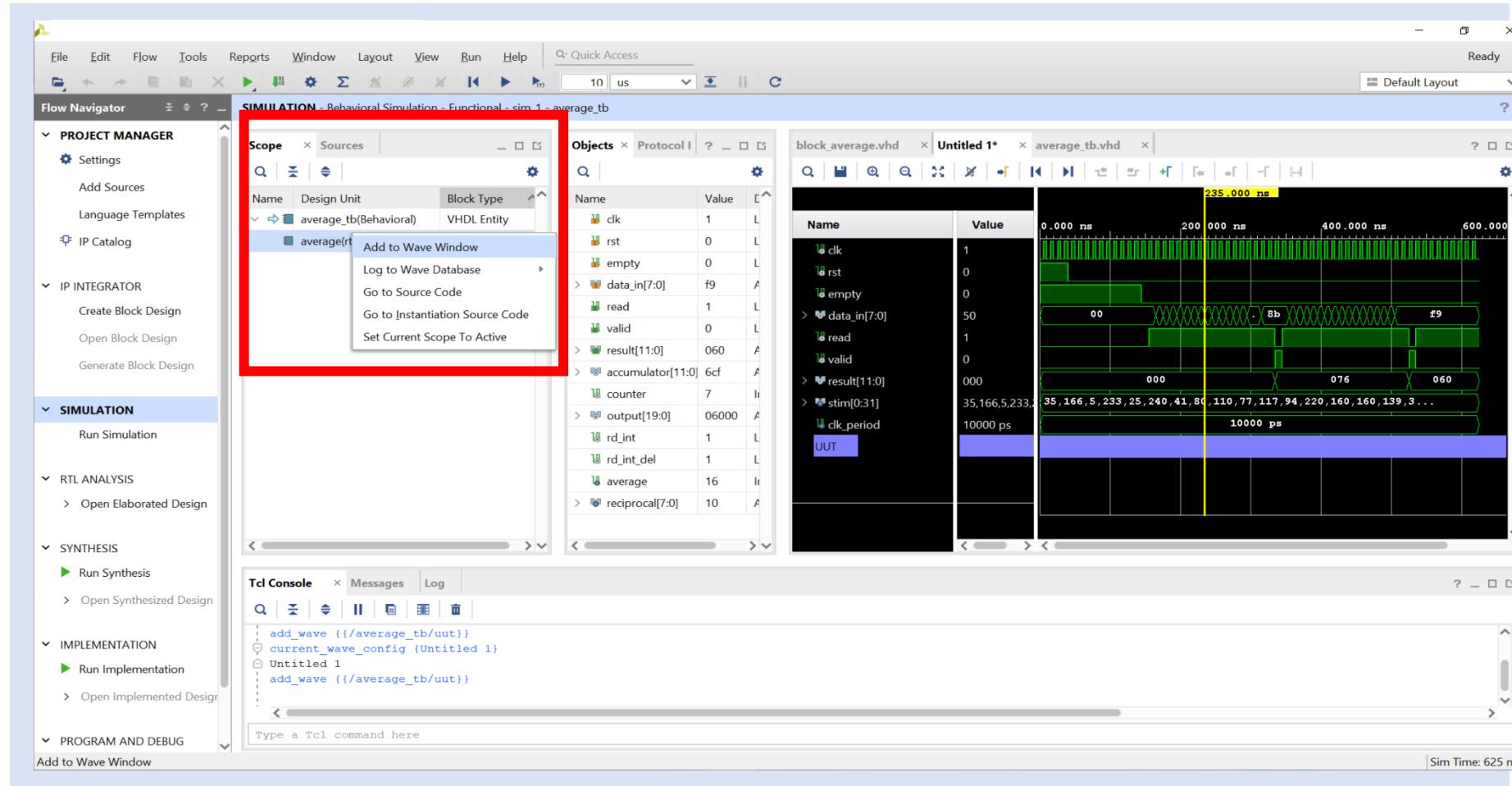
**Step 19 – When prompted, enter the name UUT and you will see the new divider in the waveform.**



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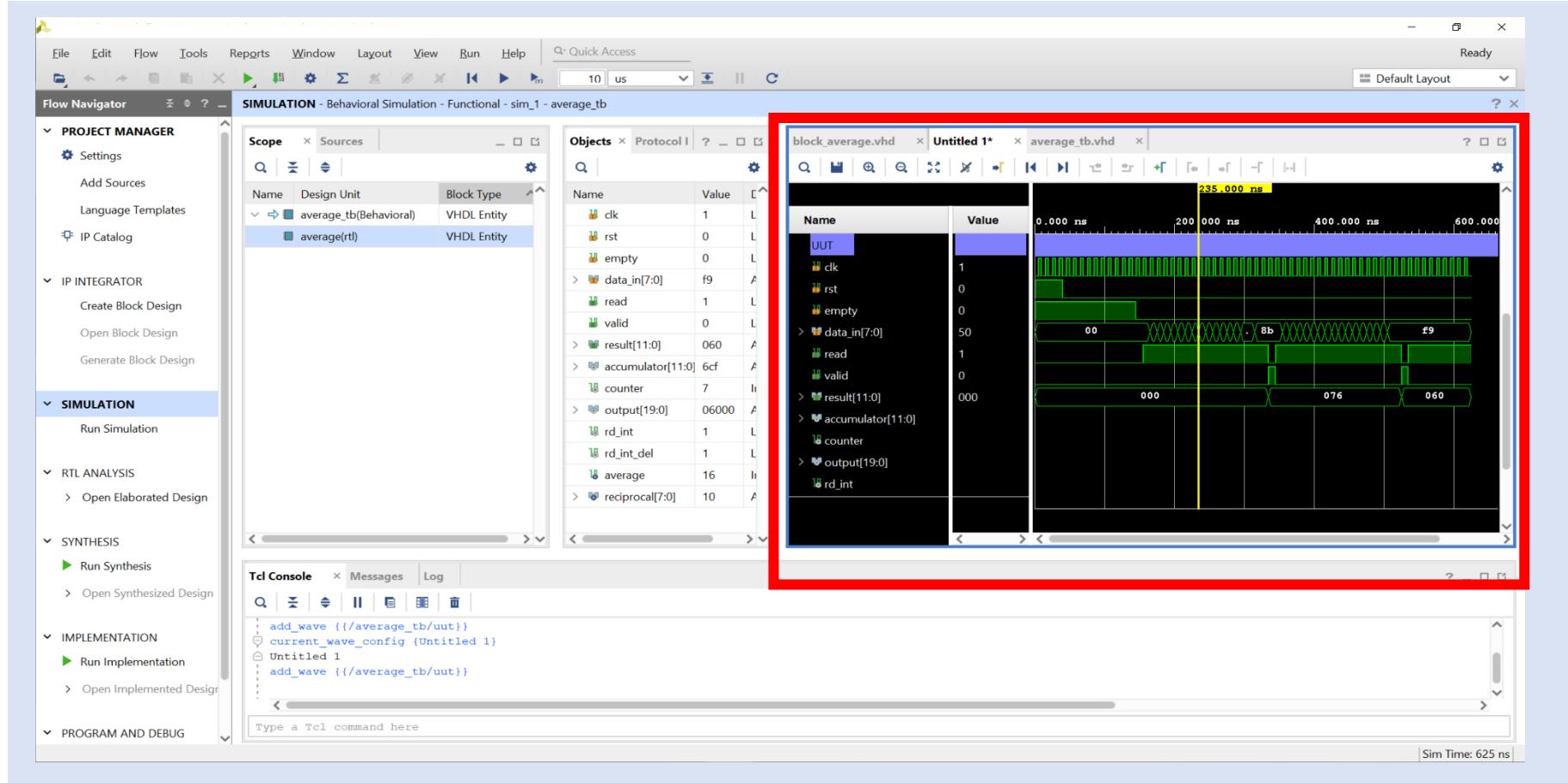
**Step 20 – To add in the UUT, right click on the UUT under the scope and select Add to Wave Window.**



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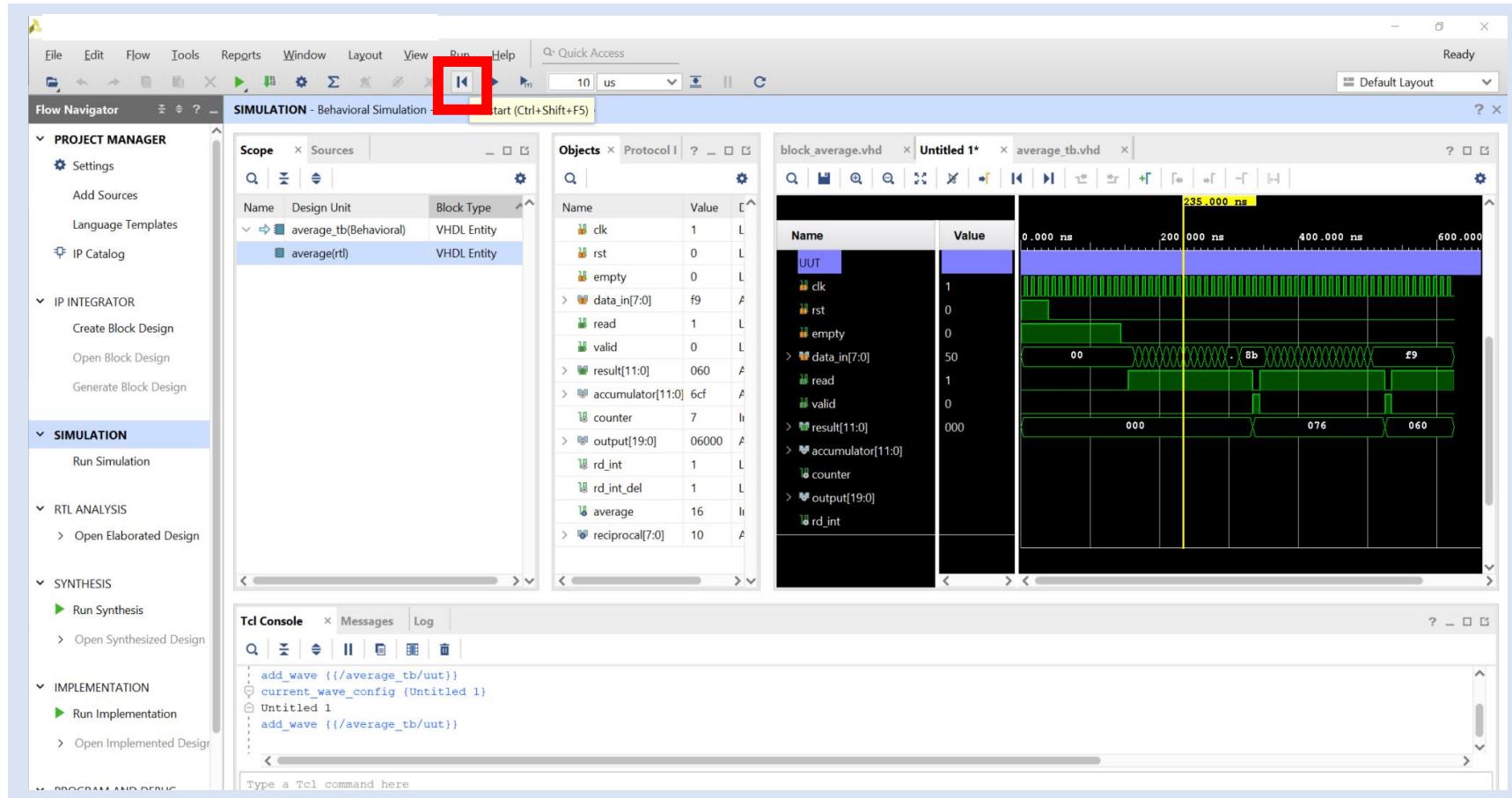
**Step 21** – This will add in the UUT signals, however, some information may be missing as it was not saved during the simulation.



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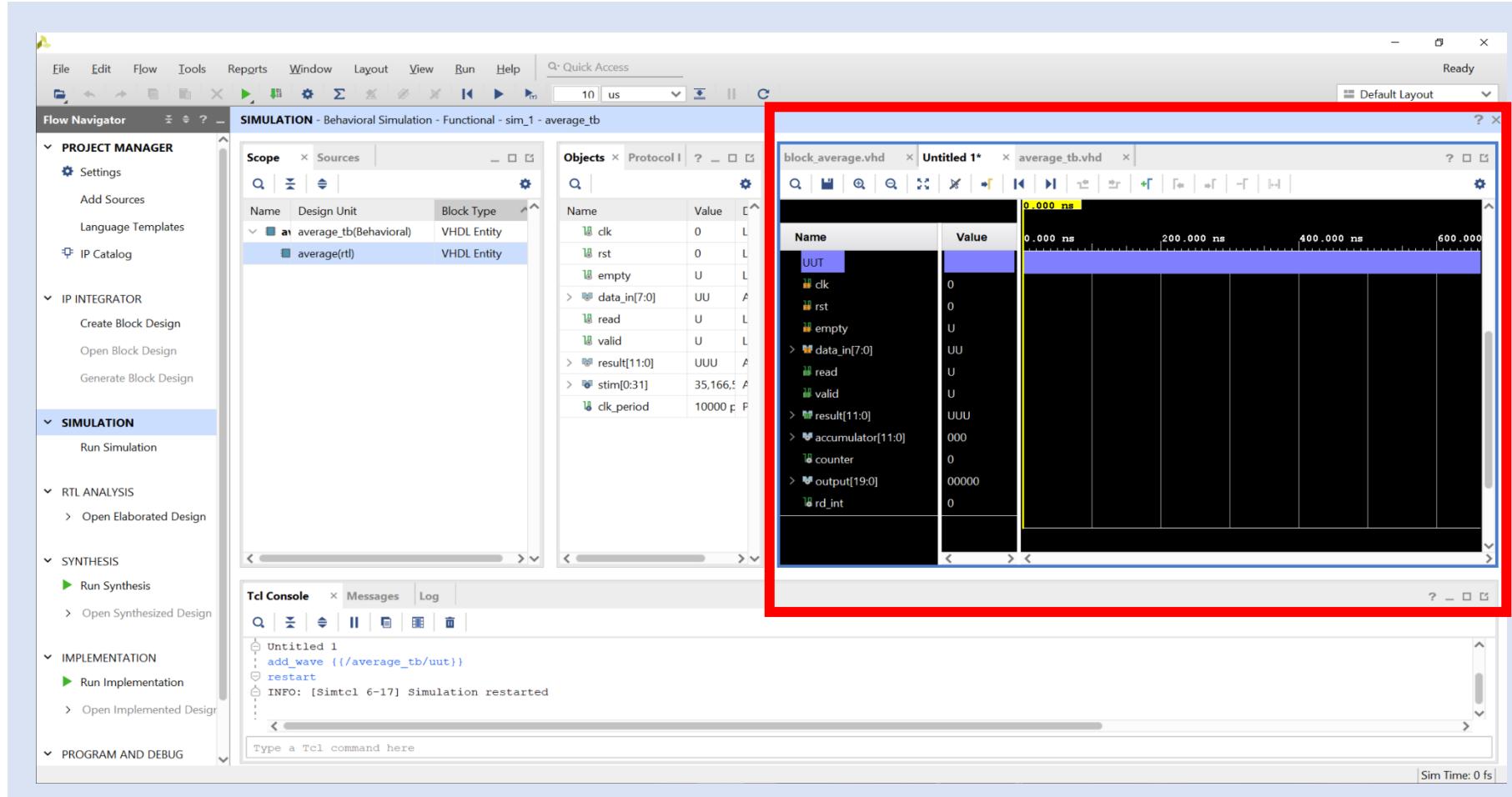
**Step 22 –** To add in the missing waveform, we need to restart the simulation. Select **Restart** from menu bar.



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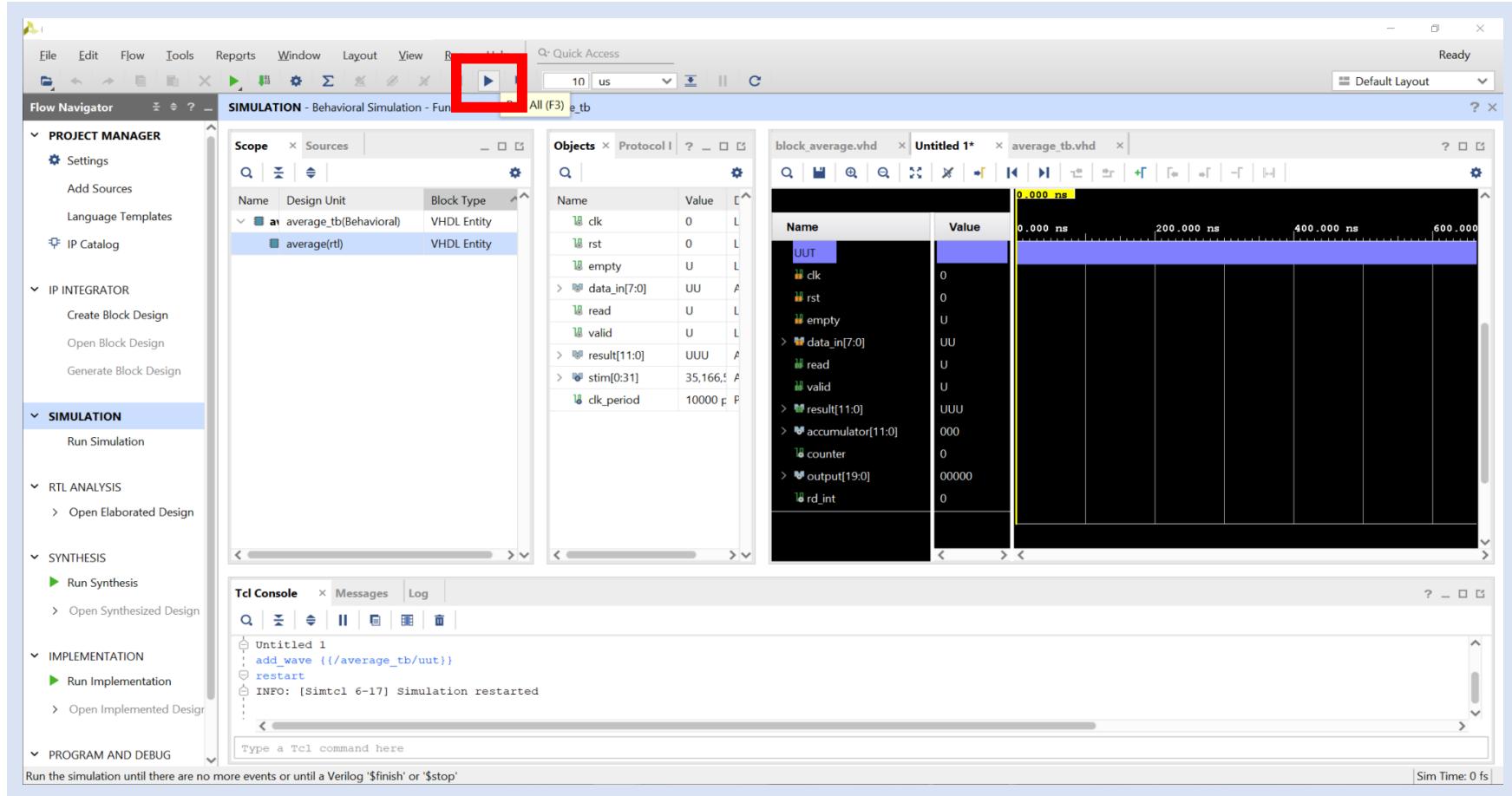
**Step 23 – This will clear all waveform data and restart the simulation.**



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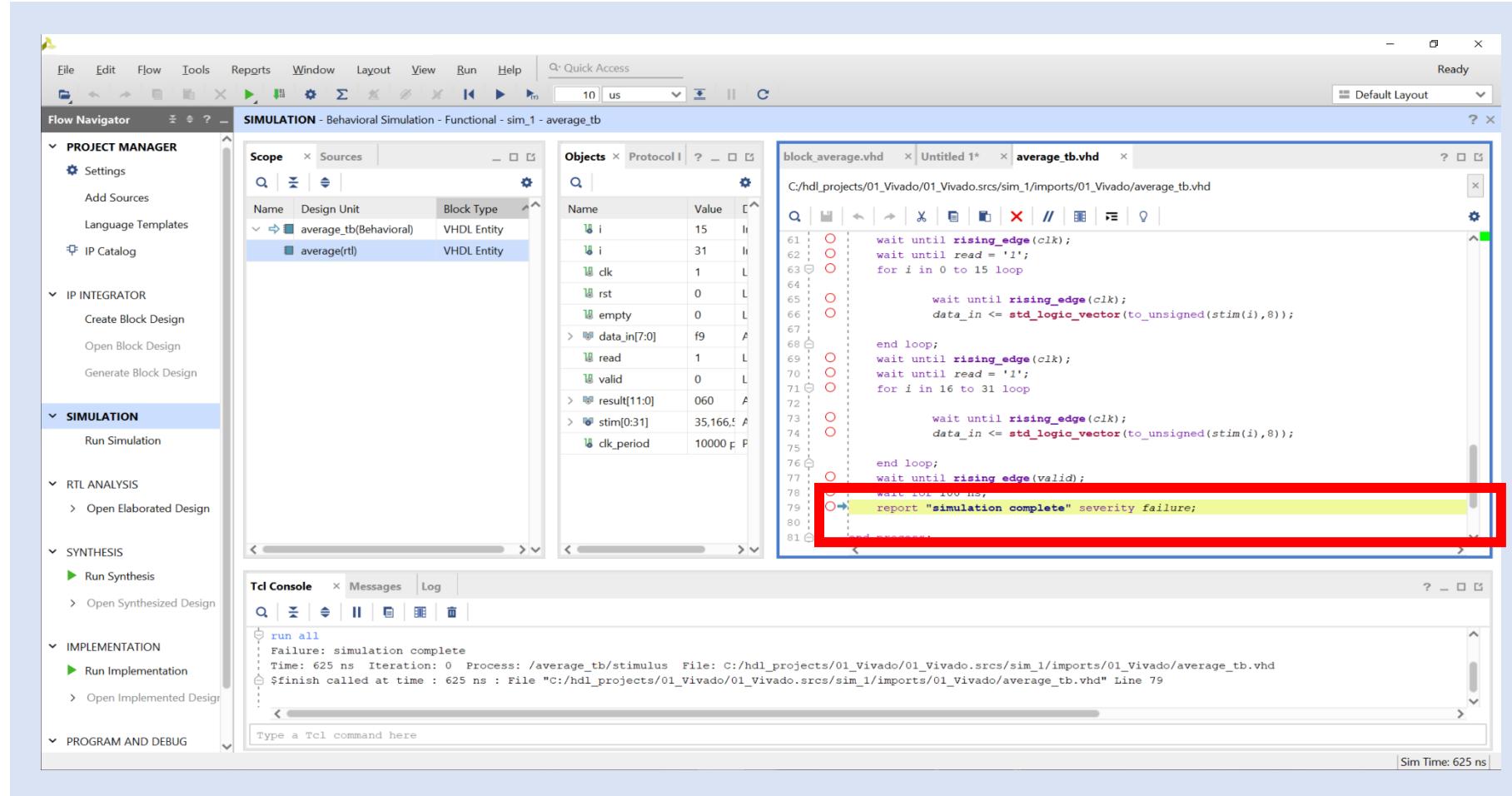
**Step 24 –** To rerun the simulation, select the **Run button** on the menu. The simulation will stop automatically.



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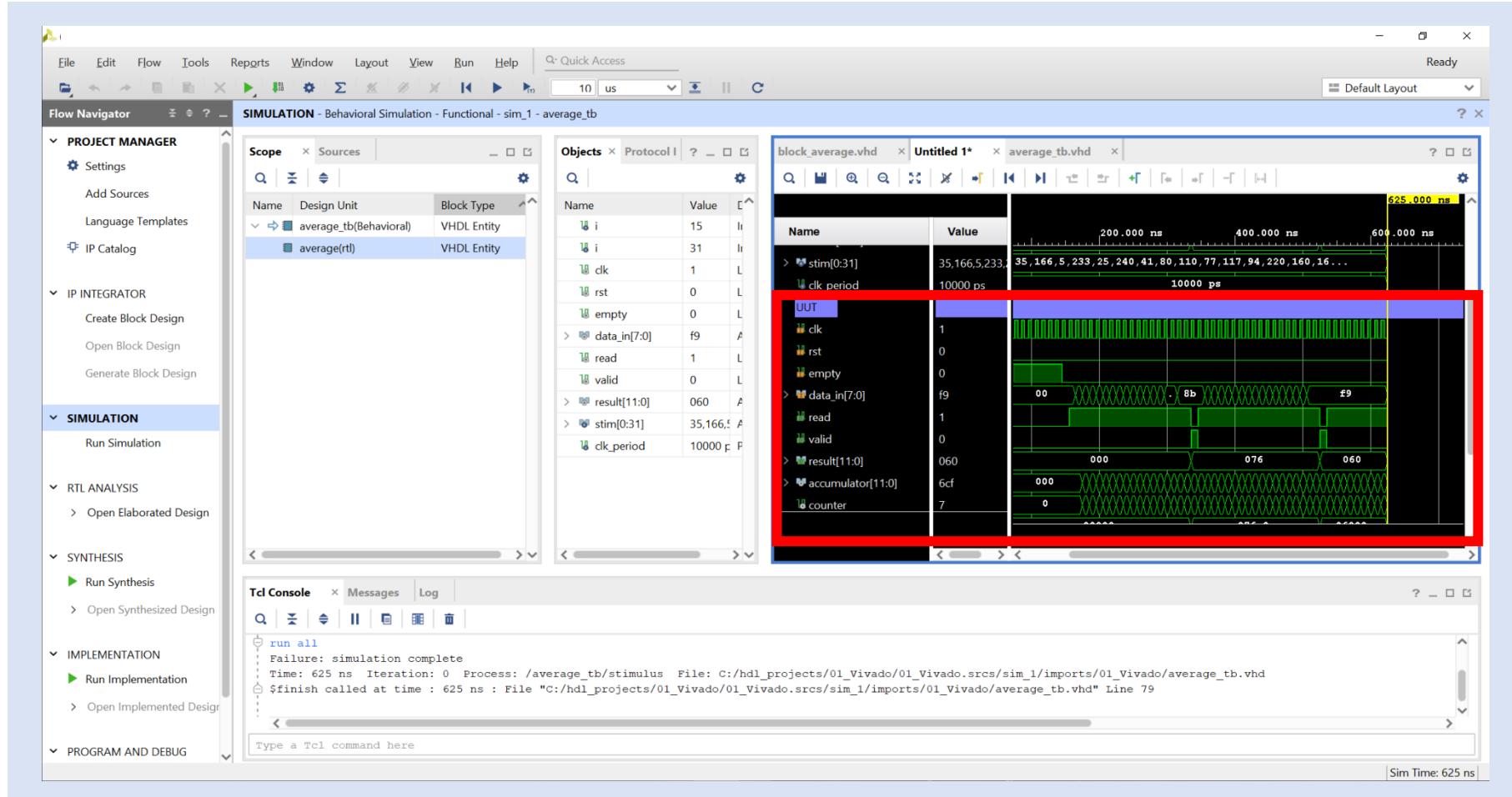
**Step 25 –** When the simulation completes, you will see the highlighted line in the test bench.



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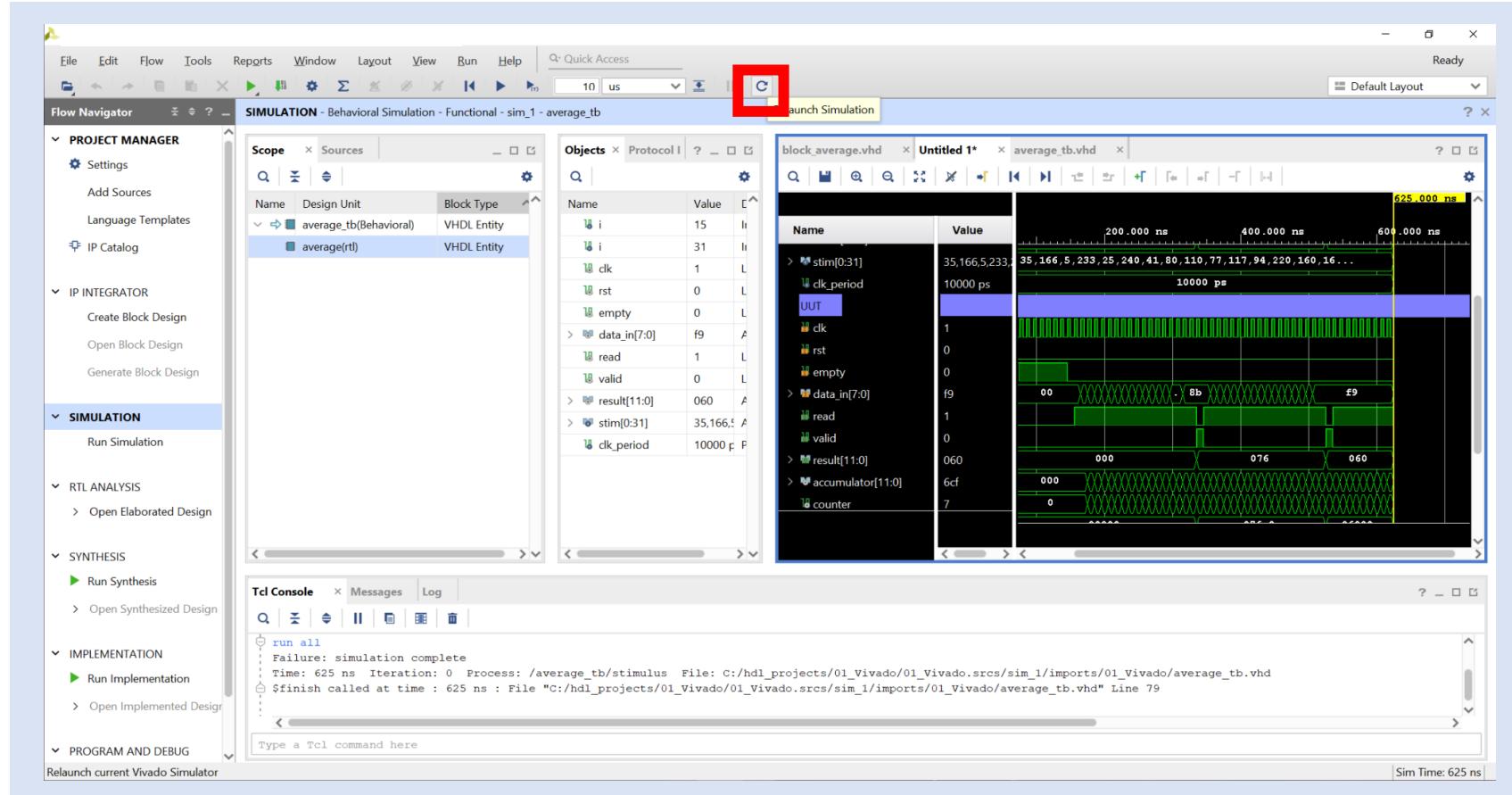
**Step 26 – Selecting the **waveform** tab again will show all the signals for the UUT.**



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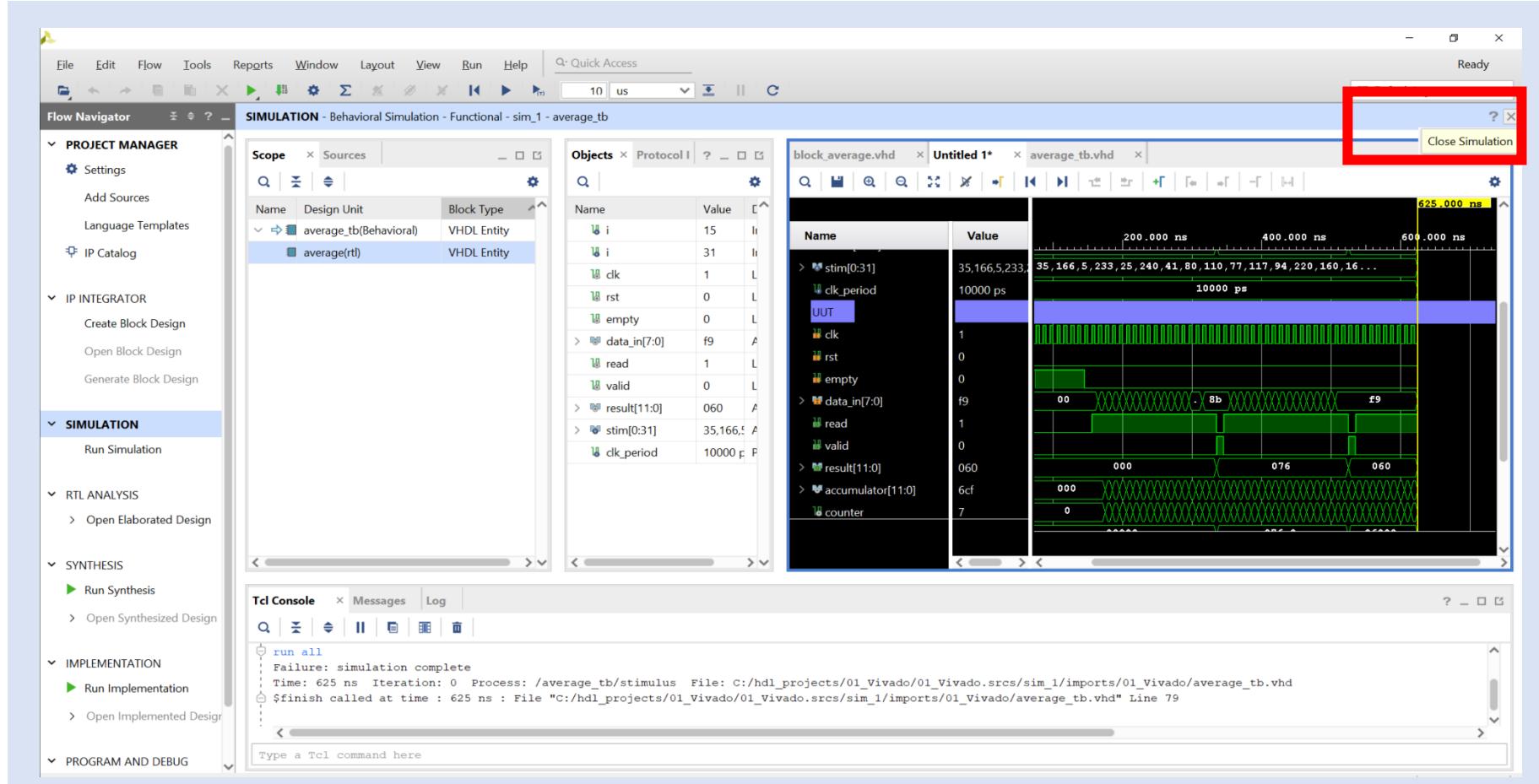
**Step 27 –** If you make changes to the source code, you need to relaunch the simulation. This can be achieved using the relaunch button on the menu.



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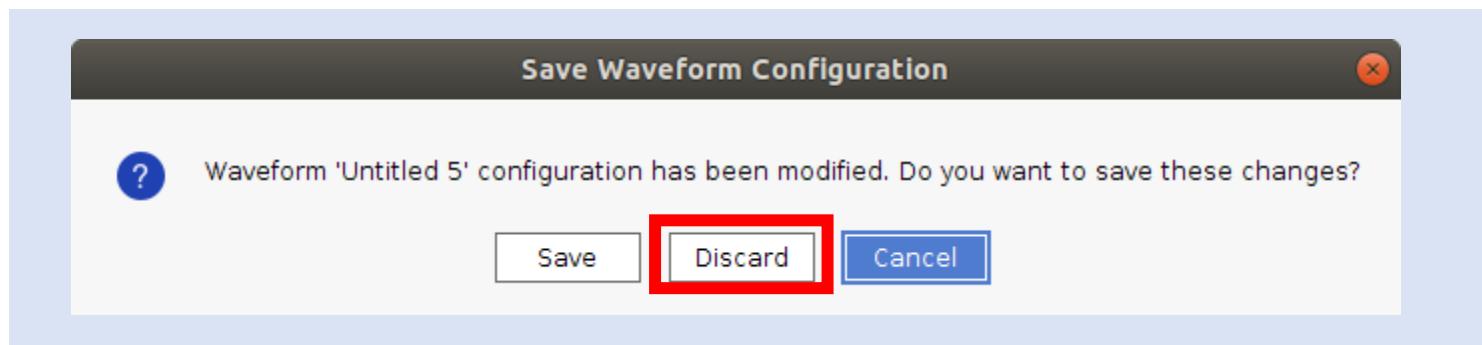
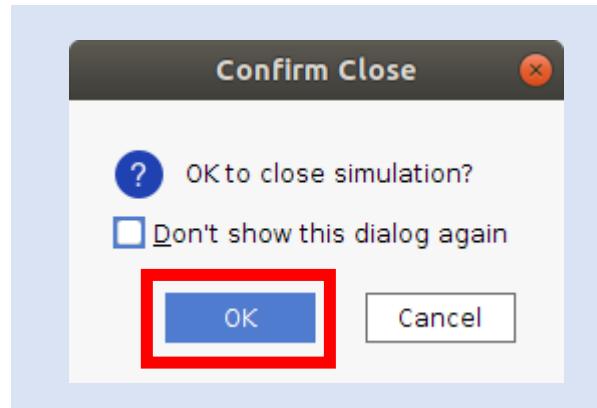
**Step 28 –** With the simulation complete, we are now ready to implement the design. Close the simulation view.



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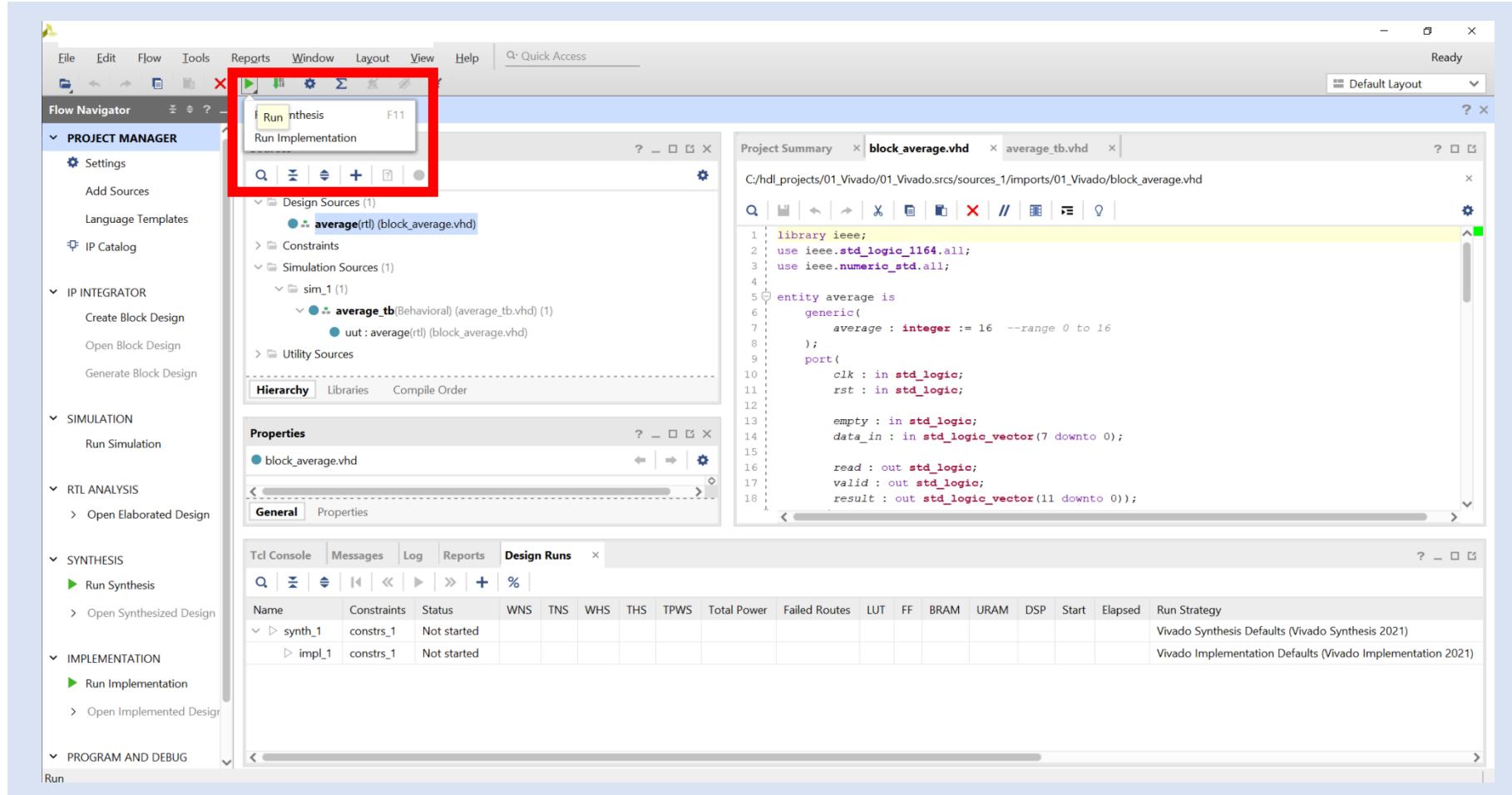
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**Step 29 –** When asked to confirm, click **OK**. If a save waveform dialog pops up, select **Discard**.



# Lab: Overview and Introduction to AMD Vivado™

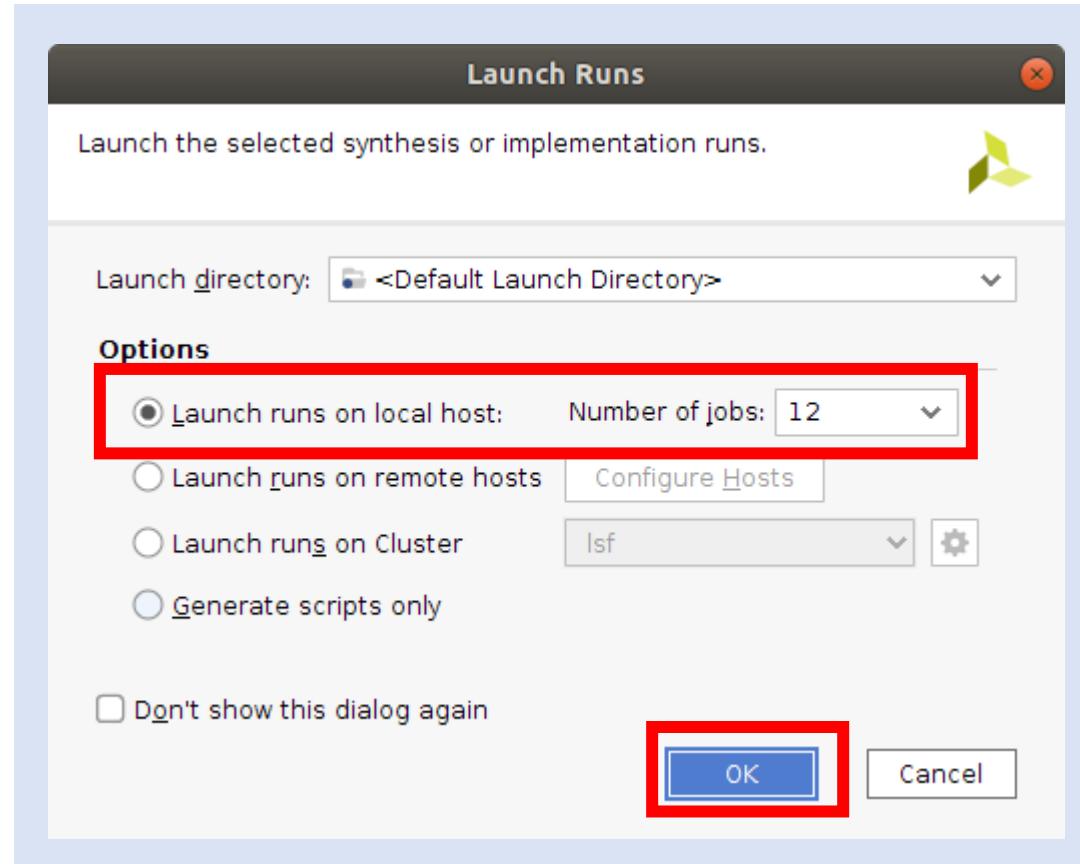
**Step 30 – To synthesize the design, click the green run arrow and select Run Synthesis.**



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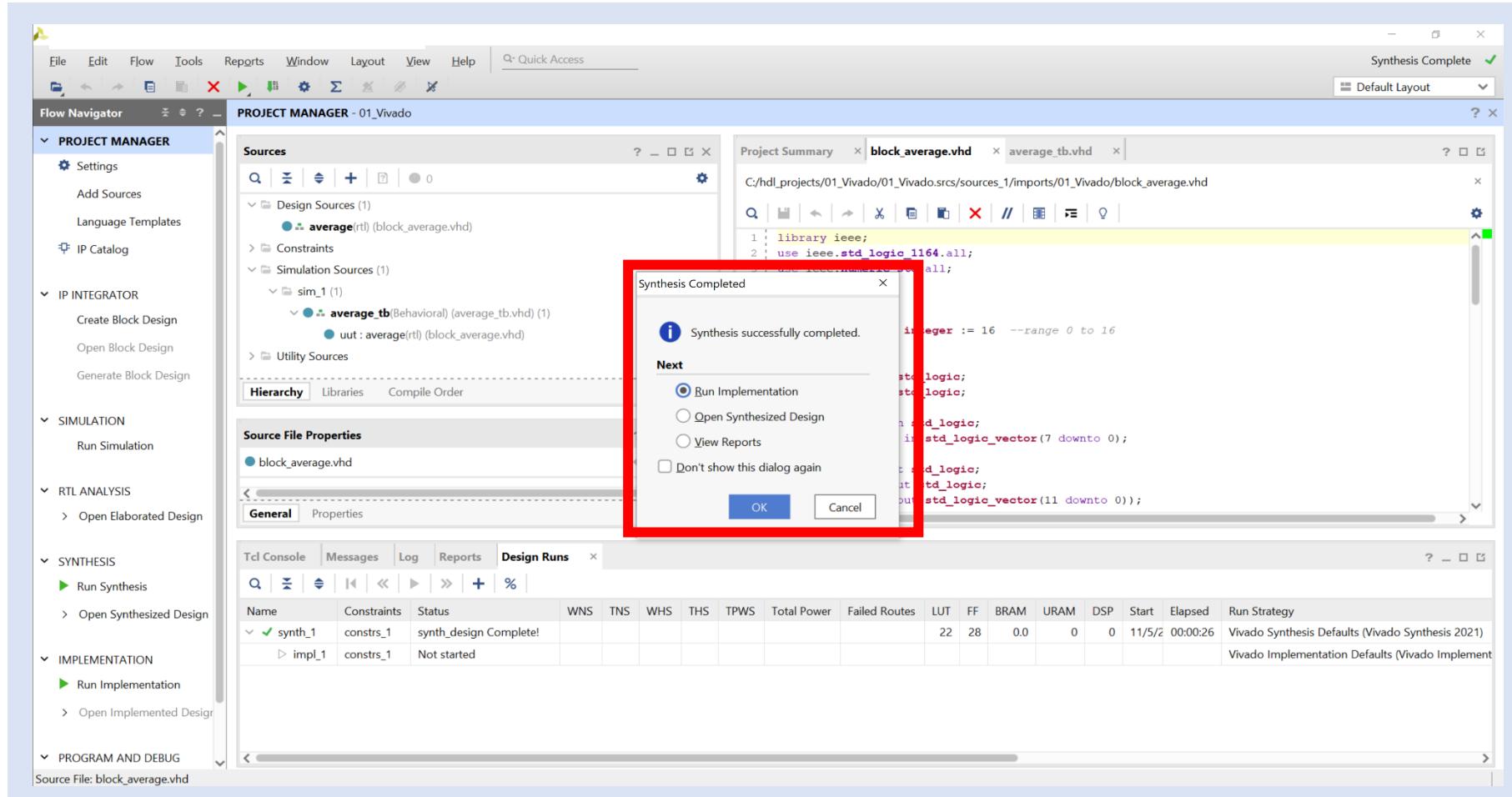
**Step 31 –** On the Launch Runs dialog, select the number of jobs you want to run on your system and click **OK**.



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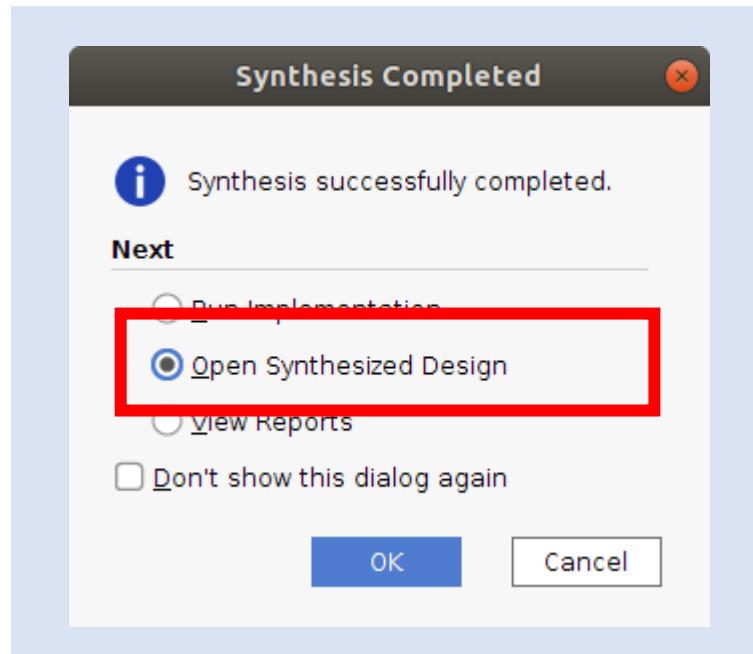
**Step 32 –** When synthesis is complete, you will see a dialog box appear.



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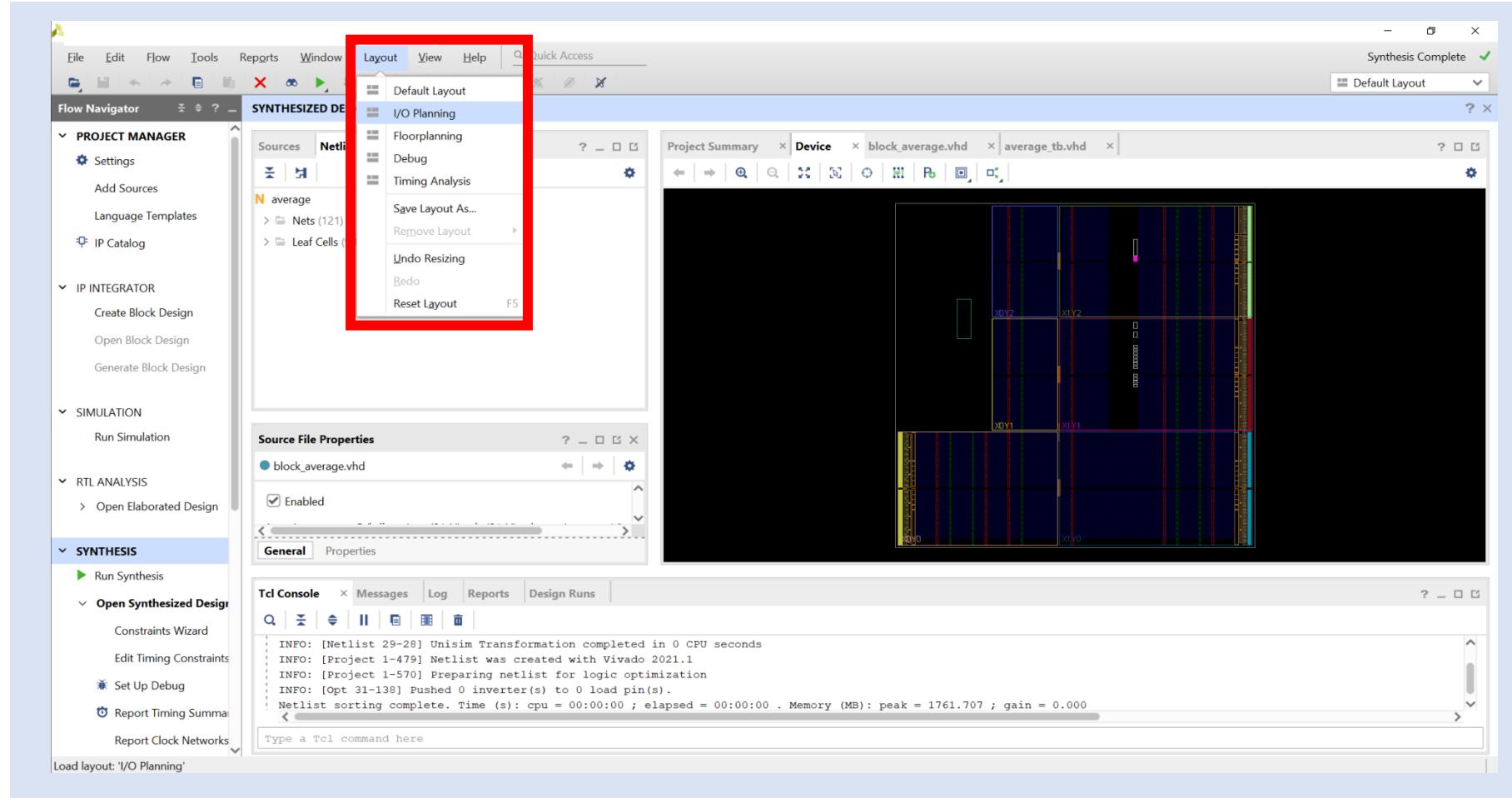
## Step 33 – Select Open Synthesized Design.



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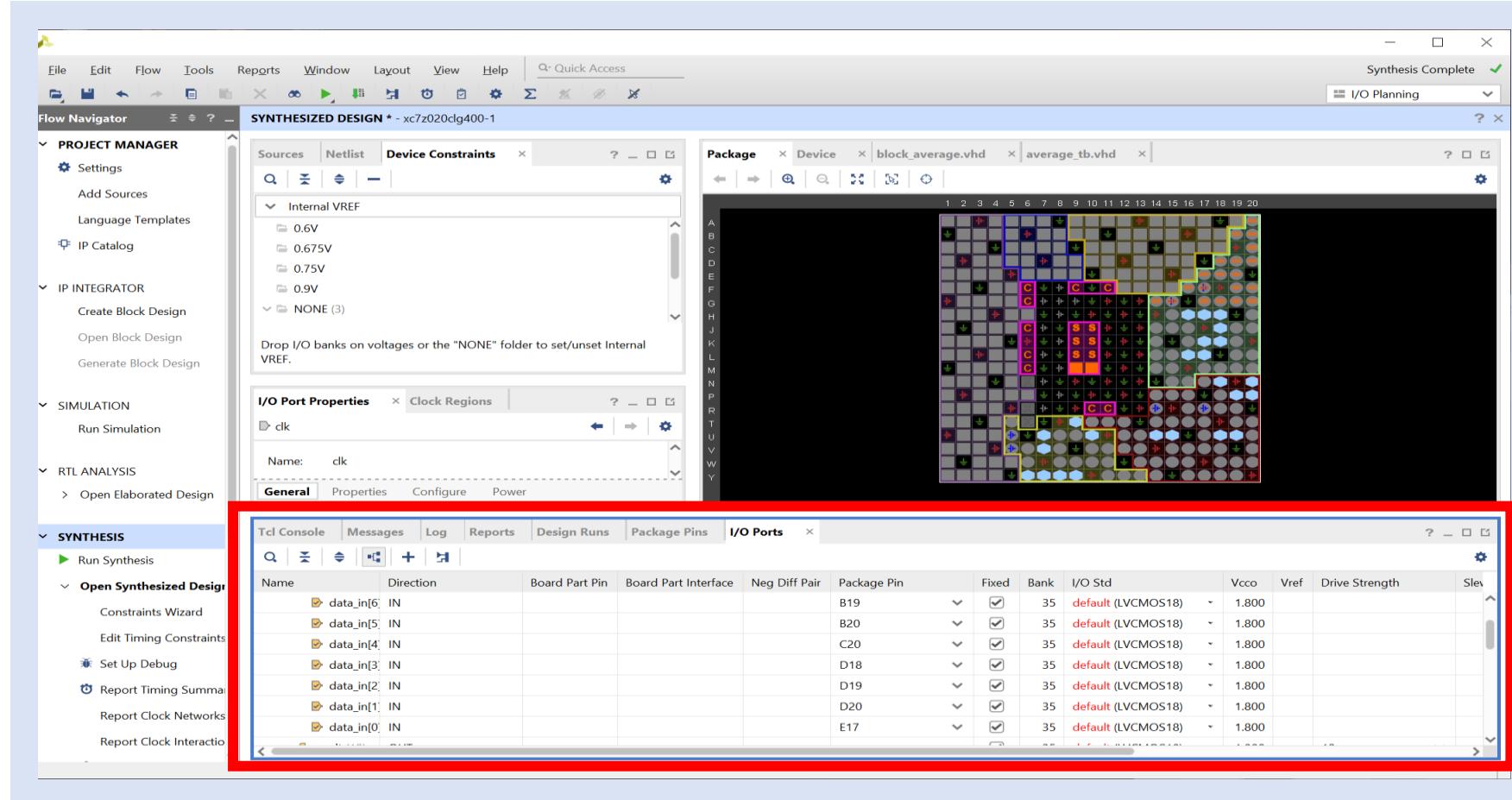
**Step 34 –** This will open the synthesis view. From the menu layout, select I/O Planning.



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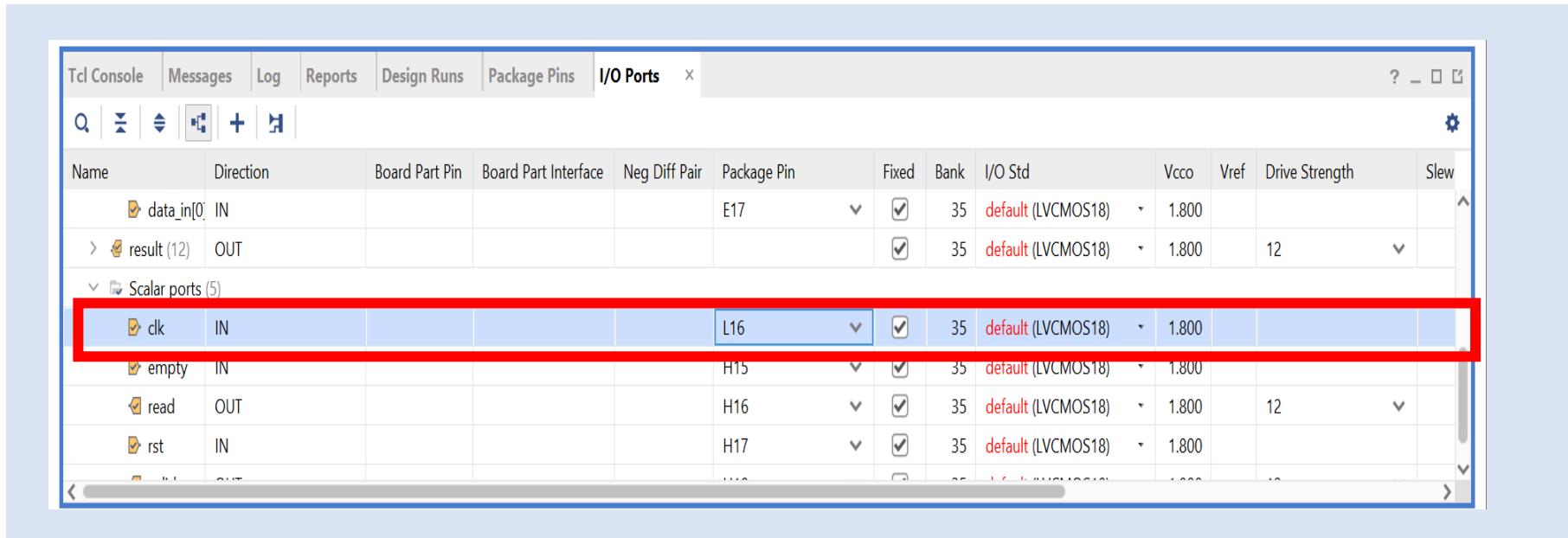
**Step 35 – Expand the Data\_In, Result and Scalar Ports and assign them to pins. All EXCEPT the clock pin can be assigned to any pin.**



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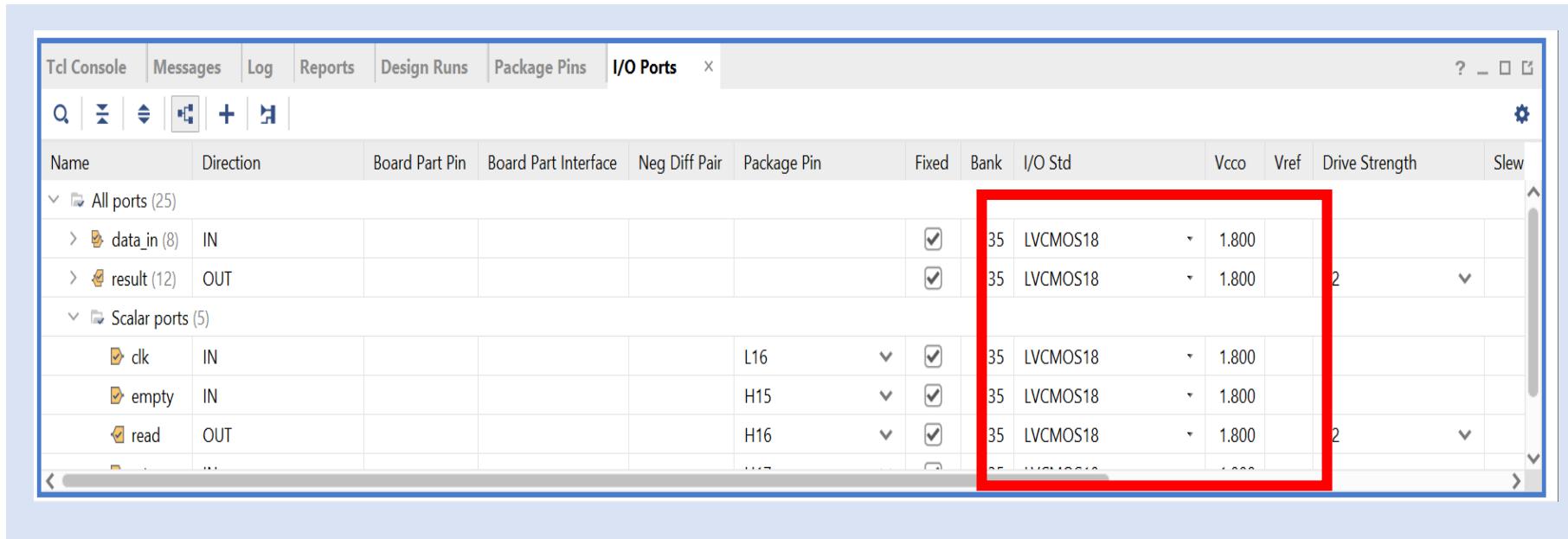
# Lab: Overview and Introduction to AMD Vivado™

**Step 36 – Assign the clock pin to L16.** Clocks have to be assigned to clock capable pins.



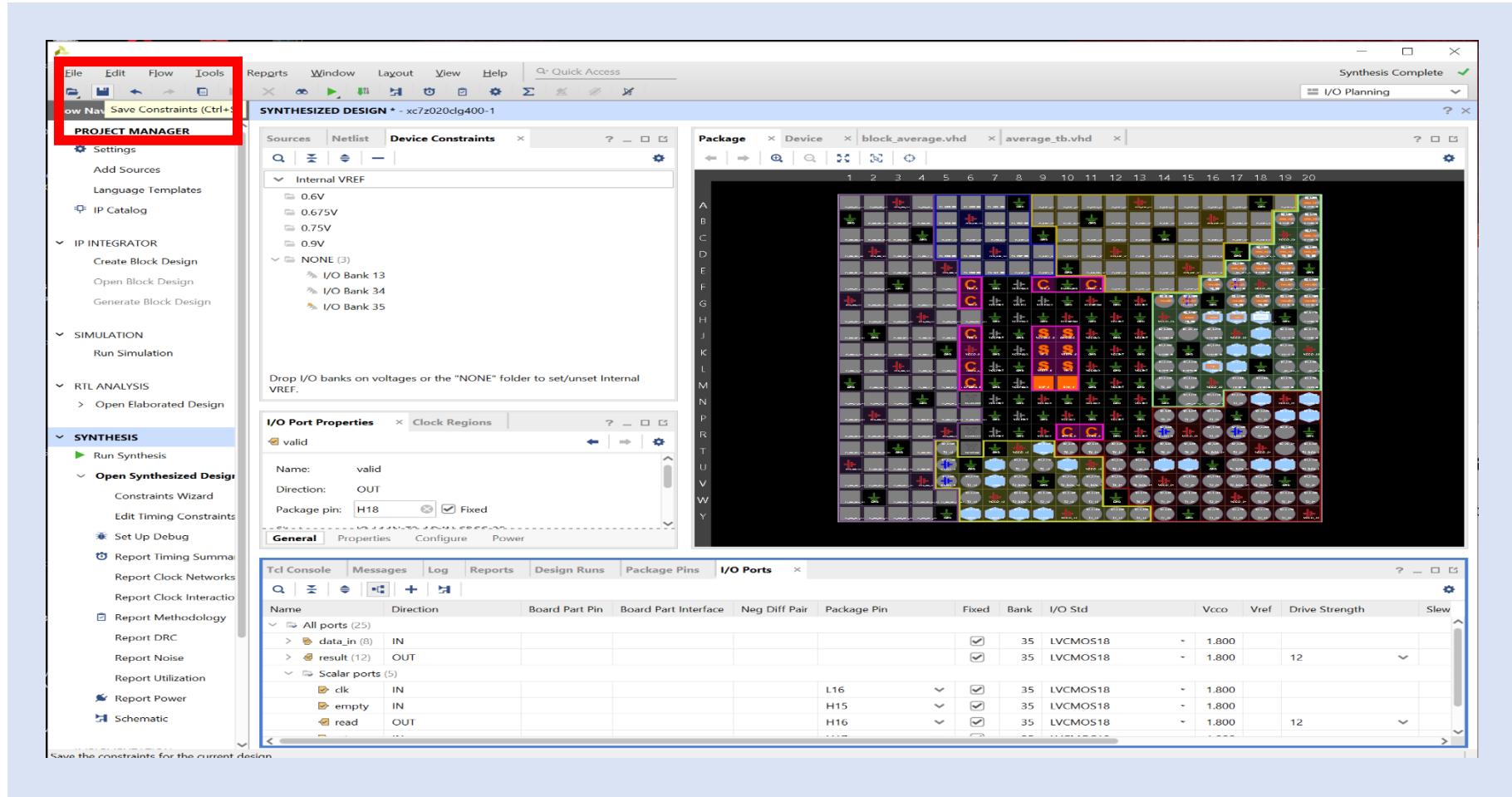
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**Step 37 – Ensure the IO Standard is set to LVC MOS18. Do not leave it as default because this will lead to a failure to implement and generate a bitstream.**



# Lab: Overview and Introduction to AMD Vivado™

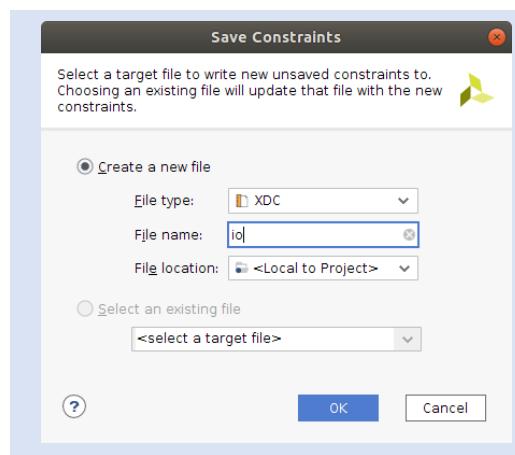
Step 38 – Save the Constraints we just edited.



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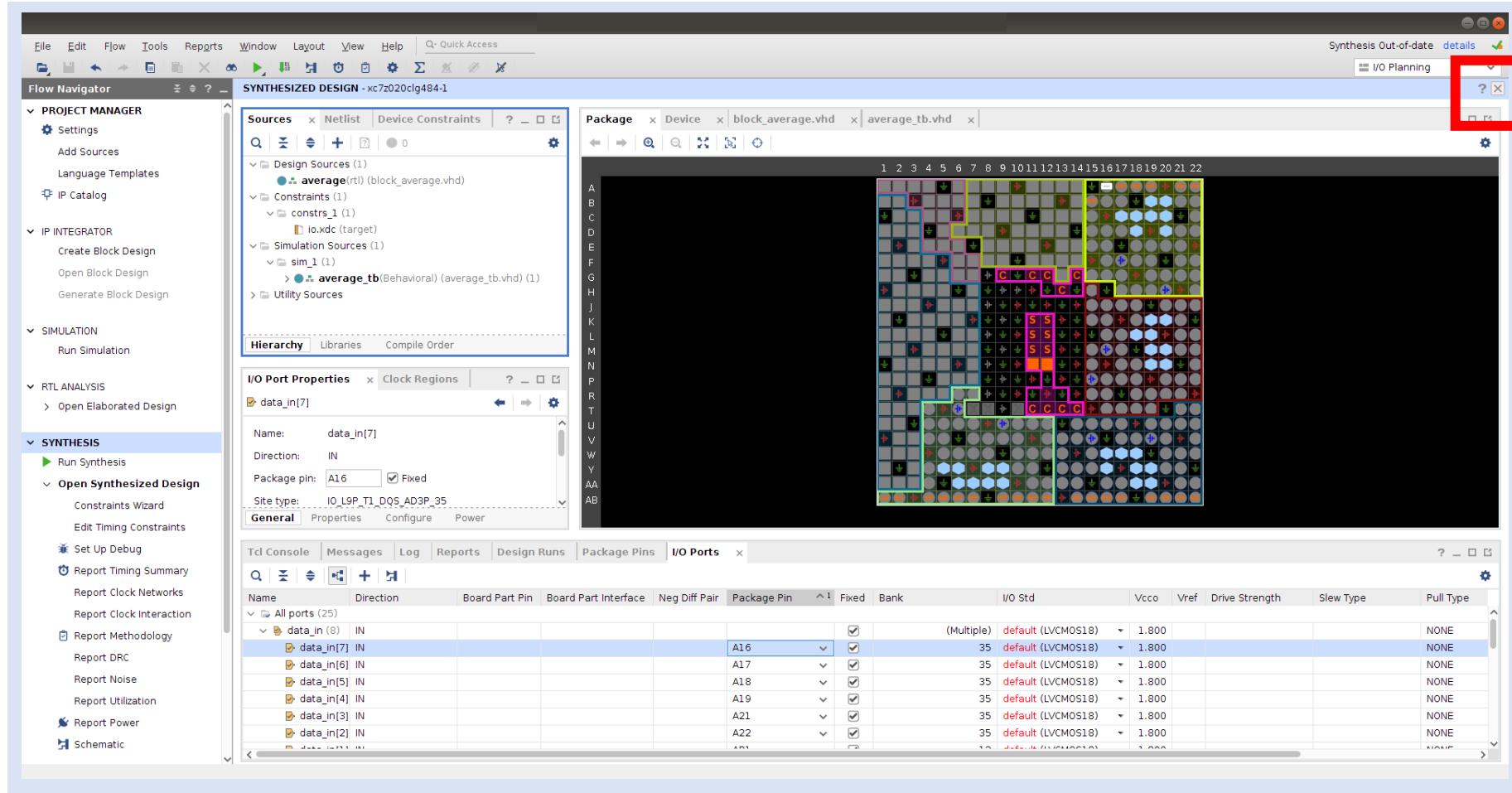
**Step 39** – This will present two new dialogs. Click **OK** on the first and enter a **file name** for the second.



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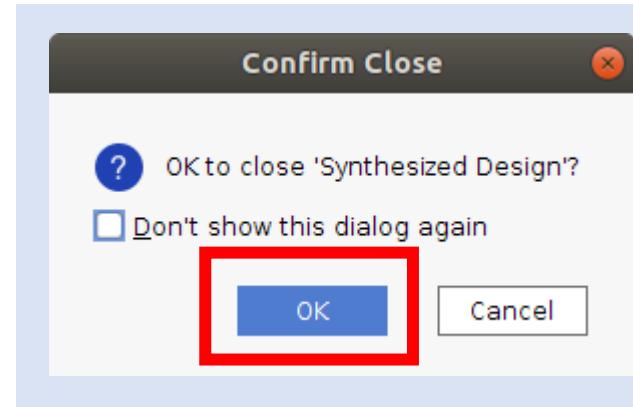
## Step 40 – Close the Synthesis View.



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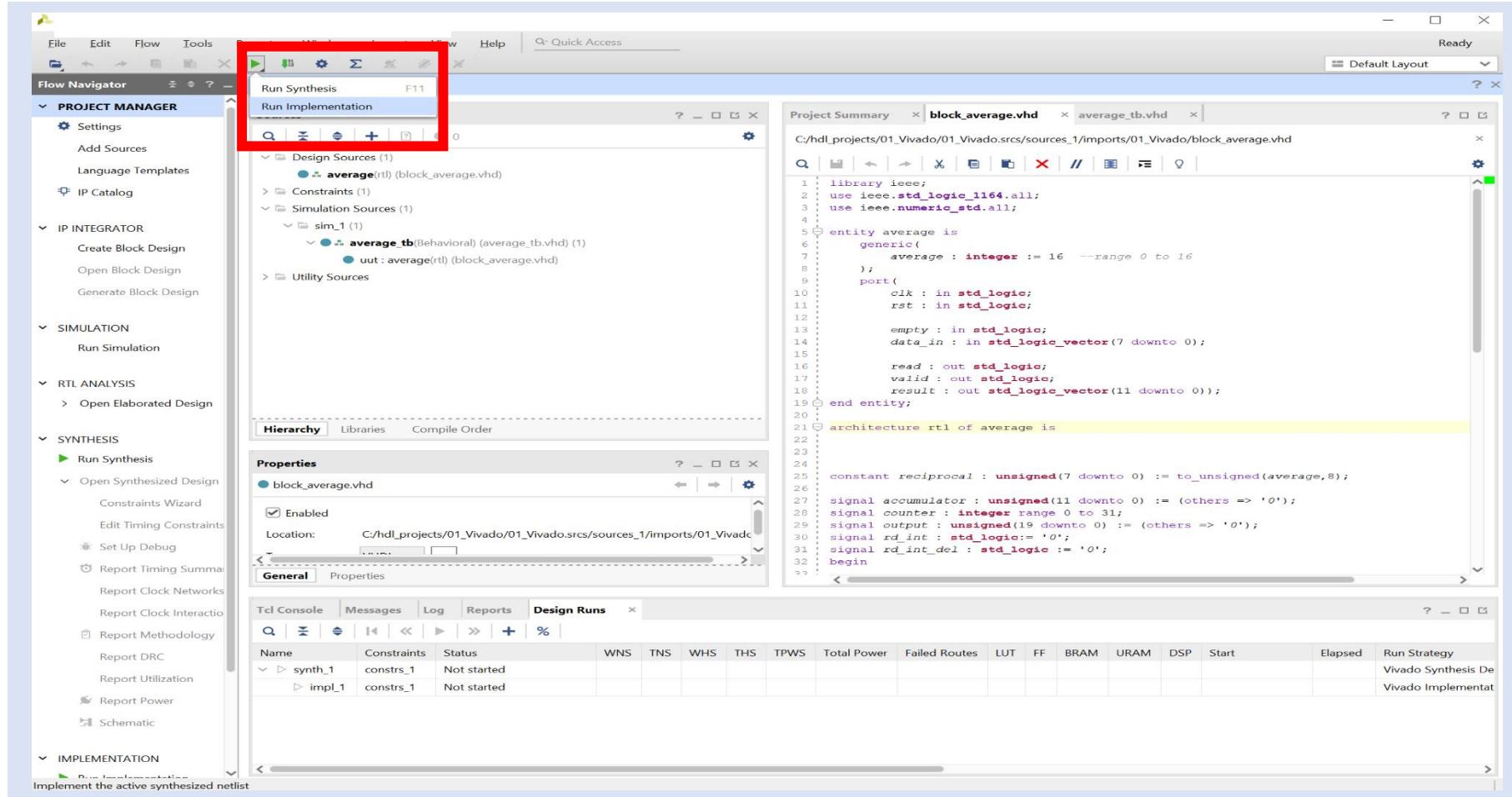
# Lab: Overview and Introduction to AMD Vivado™

**Step 41** – Confirm the decision to close by clicking **OK**. This will take us back to the project manager view.



# Lab: Overview and Introduction to AMD Vivado™

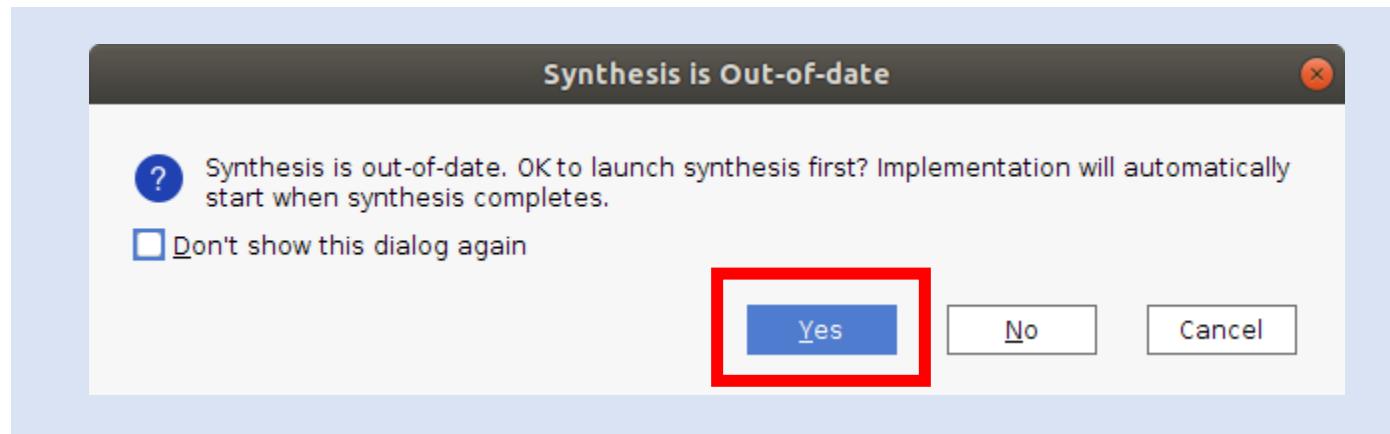
## Step 42 – We are now ready to Run Implementation.



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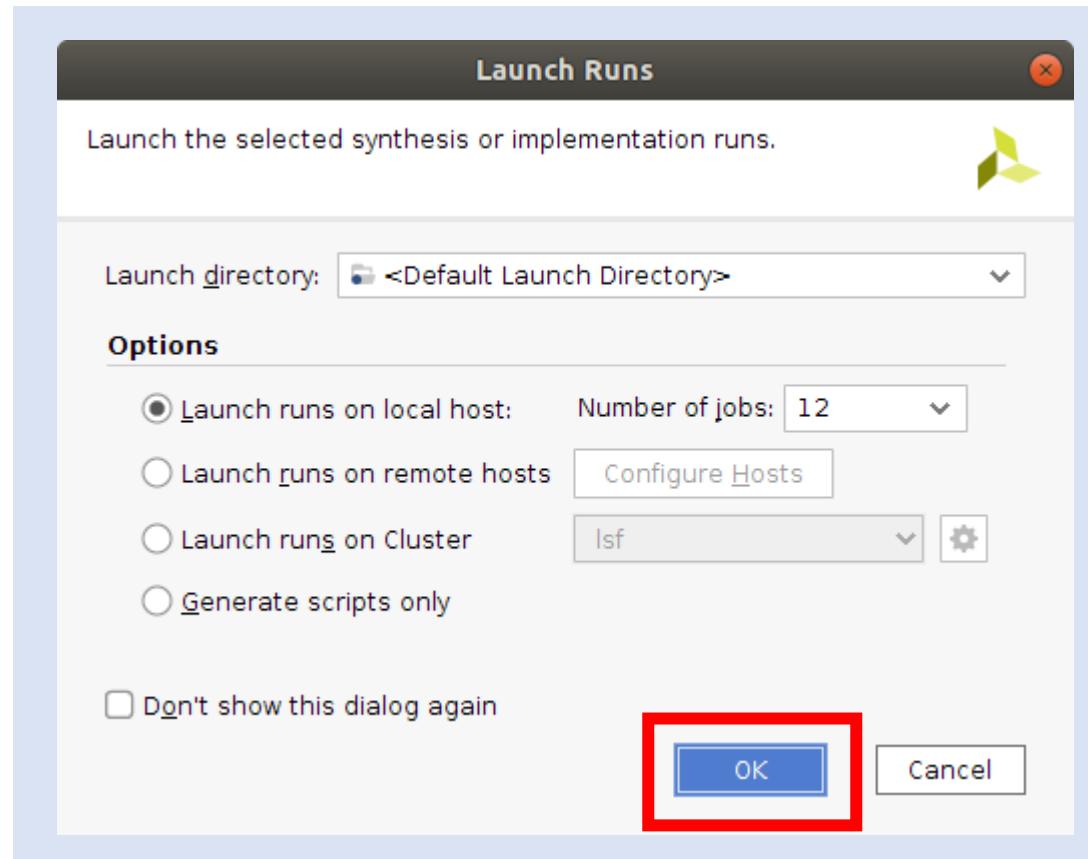
# Lab: Overview and Introduction to AMD Vivado™

**Step 43 – Click Yes when the Synthesis Out-of-Date dialog pops up.**



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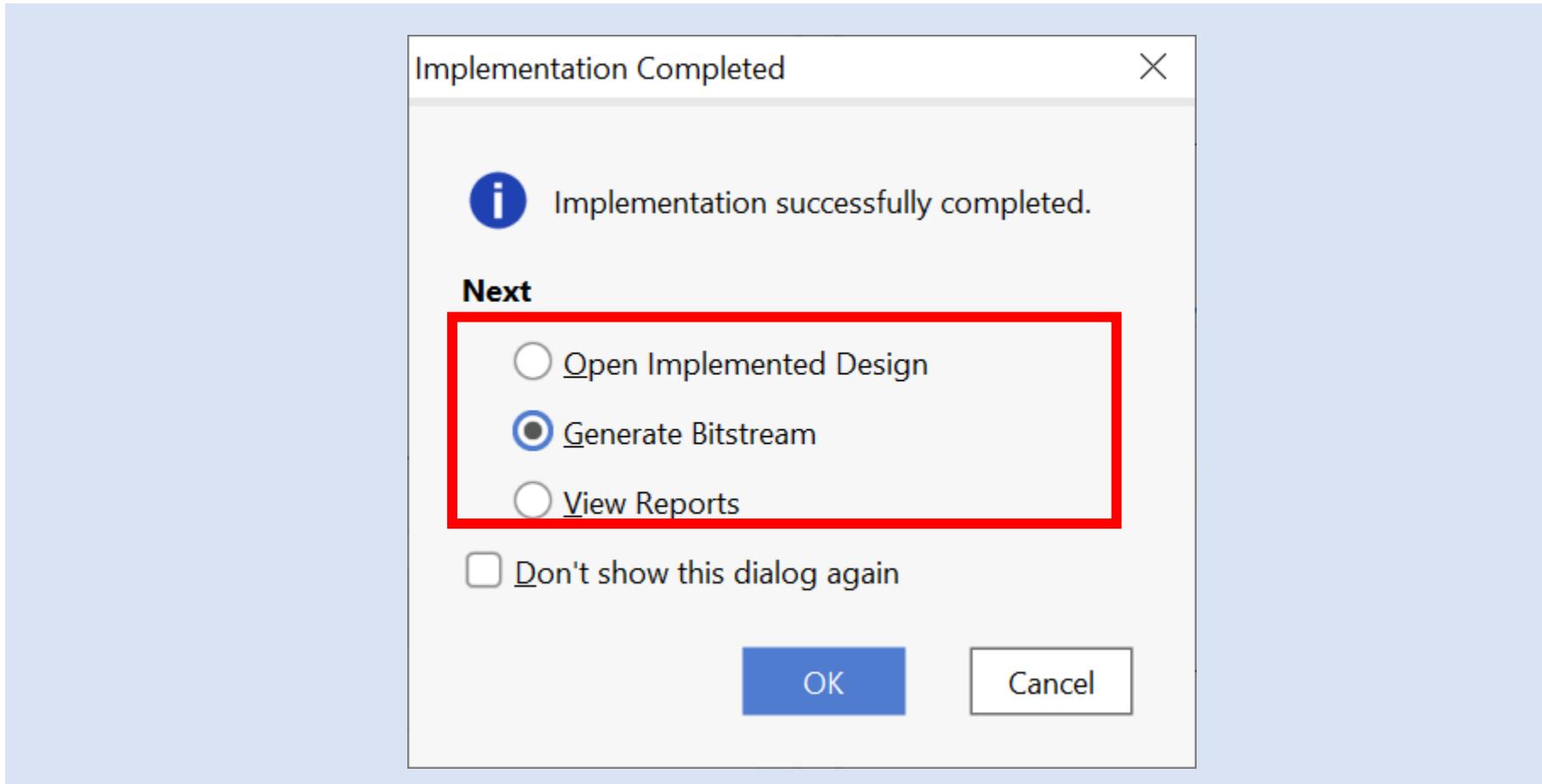
**Step 44 – Select OK on the Launch Runs dialog.**



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# Lab: Overview and Introduction to AMD Vivado™

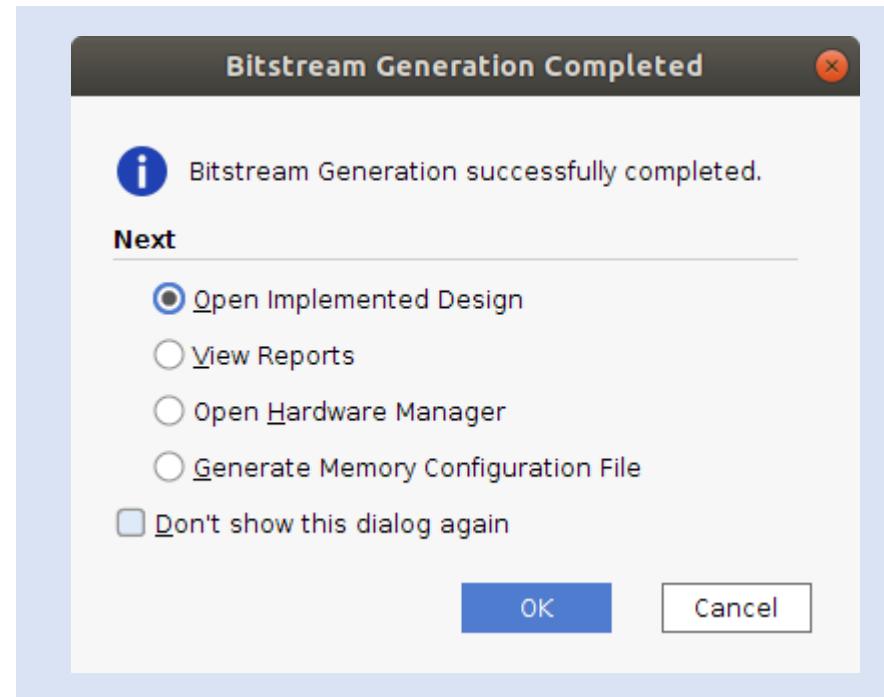
**Step 45 –** When the implementation completes, you will see a dialog appear. Select **Generate Bitstream**.



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# Lab: Overview and Introduction to AMD Vivado™

**Step 46 –** A dialog box will appear when the bitstream generates. Congratulations! You have completed your first Vivado FPGA implementation.



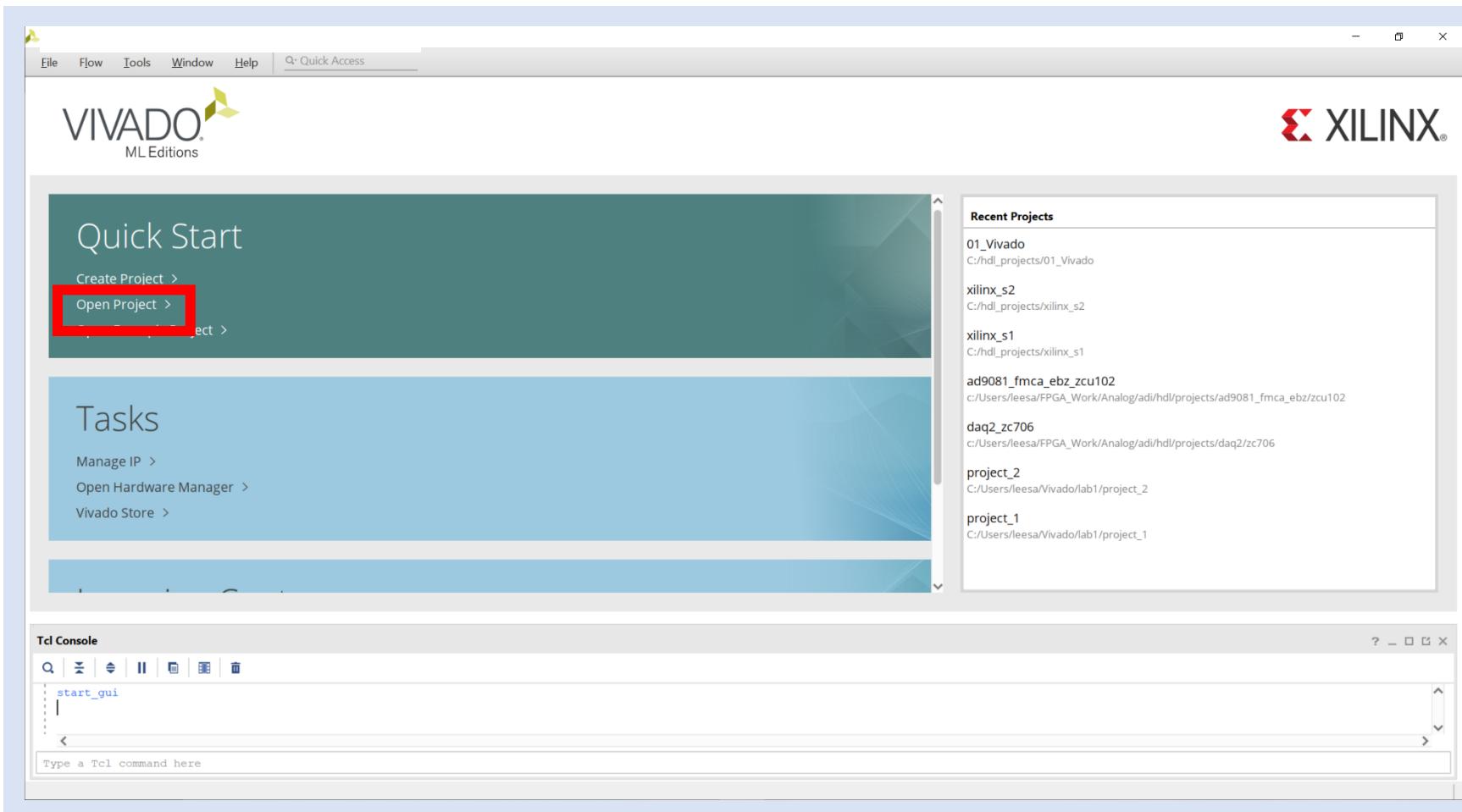
# Lab

## Intermediate AMD Vivado™

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# Lab: Intermediate AMD Vivado™

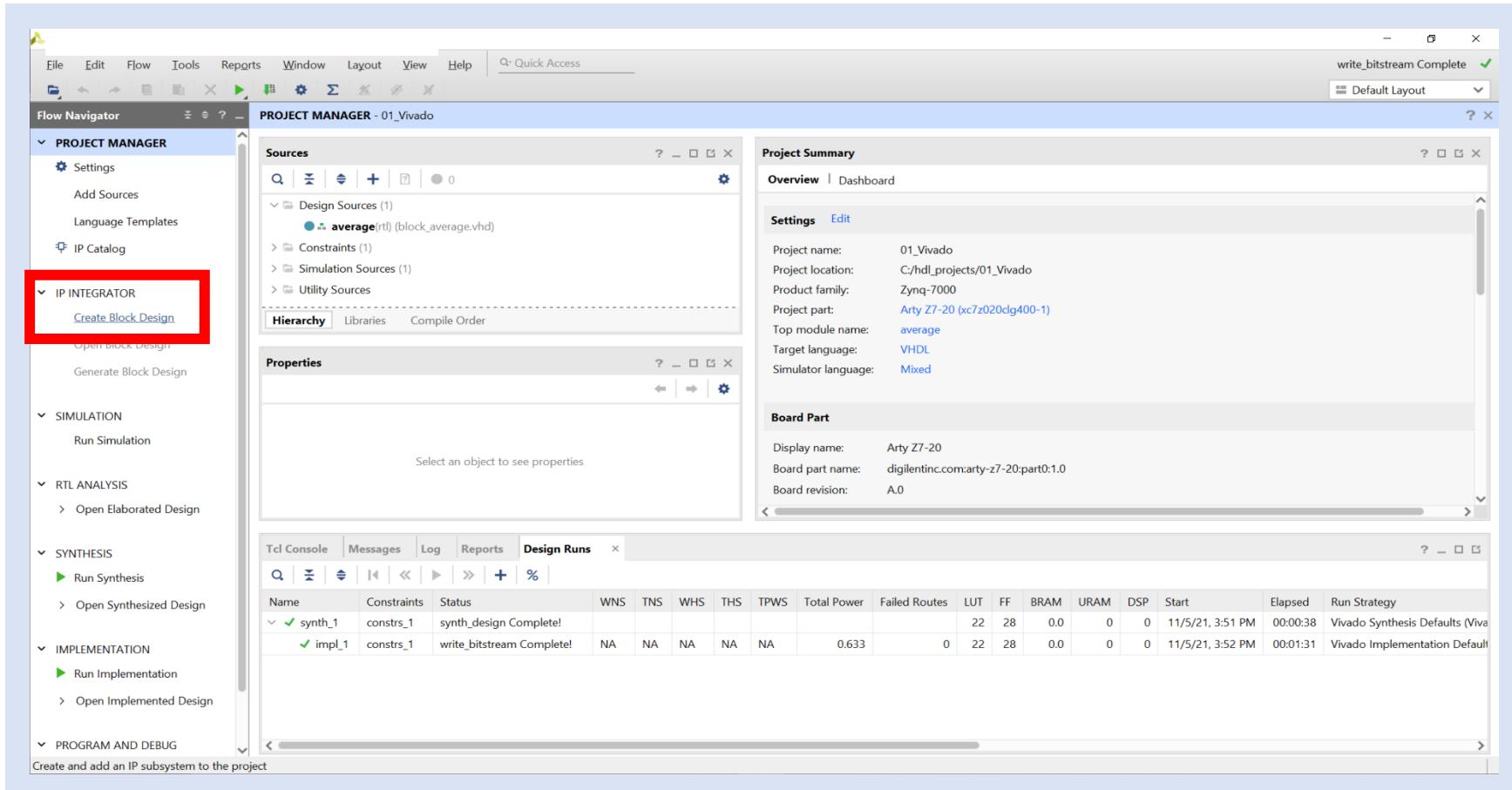
Step 1 – Open the project created in part one.



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# Lab: Intermediate AMD Vivado™

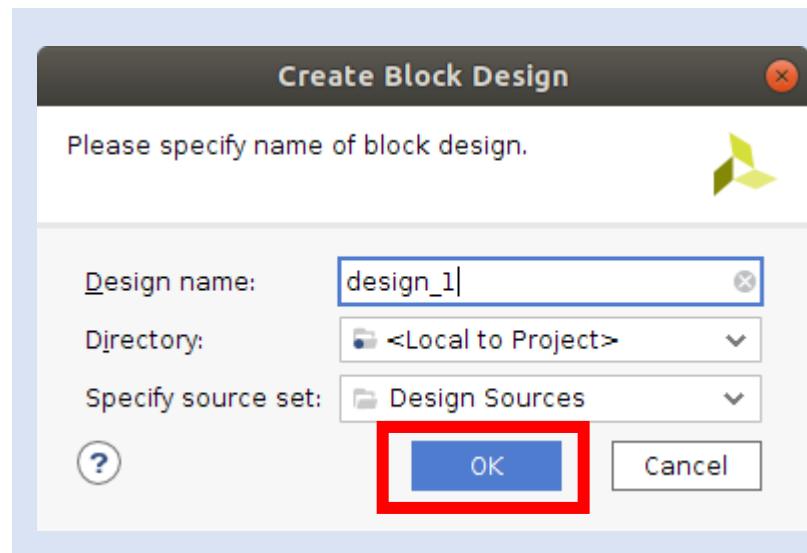
Step 2 – This will open in project management view. Click on **Create Block Diagram**.



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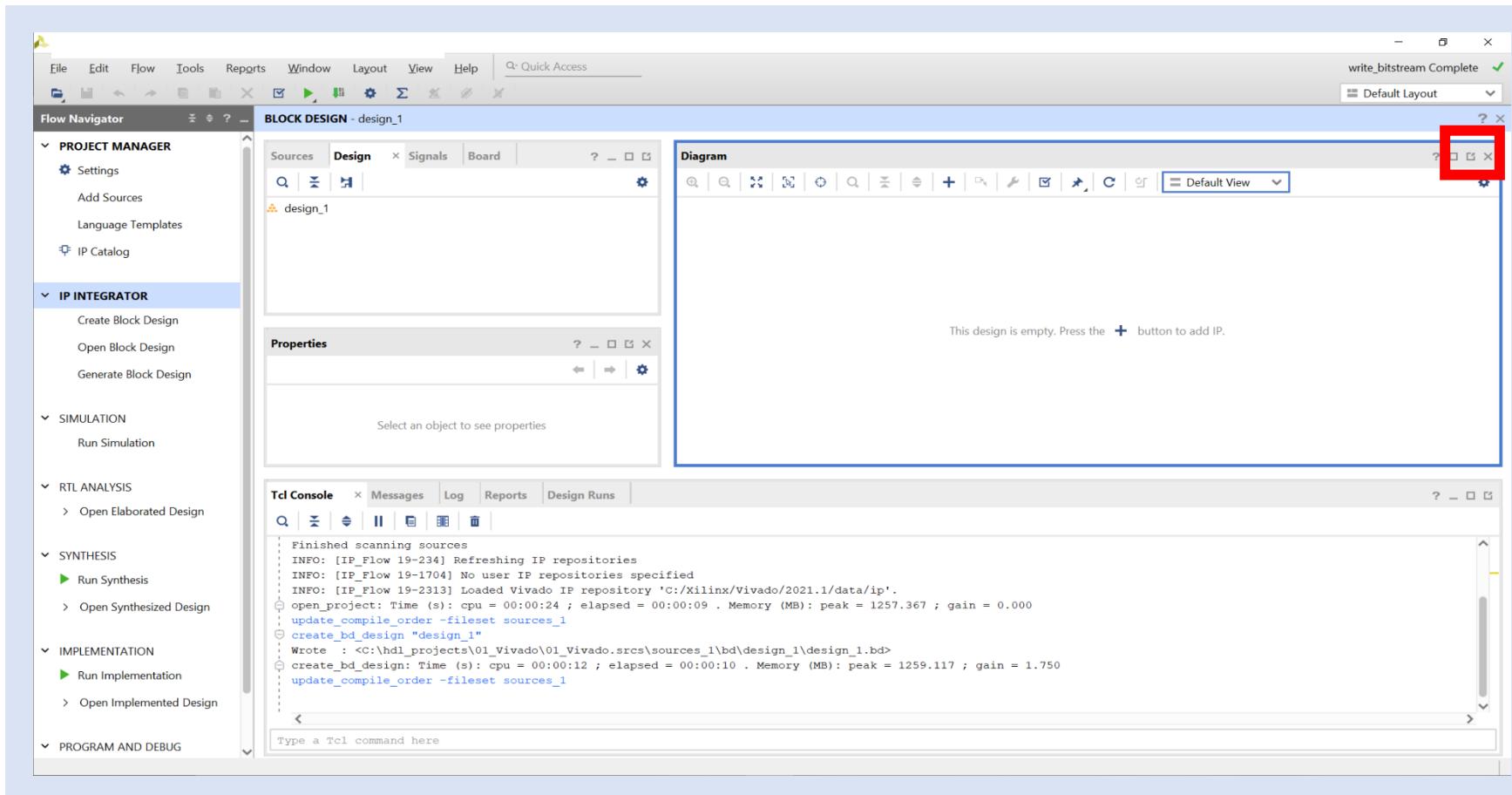
# Lab: Intermediate AMD Vivado™

**Step 3 – Leave the predefined name and locations unchanged and click **OK**.**



# Lab: Intermediate AMD Vivado™

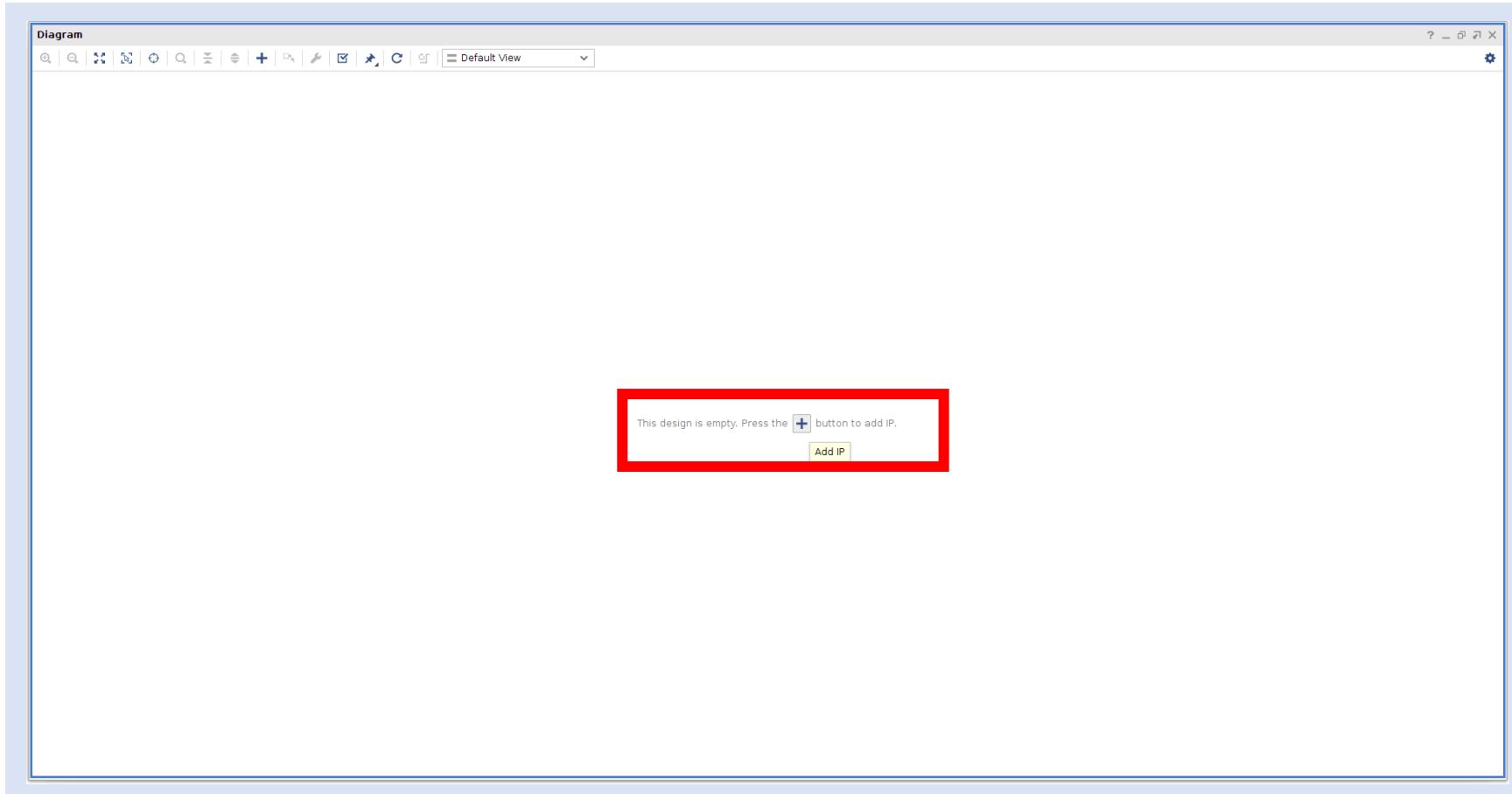
Step 4 – Undock the block diagram window and maximize it.



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# Lab: Intermediate AMD Vivado™

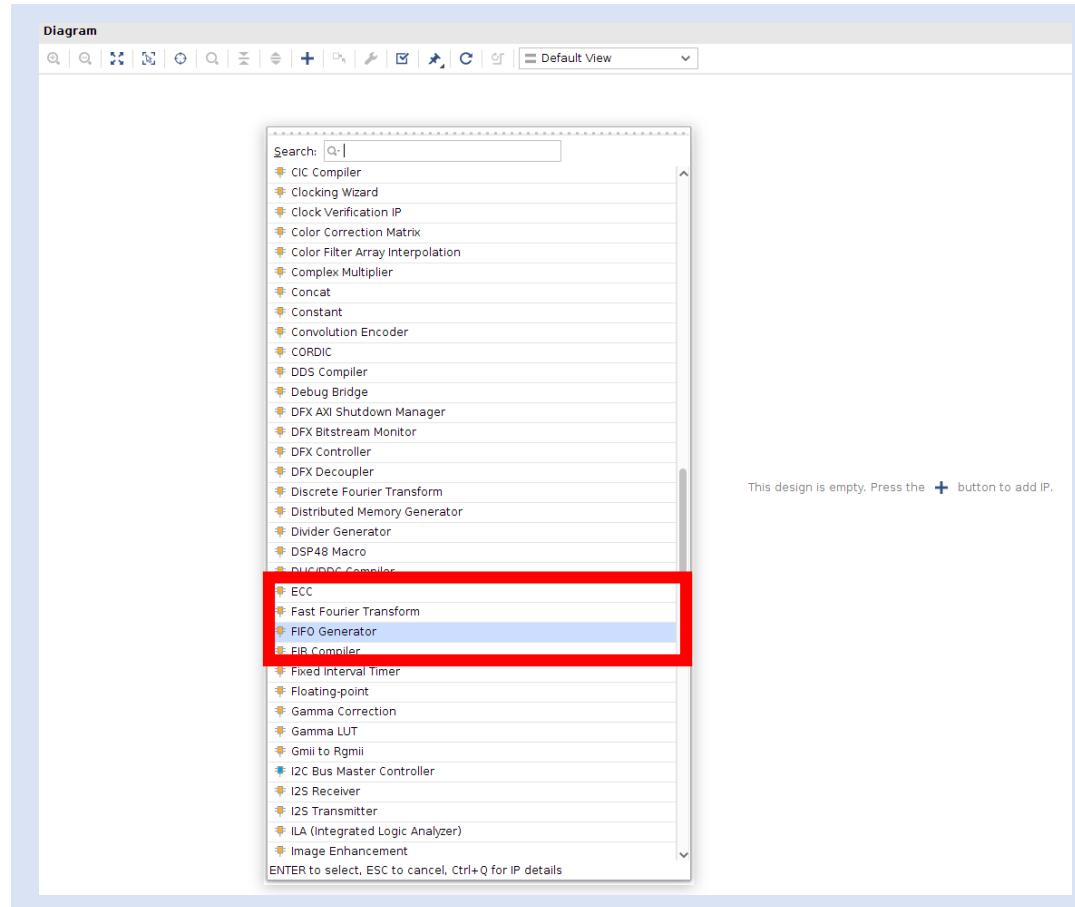
**Step 5 – We are going to add in new IP. Click on the + button.**



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# Lab: Intermediate AMD Vivado™

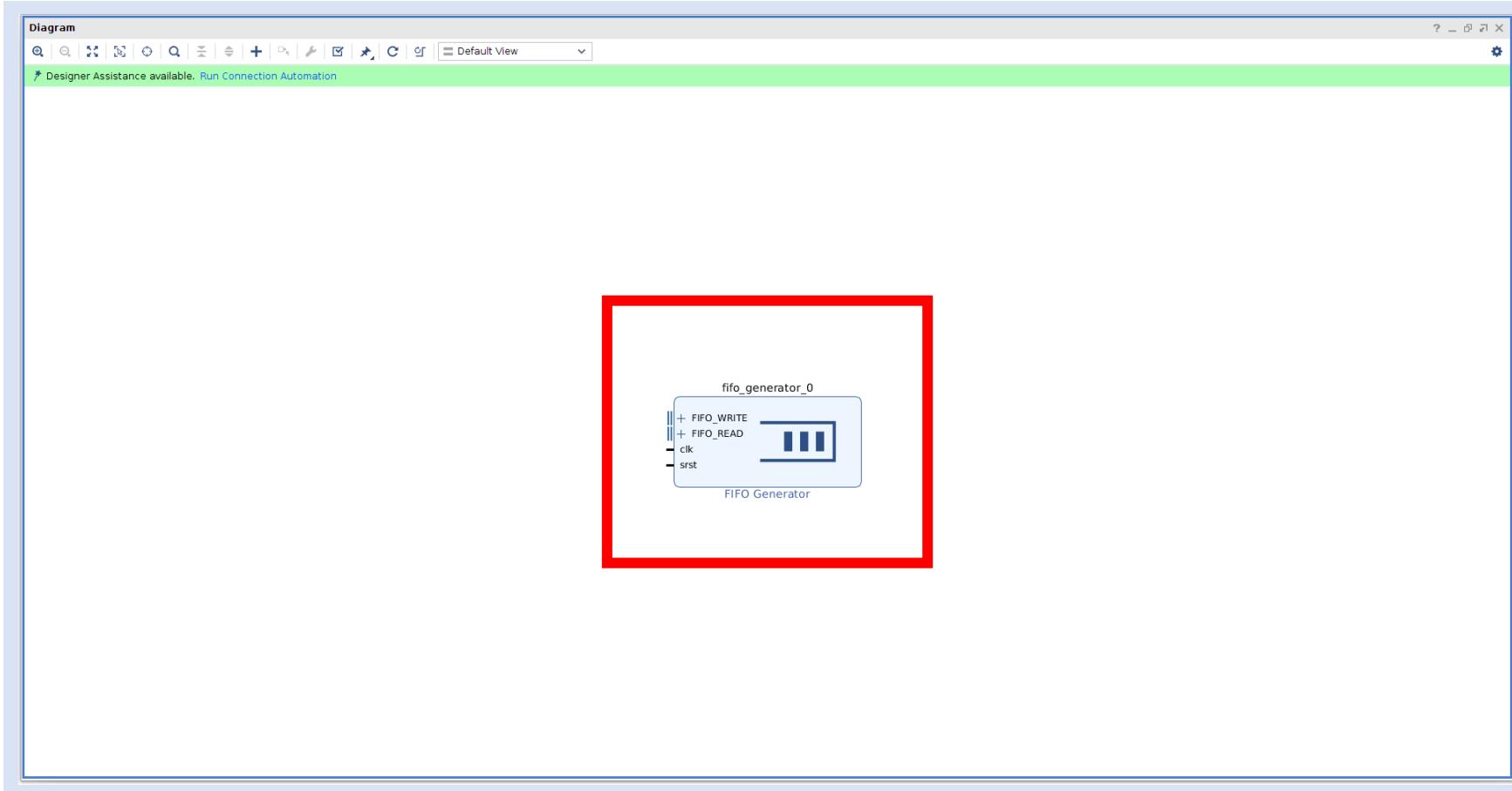
**Step 6 – Select the FIFO Generator.** This will add a FIFO to the block diagram.



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# Lab: Intermediate AMD Vivado™

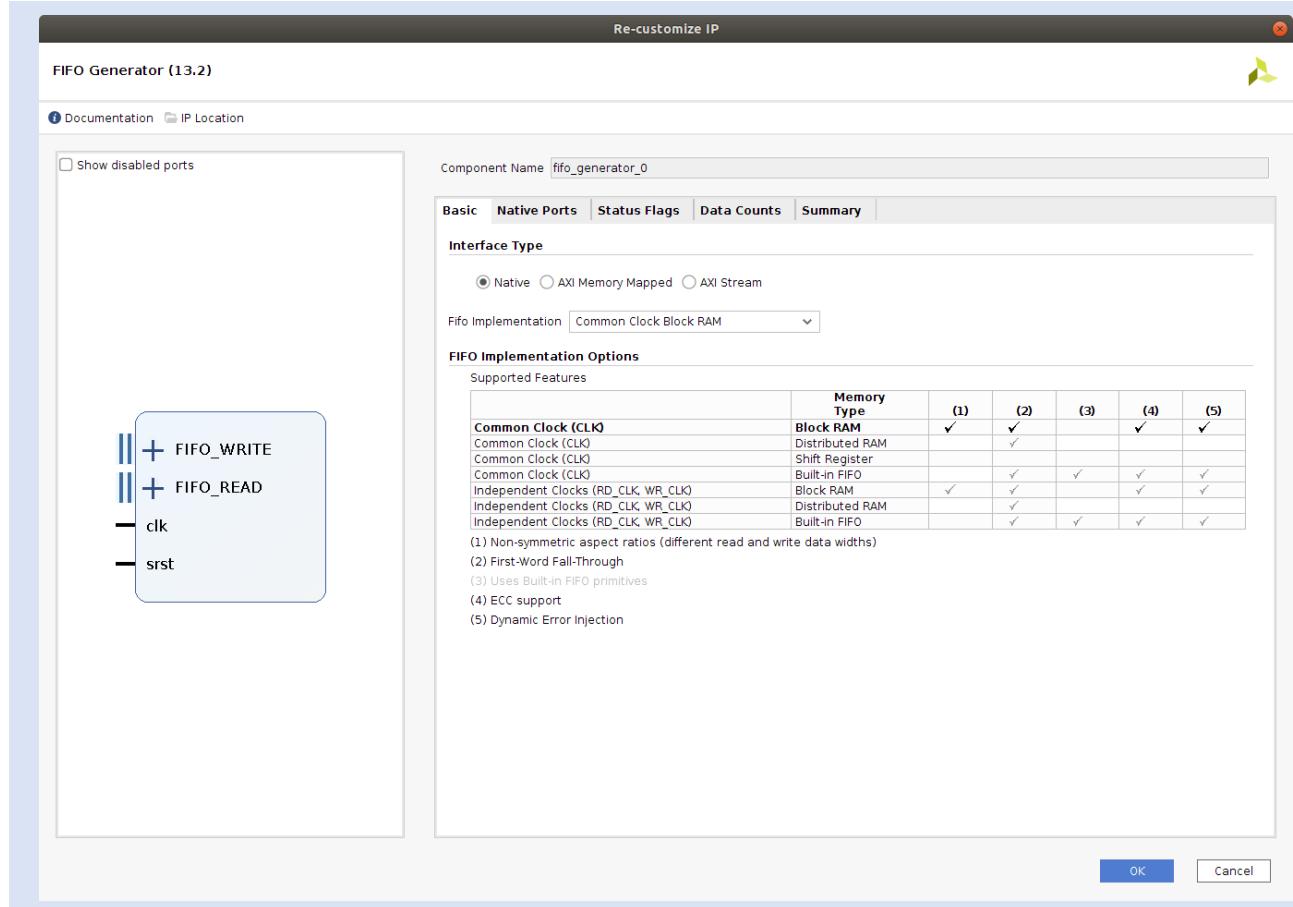
**Step 7 – Double click on the FIFO Generator to customize it.**



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# Lab: Intermediate AMD Vivado™

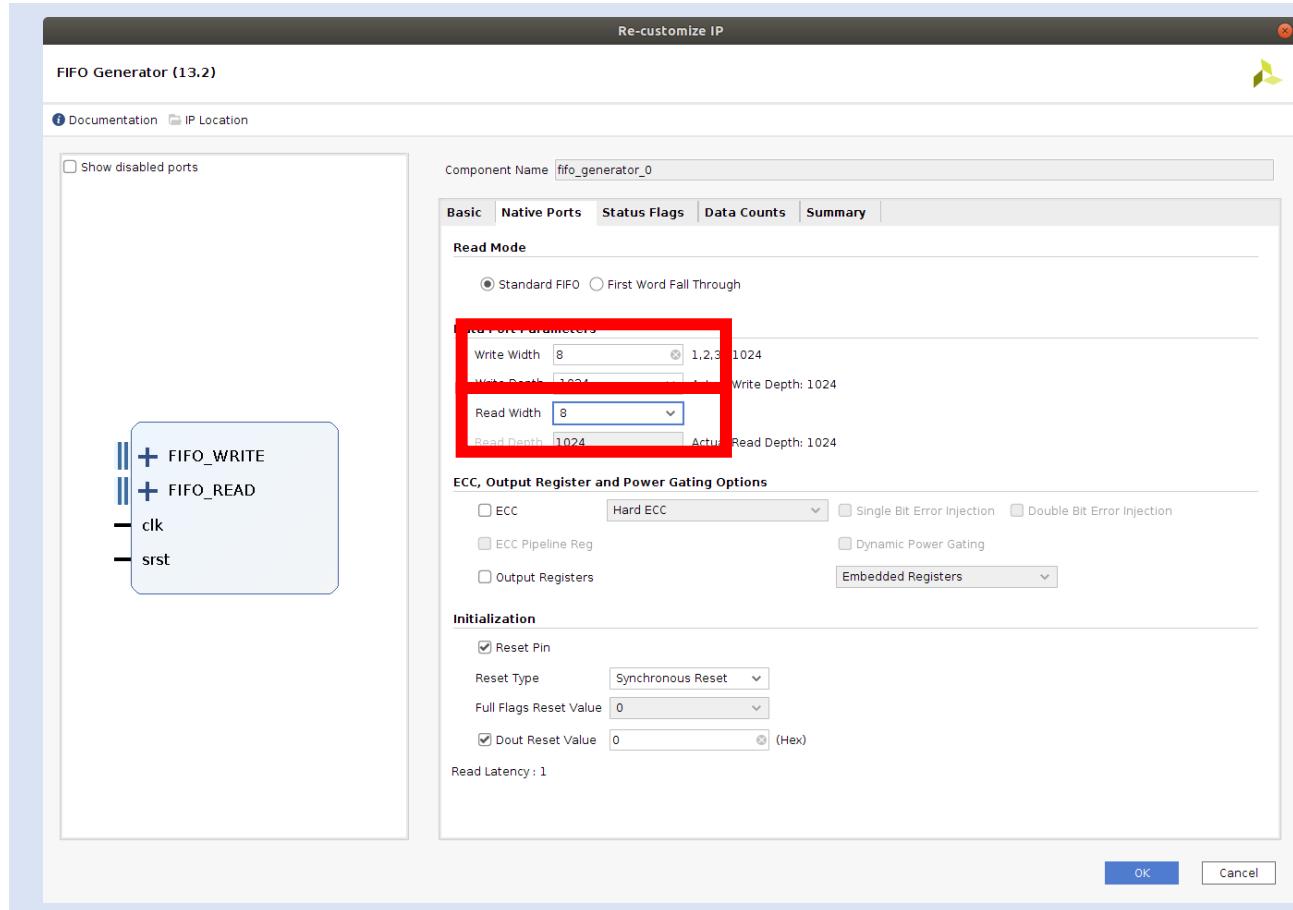
Step 8 – Leave the first page unchanged.



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# Lab: Intermediate AMD Vivado™

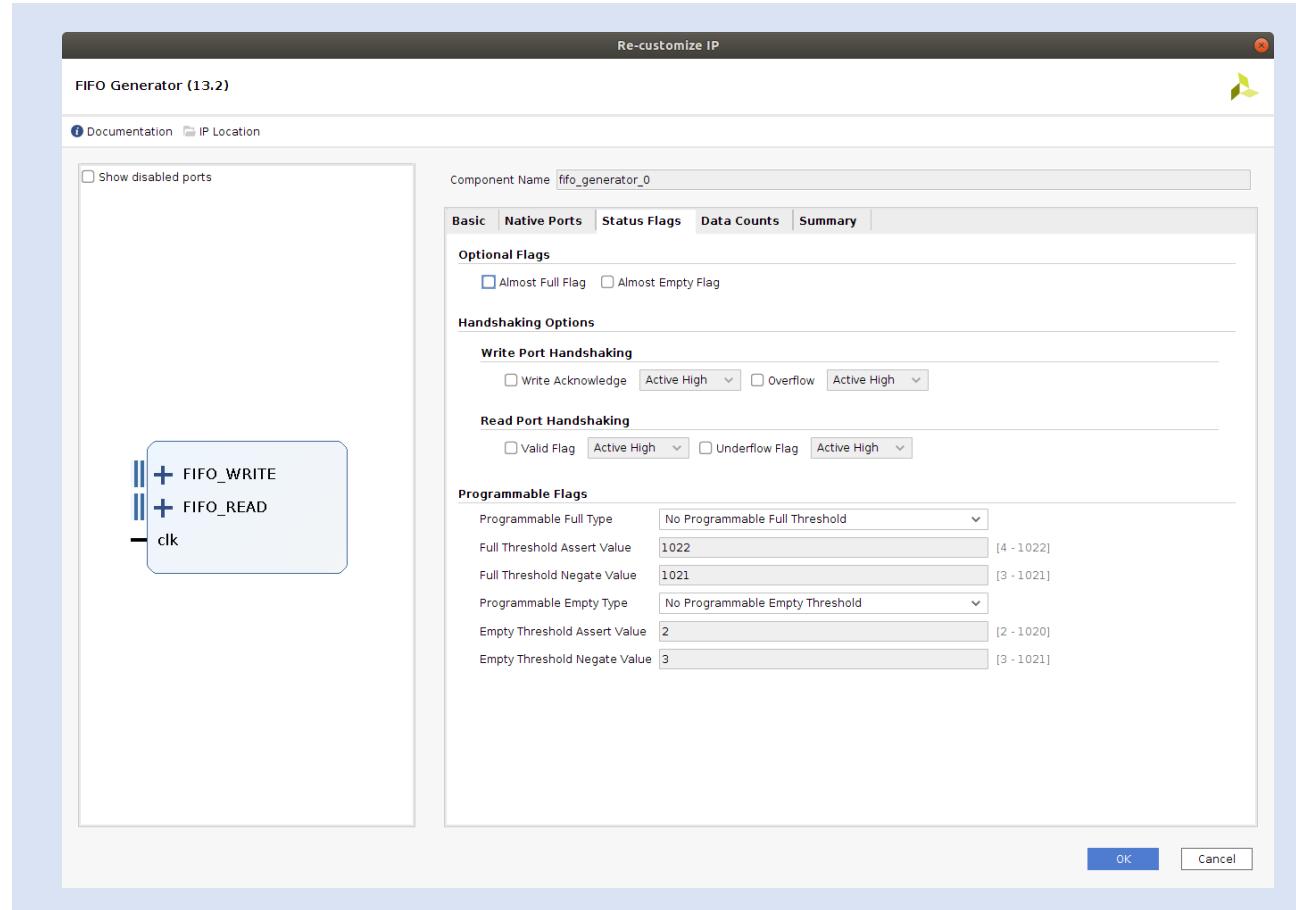
## Step 9 – Change the Write and Read Width to be 8 bits.



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# Lab: Intermediate AMD Vivado™

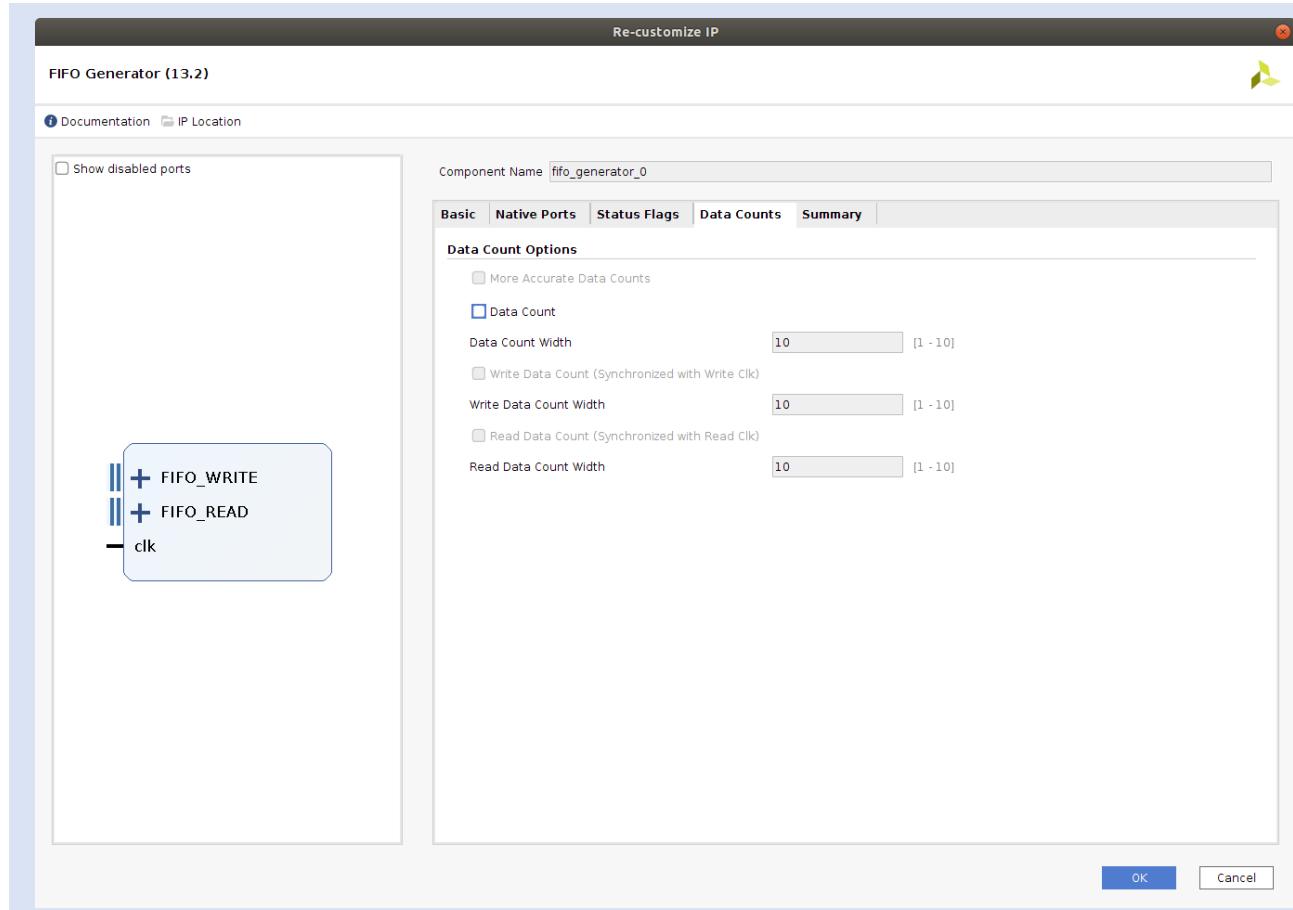
**Step 10 – Leave the third page unchanged.**



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# Lab: Intermediate AMD Vivado™

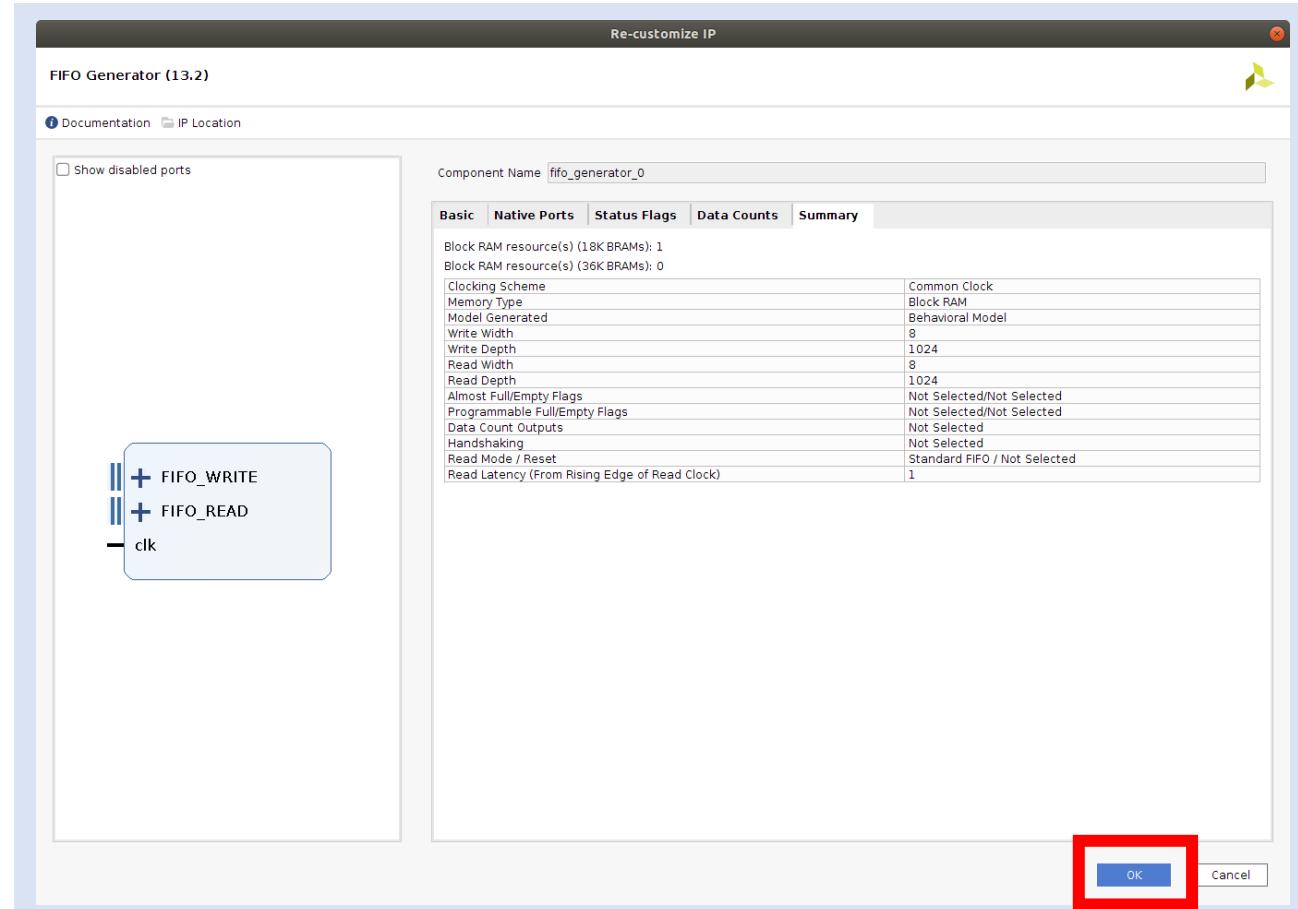
**Step 11 – Leave the fourth page unchanged.**



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# Lab: Intermediate AMD Vivado™

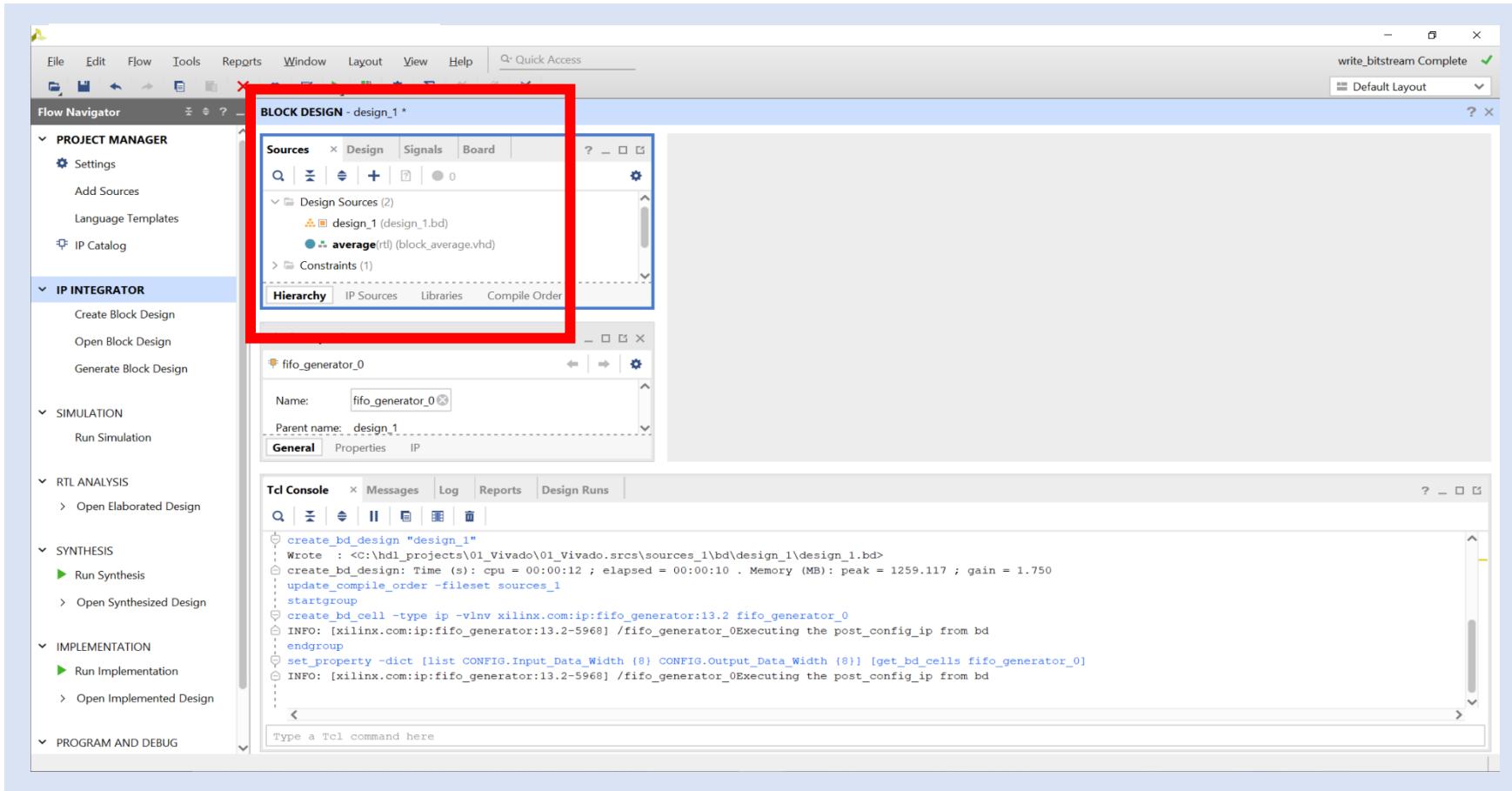
**Step 12 –** Leave the final page unchanged. Note that the FIFO OP are unregistered. Click **OK**.



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# Lab: Intermediate AMD Vivado™

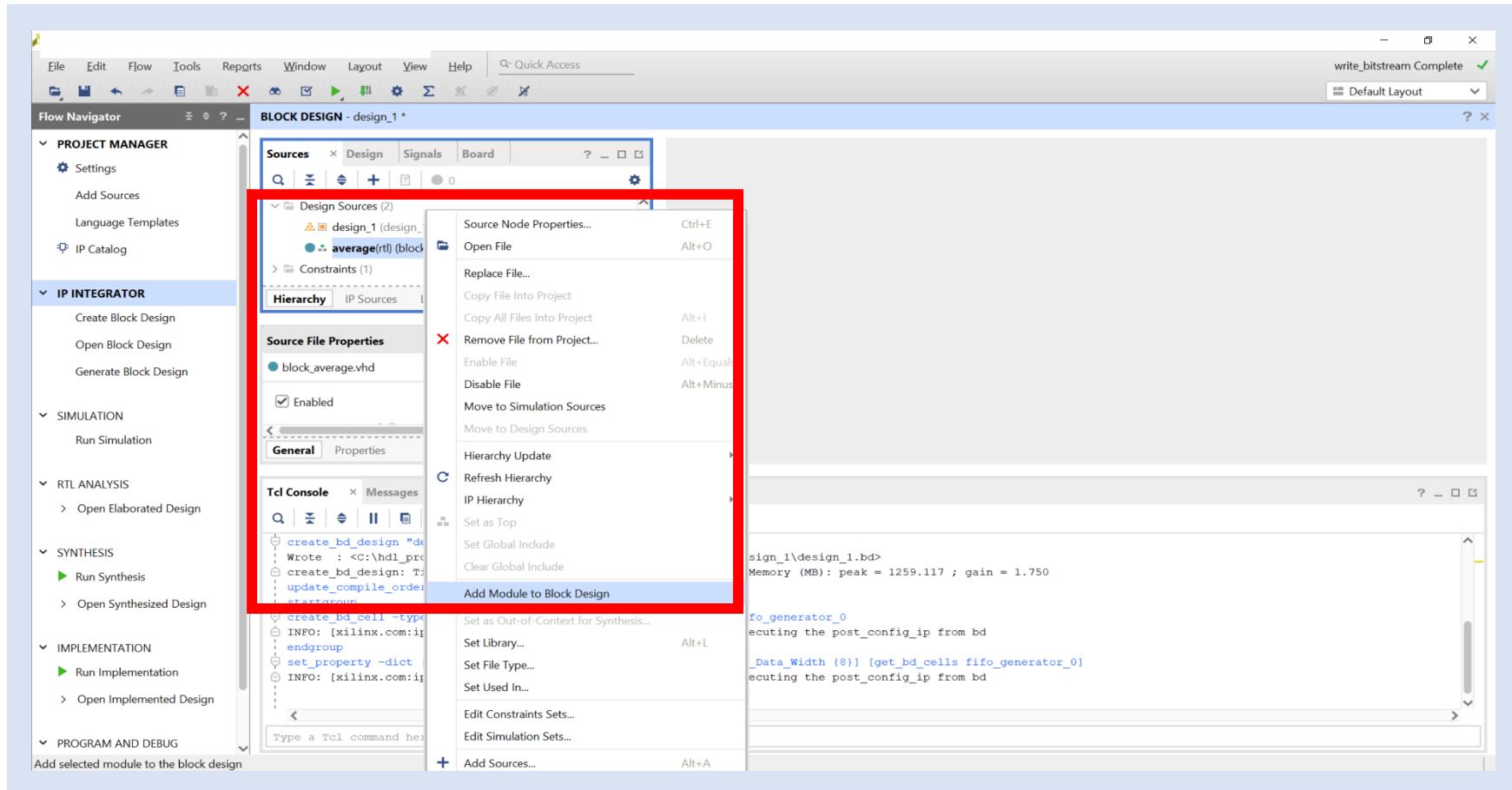
**Step 13 – Click back on the Vivado Project Management view you will see the block diagram under the design sources.**



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# Lab: Intermediate AMD Vivado™

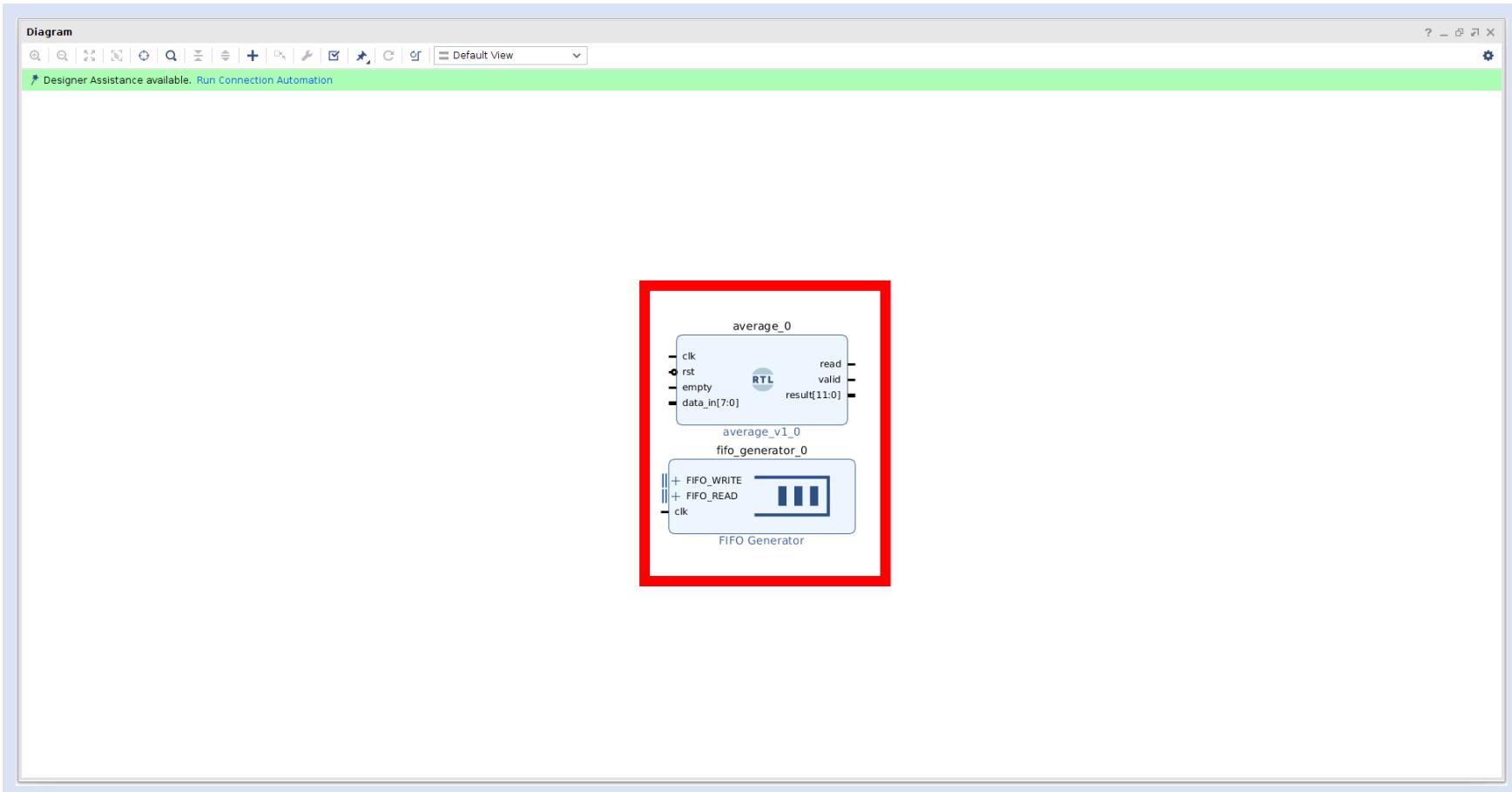
**Step 14 – Right click on the average RTL block and select Add Module to Block Design.**



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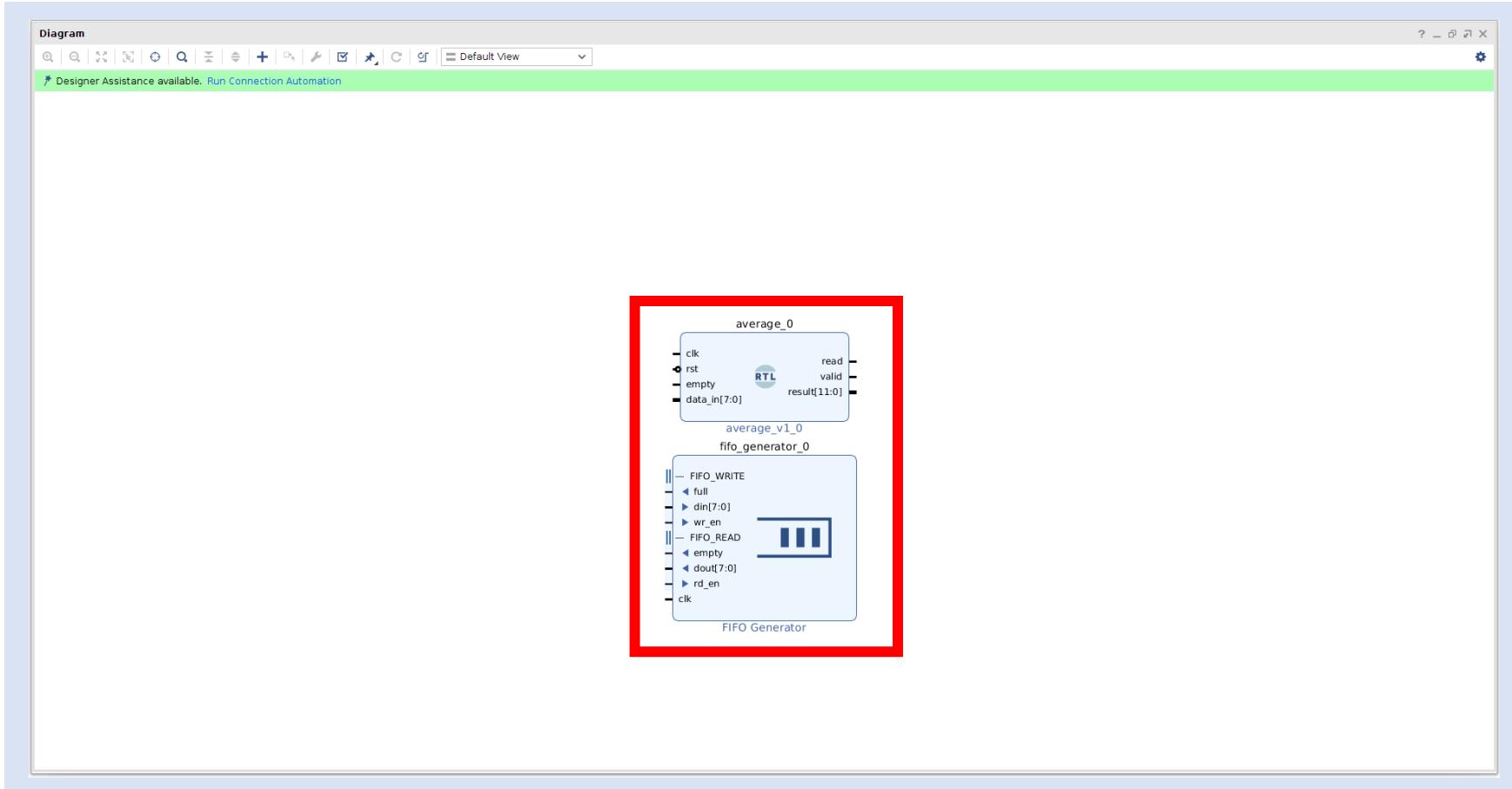
**Step 15 –** This will add the average block to the block diagram.



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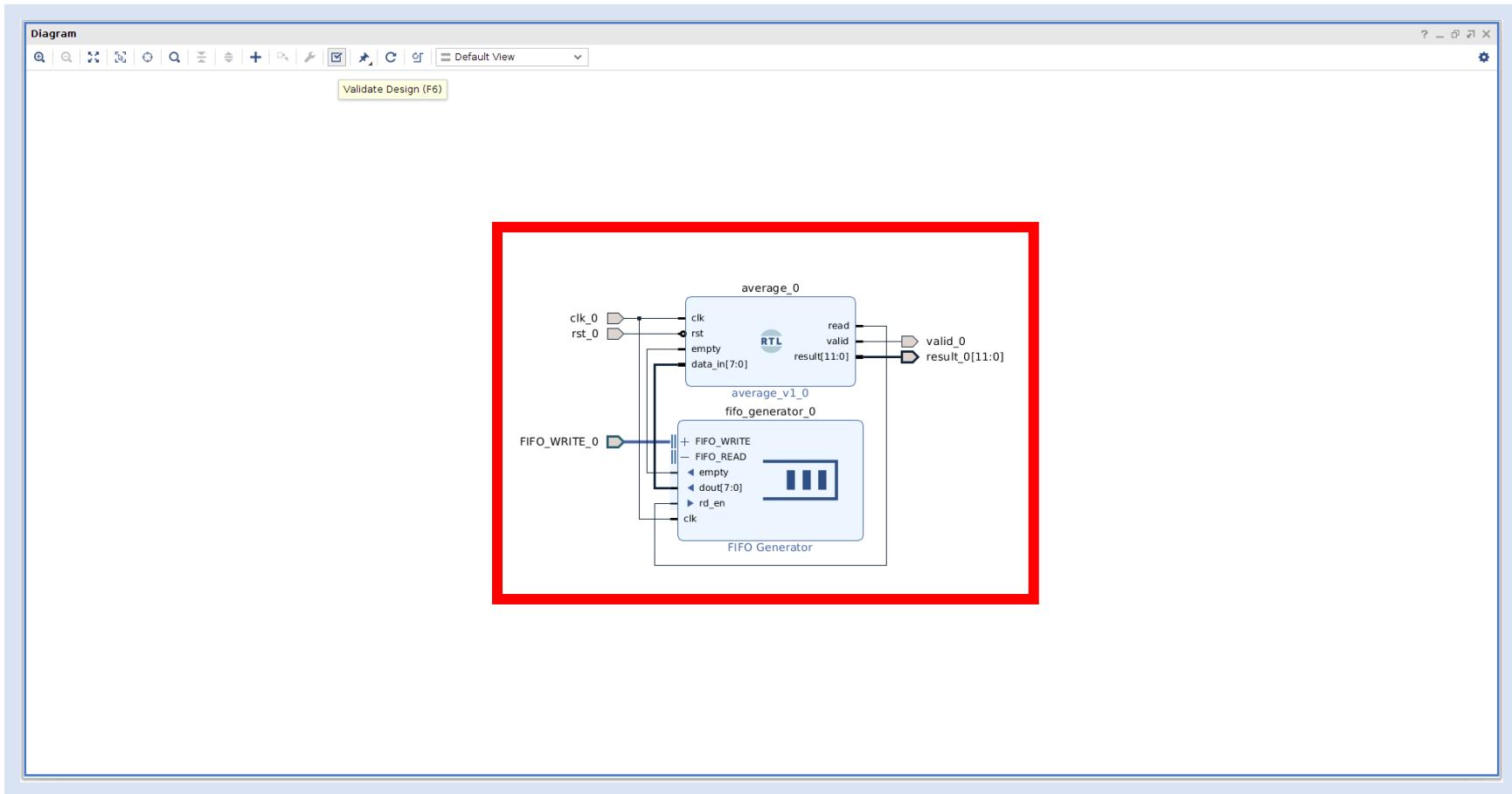
**Step 16 – Expand the FIFO Write and Read Interfaces.**



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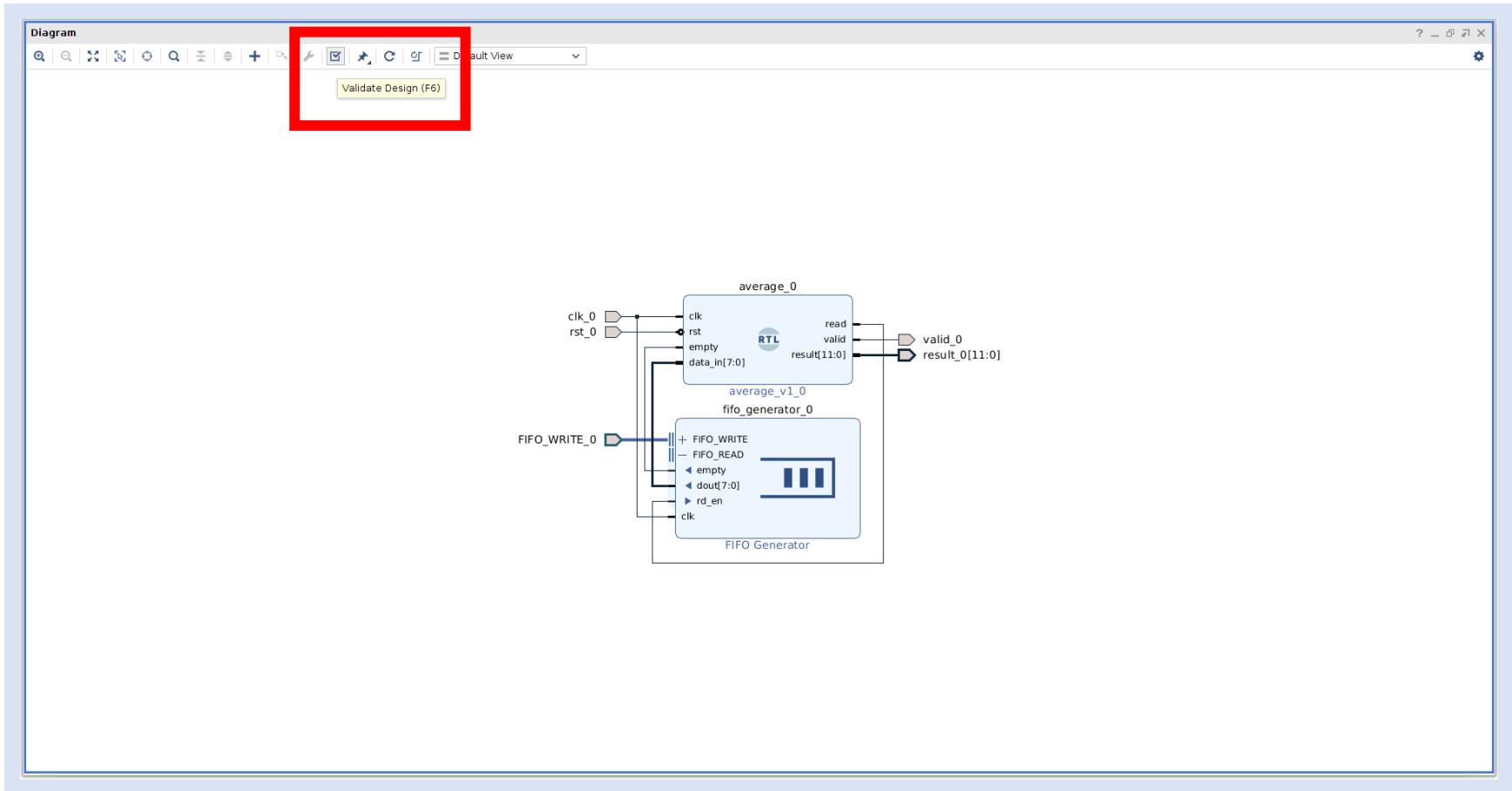
**Step 17 –** Make the Clk, Reset, Result, Valid and FIFO Write interfaces external by right-clicking on each pin and selecting **Make External**. Connect the remaining interfaces as below.



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**Step 18 – Click on Validate Design.**



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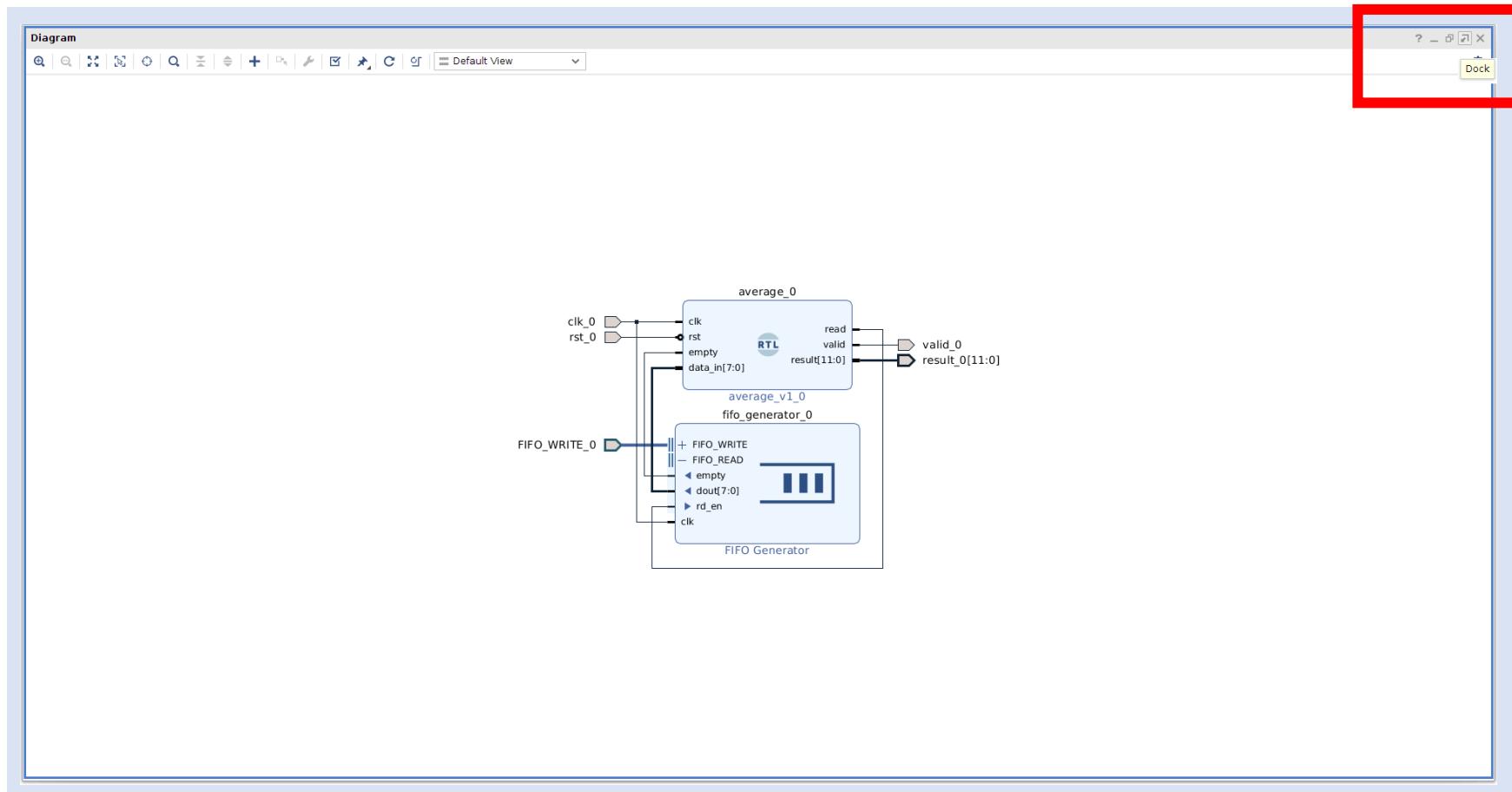
# Lab: Intermediate AMD Vivado™

**Step 19 –** The validated design should result in no error or critical warnings. Click **OK**.



# Lab: Intermediate AMD Vivado™

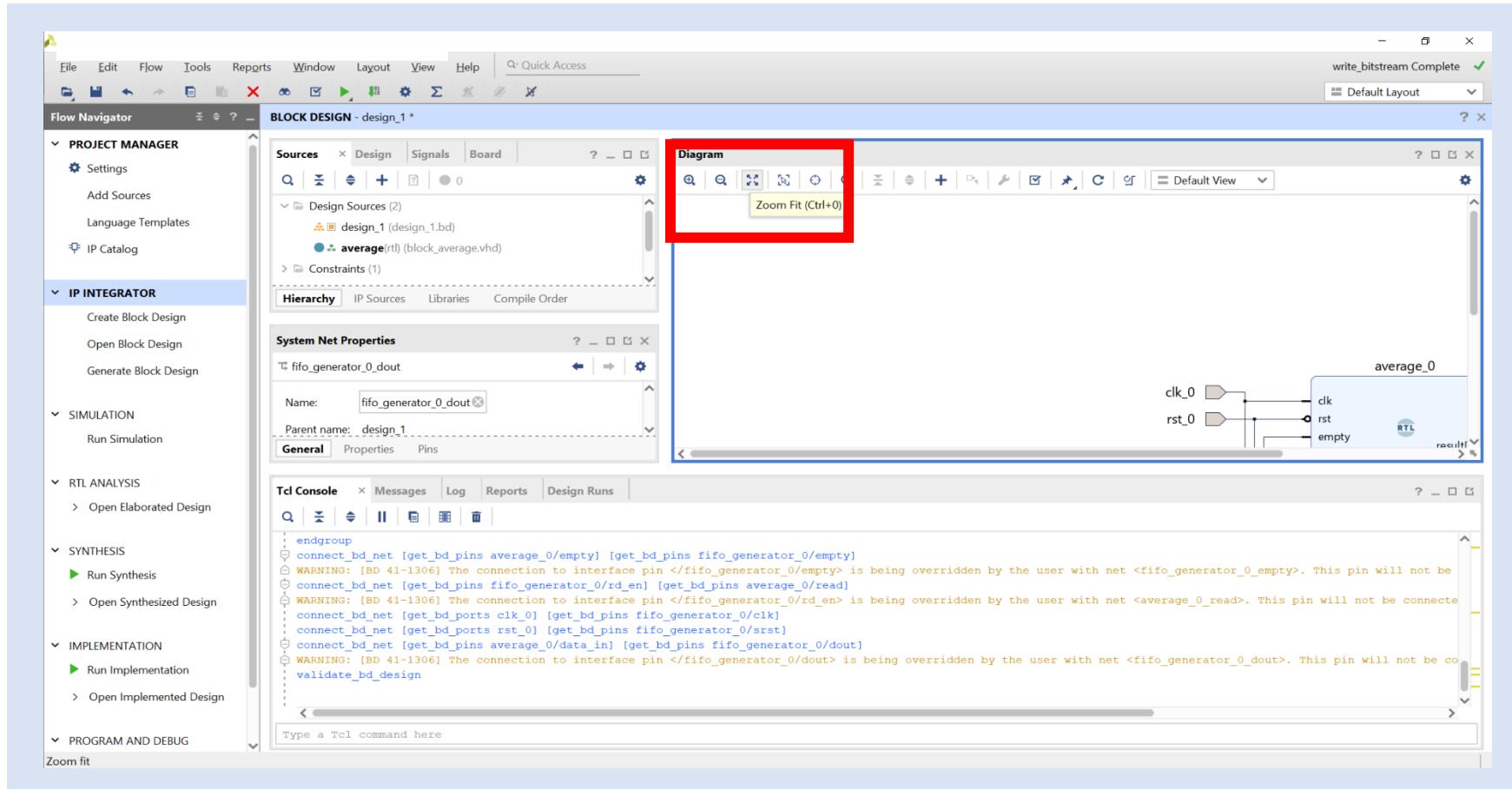
**Step 20 – Re-dock the block diagram window into the Vivado Project Manager.**



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# Lab: Intermediate AMD Vivado™

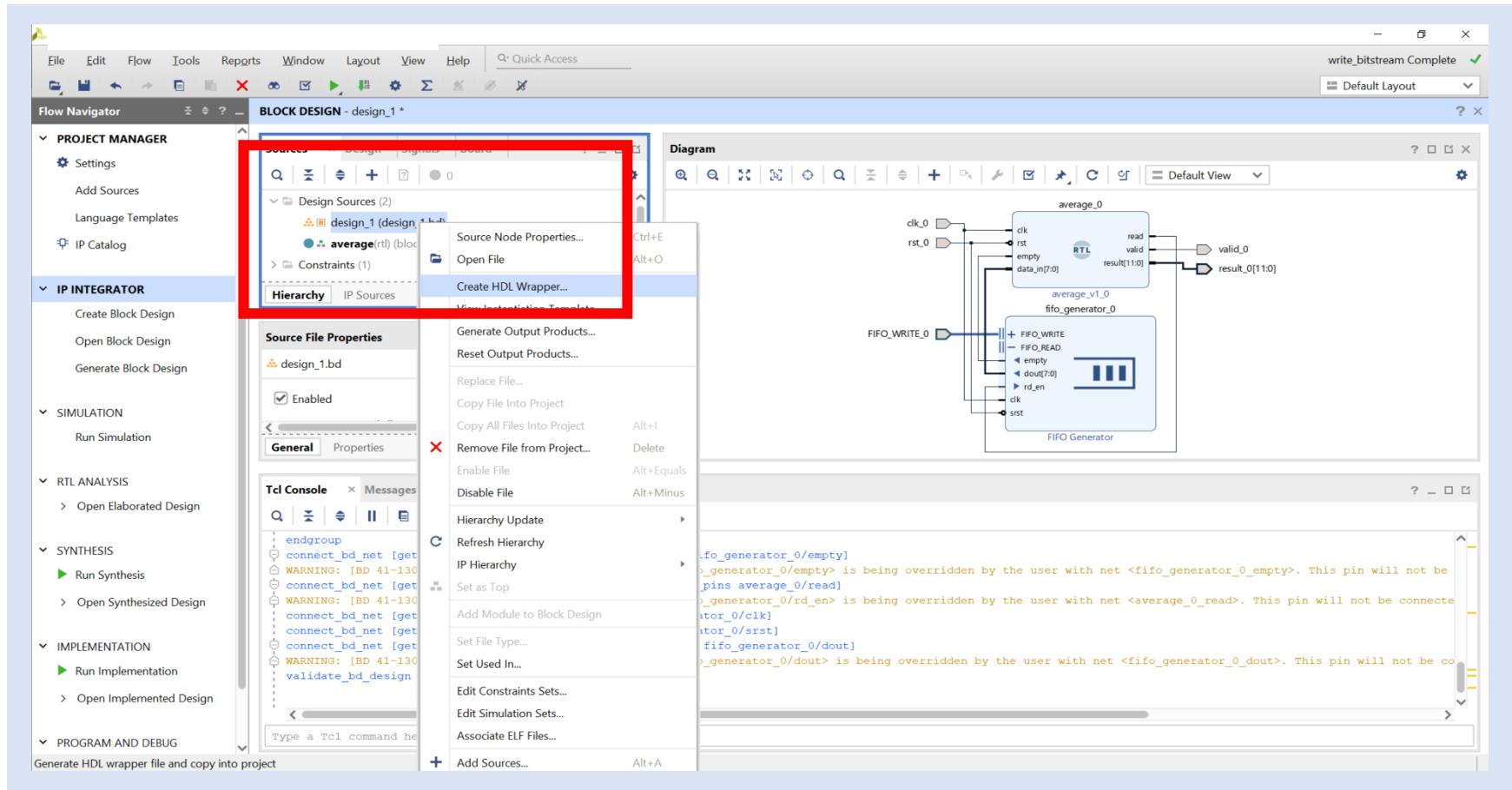
**Step 21 – Click on the Zoom Fit button to fit the design to the window.**



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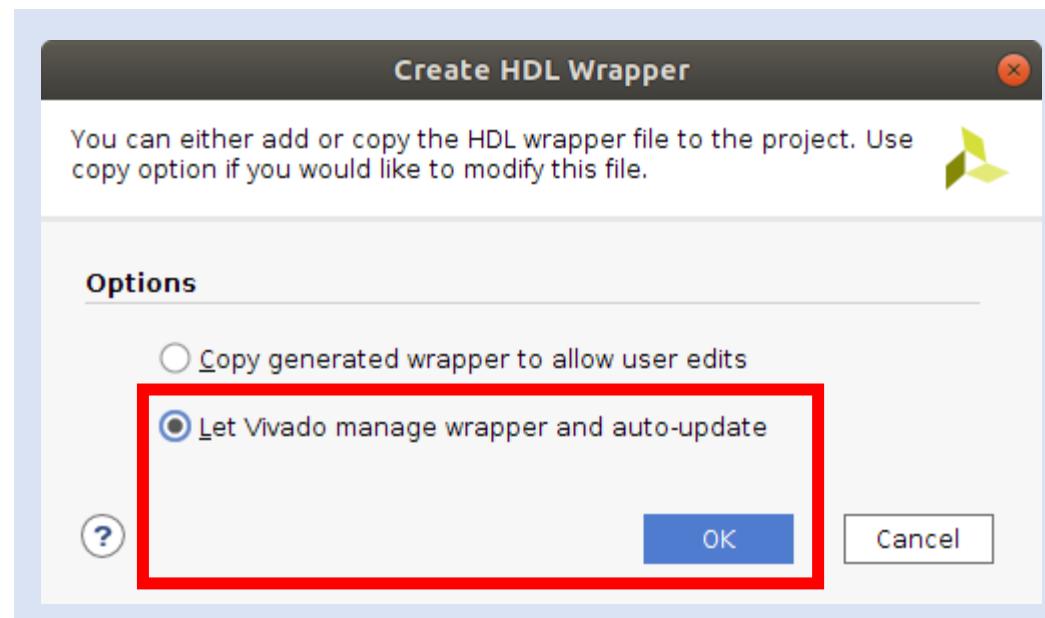
**Step 22 – Right click on the block diagram design under the Design Sources tab and select Create HDL Wrapper.**



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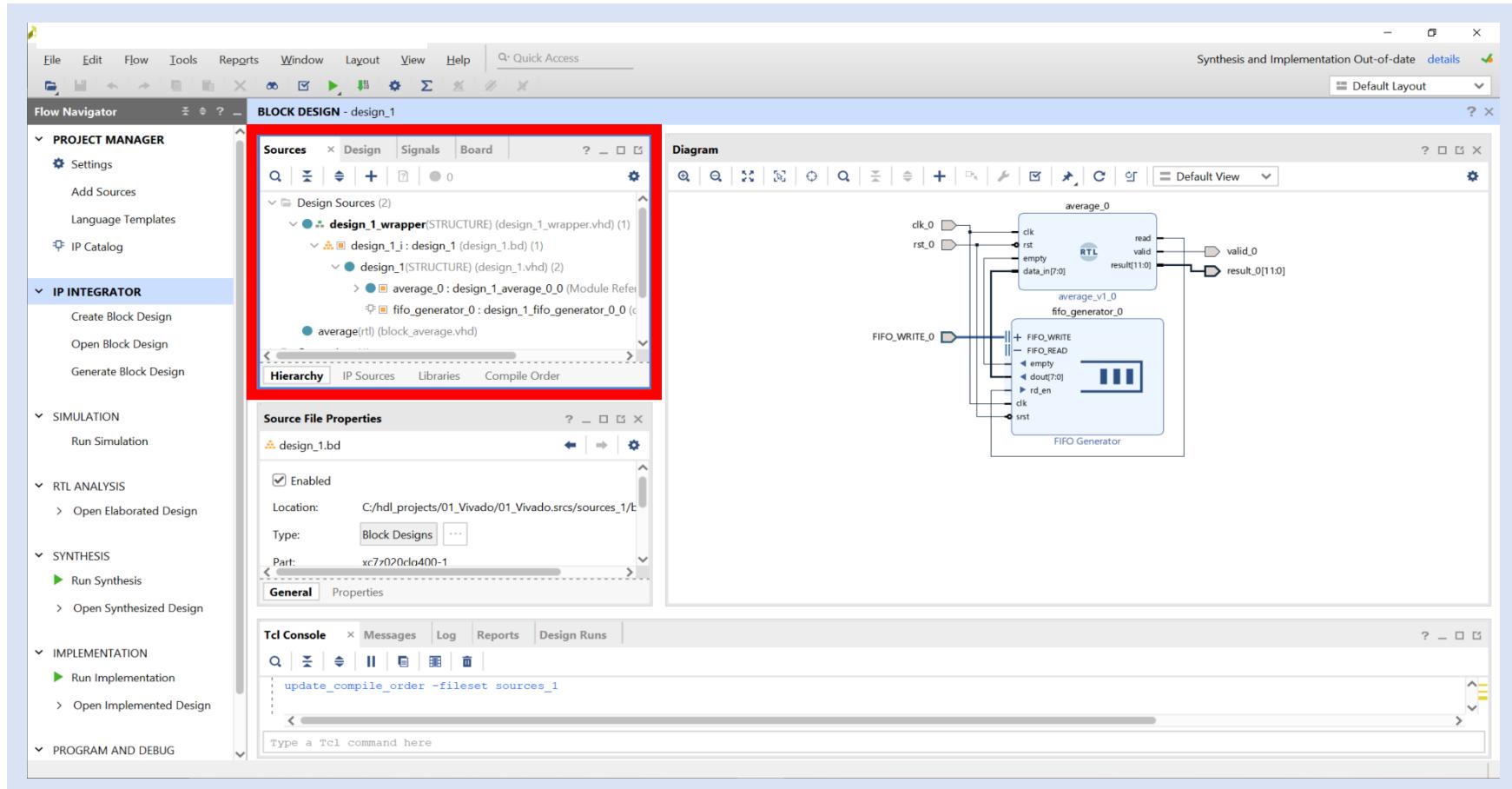
# Lab: Intermediate AMD Vivado™

**Step 23 – Allow Vivado to manage the wrapper and click **OK**.**



# Lab: Intermediate AMD Vivado™

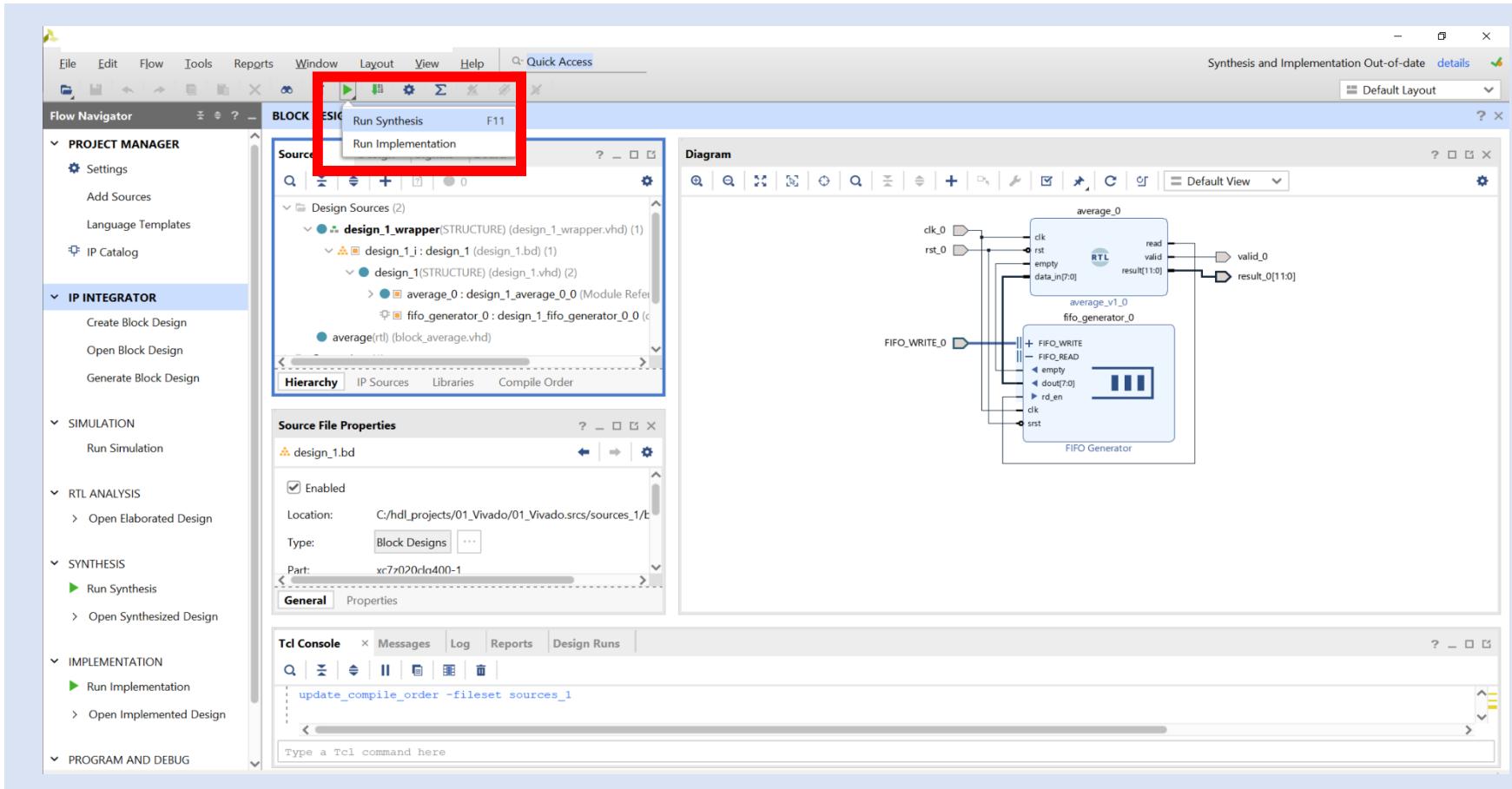
**Step 24 – Expand the newly created wrapper and you will see the entire design.**



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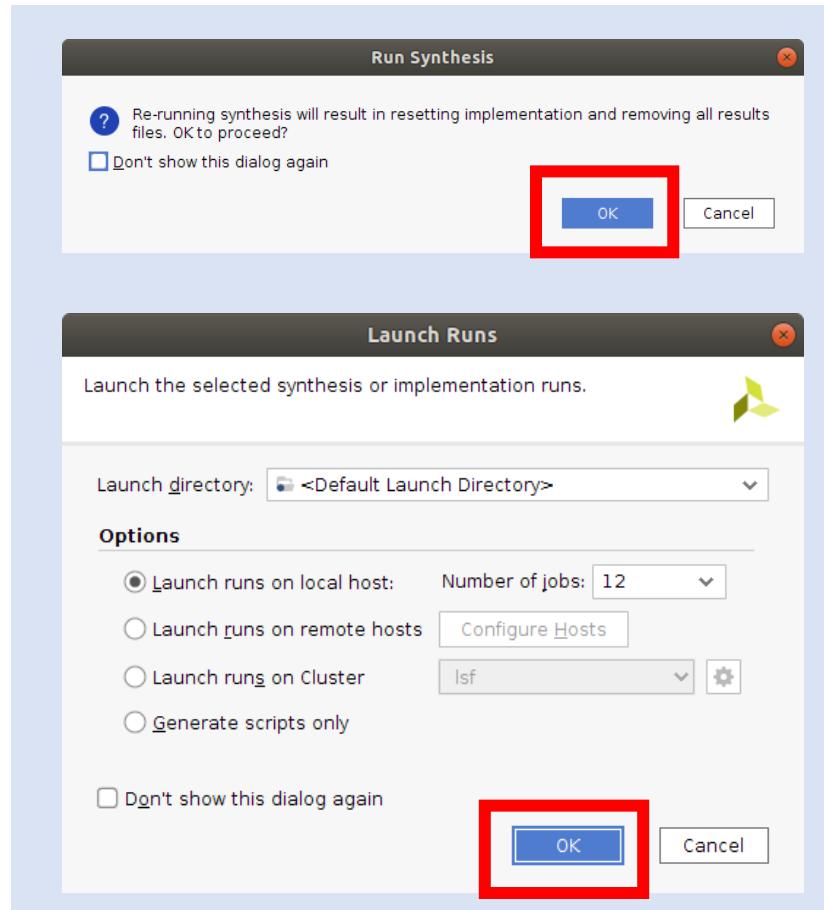
## Step 25 – Run the Synthesis.



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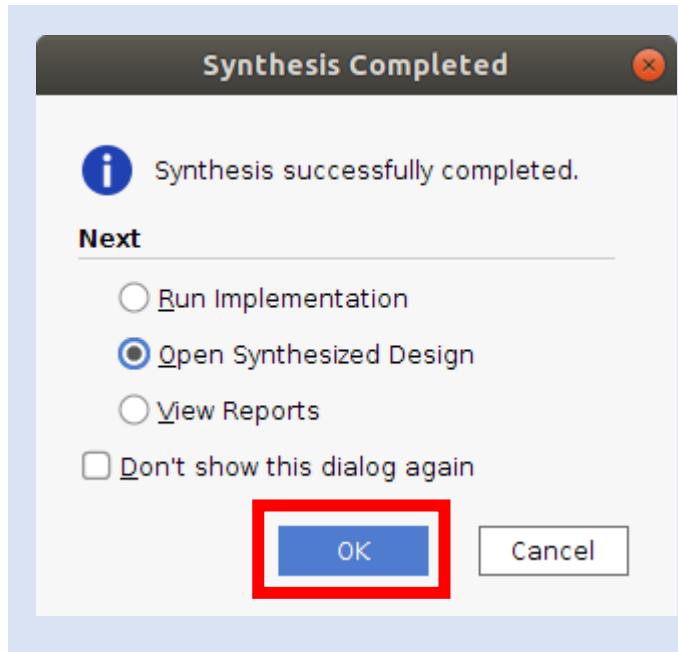
**Step 26 –** On both resultant dialogs click **OK** and wait for synthesis to complete.



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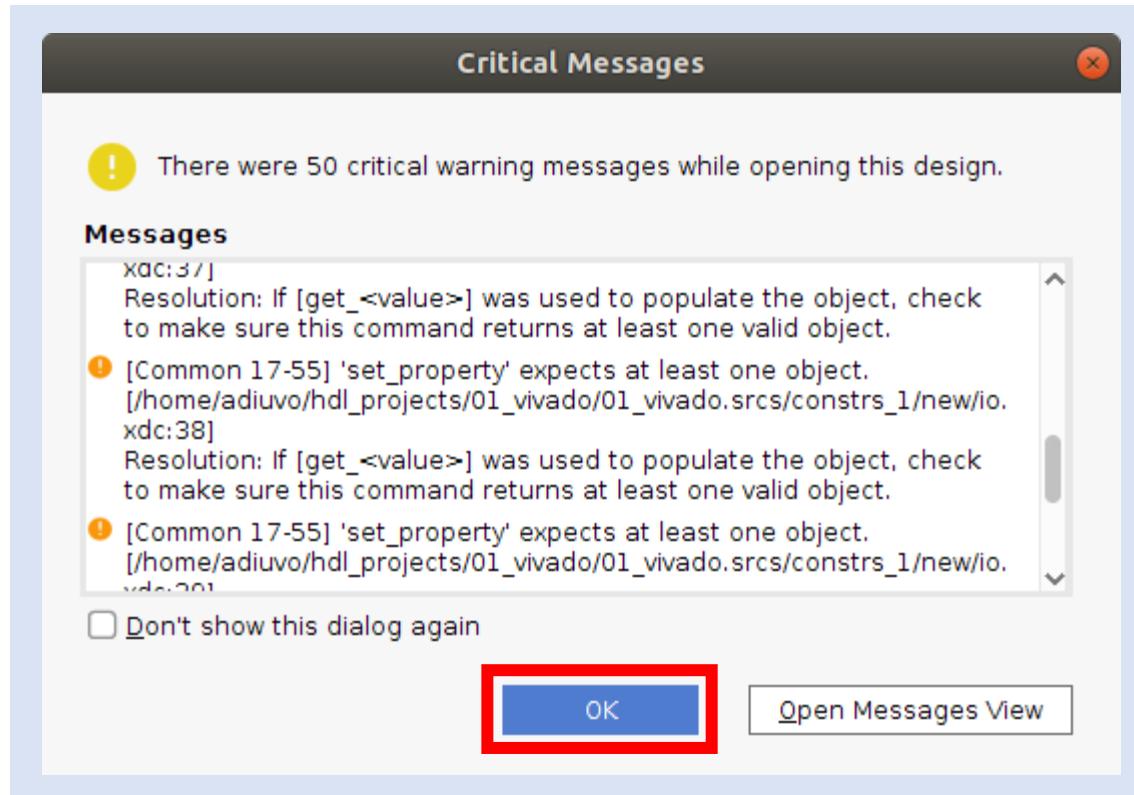
# Lab: Intermediate AMD Vivado™

**Step 27 – When synthesis completes, Open the Synthesized Design.**



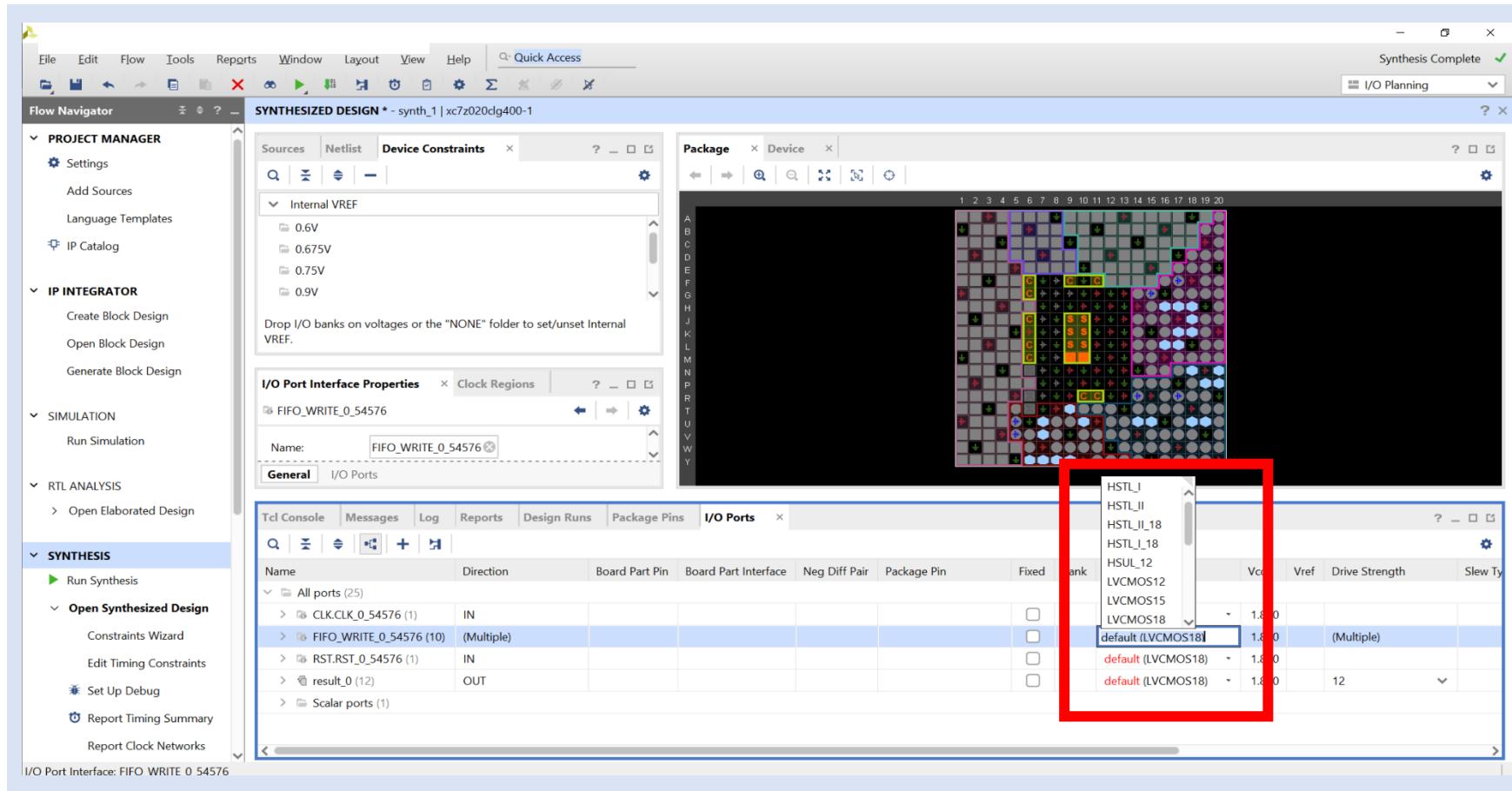
# Lab: Intermediate AMD Vivado™

**Step 28 –** If any critical warnings pop up, select **OK**. This is due to out of data constraints which we are about to address.



# Lab: Intermediate AMD Vivado™

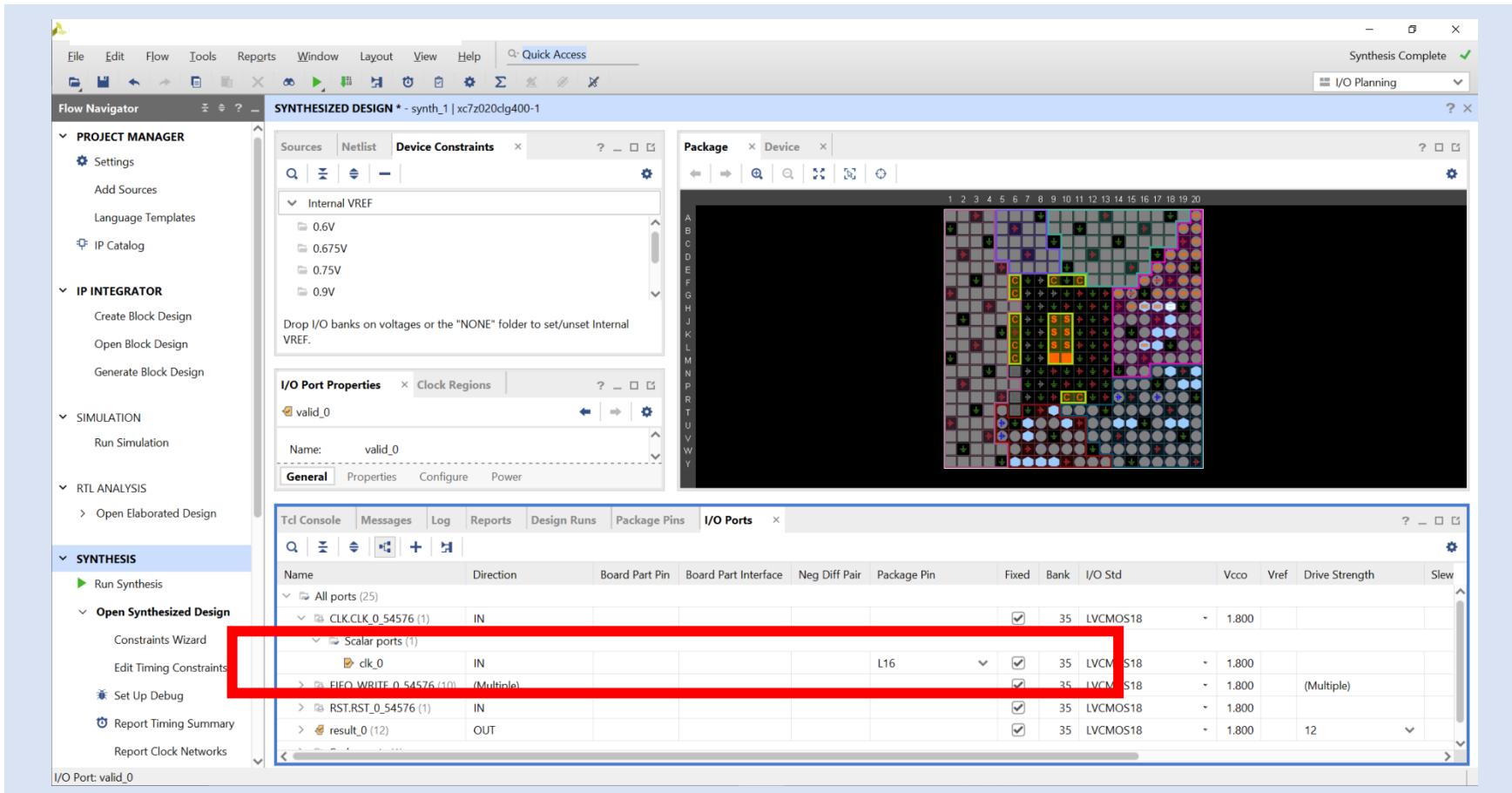
**Step 29 – Change the I/O standard from default to LVCMOS18.**



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# Lab: Intermediate AMD Vivado™

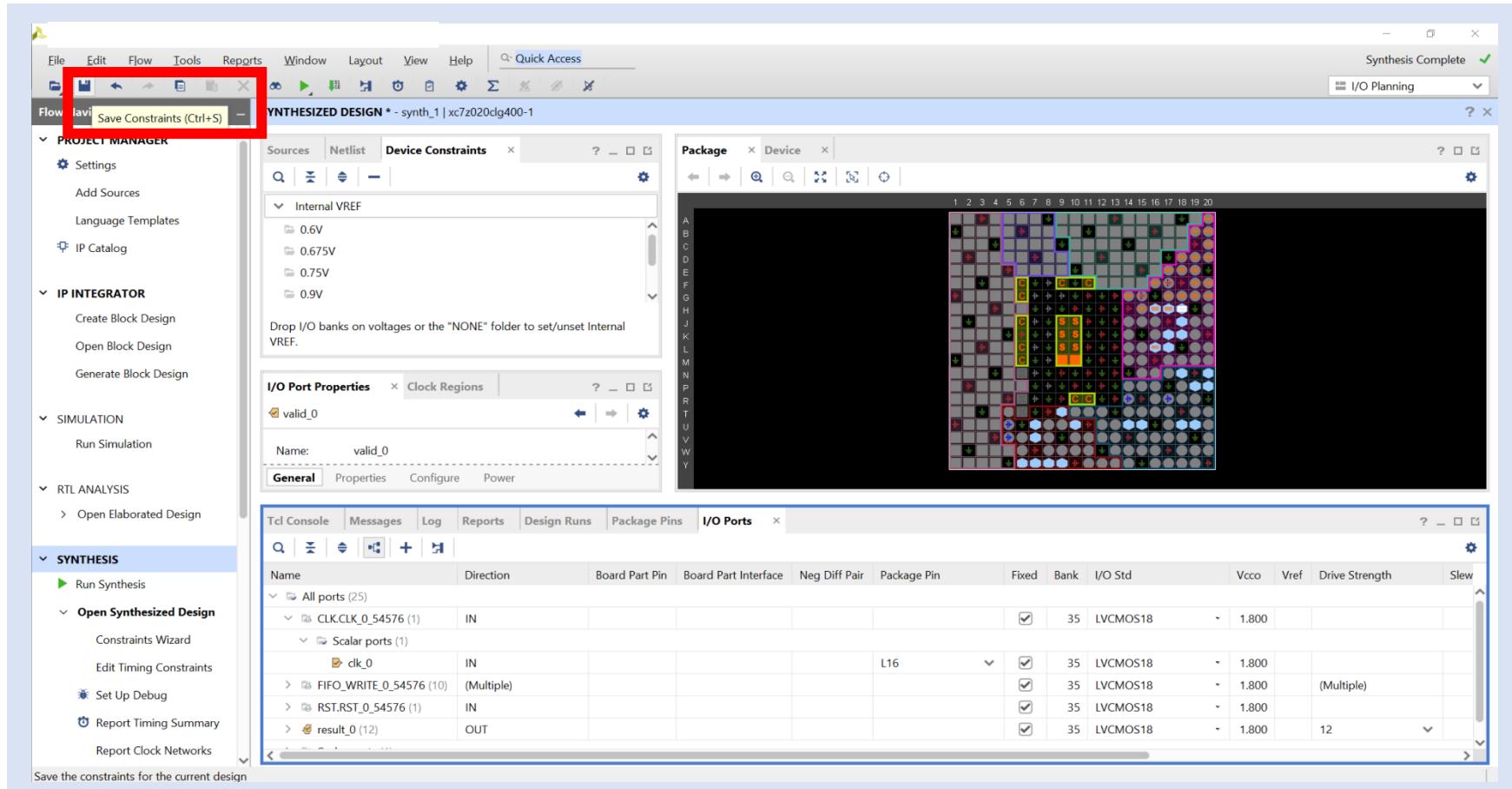
**Step 30 – Assign the clock input to pin L16. Assign all other IO to pins of your choice.**



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## Step 31 – Click on Save Constraints.



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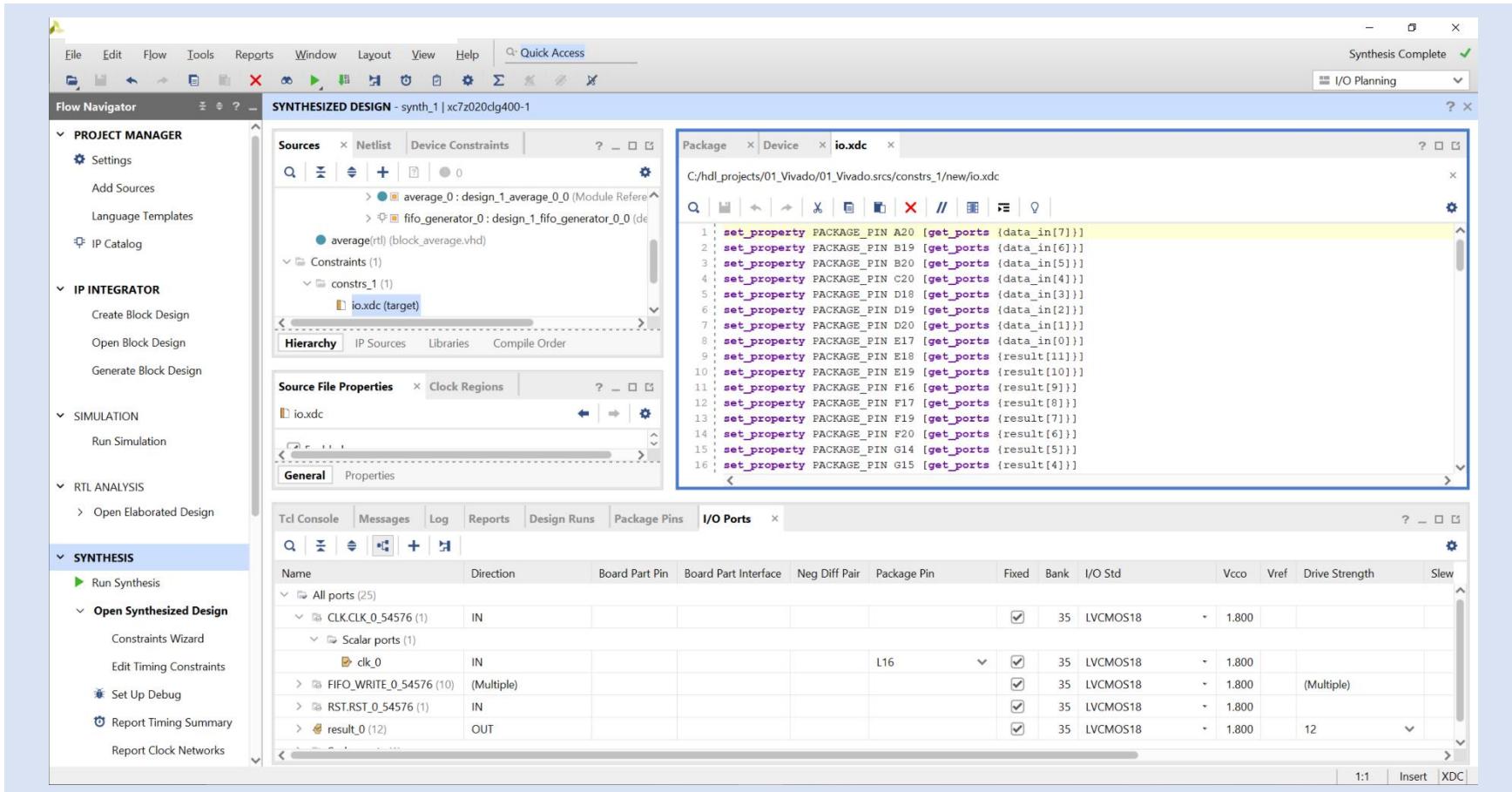
# Lab: Intermediate AMD Vivado™

**Step 32 – If an out-of-date warning appears, click OK.**



# Lab: Intermediate AMD Vivado™

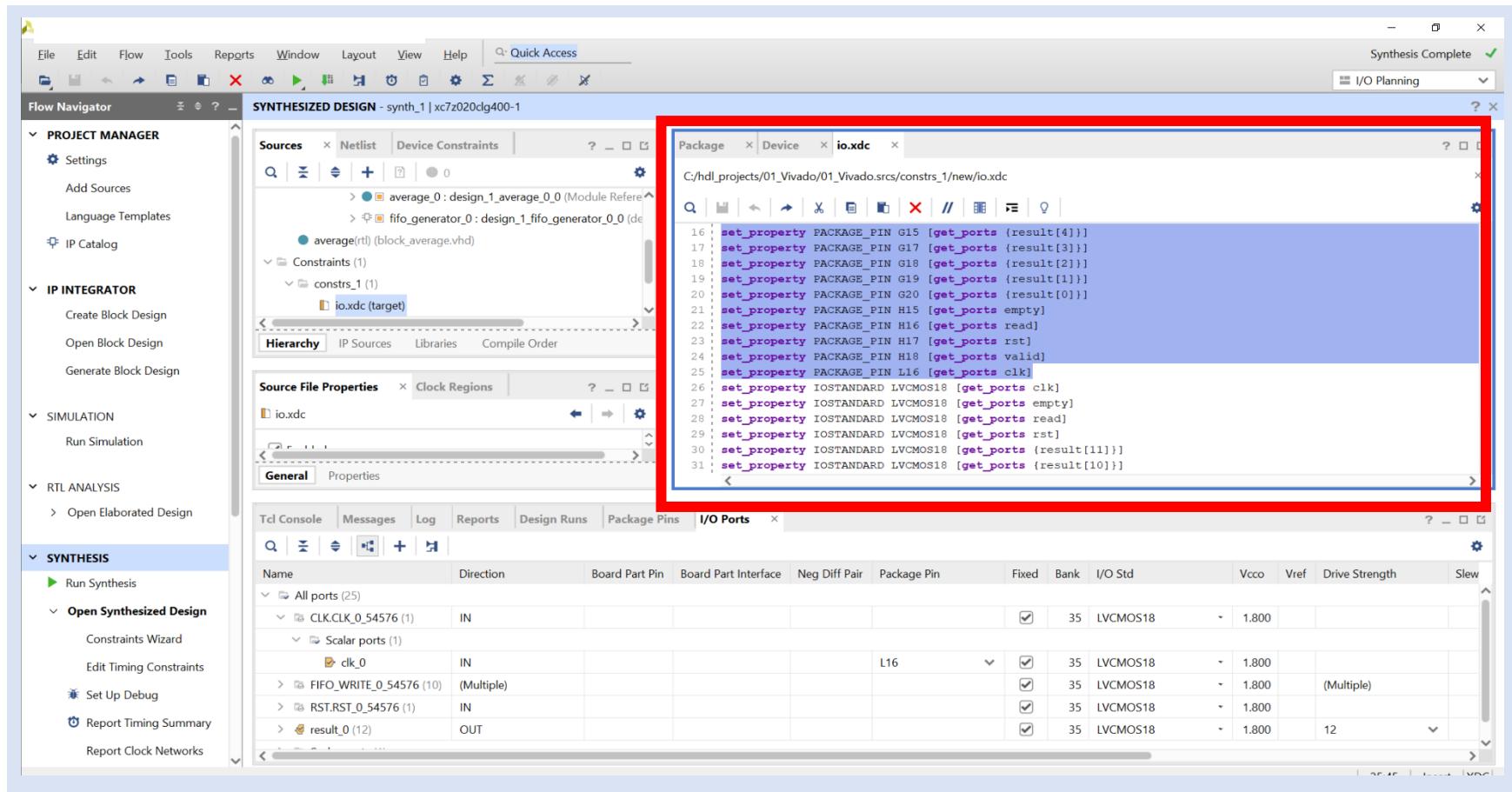
**Step 33 –** From the sources tab, open the **IO constraints**. You will see the old pin out for the previous project and your new project. This is because we have evolved the original project.



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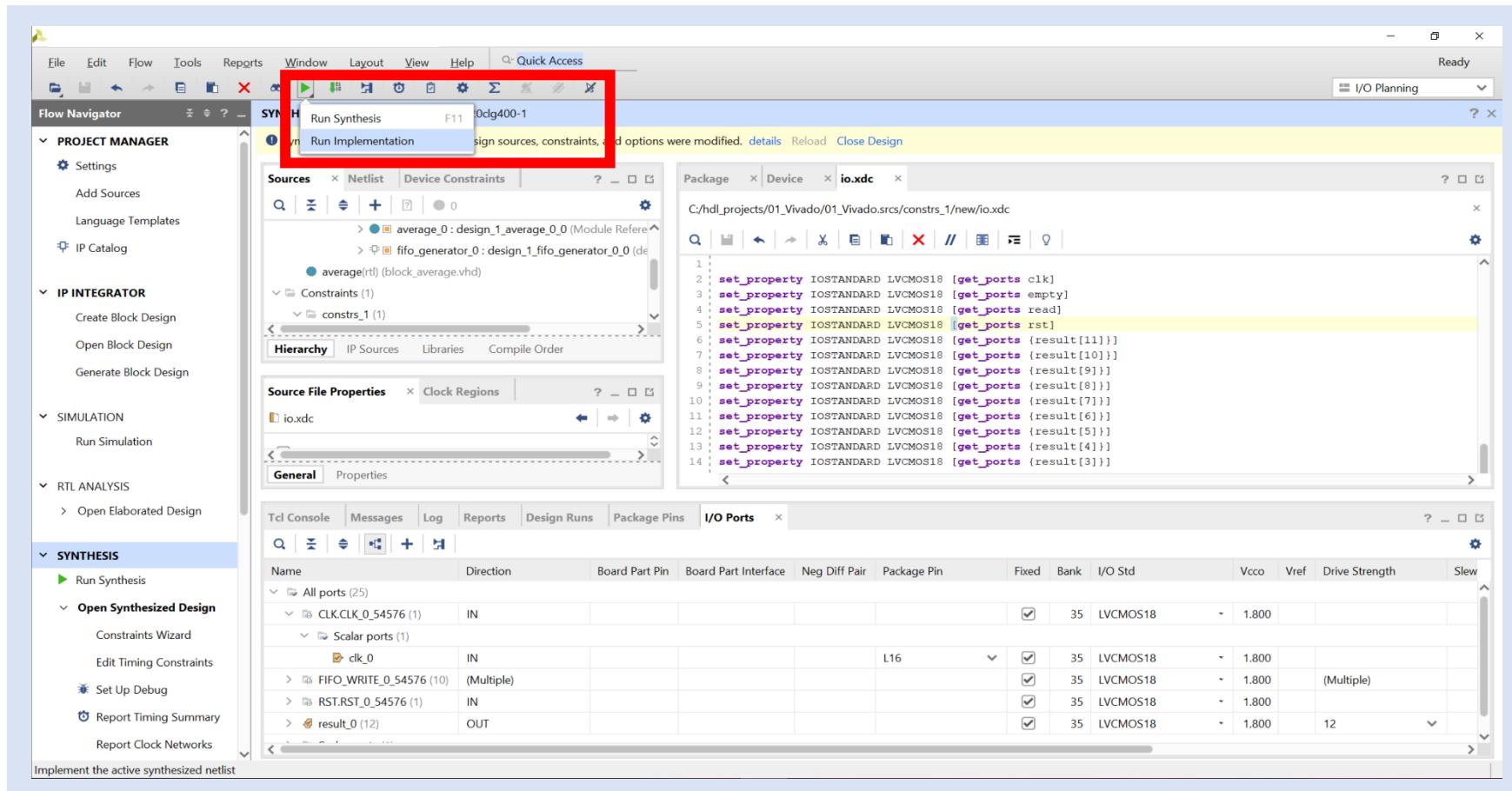
**Step 34 – Select the old constraints (at the top of the file) and delete them. Save the file.**



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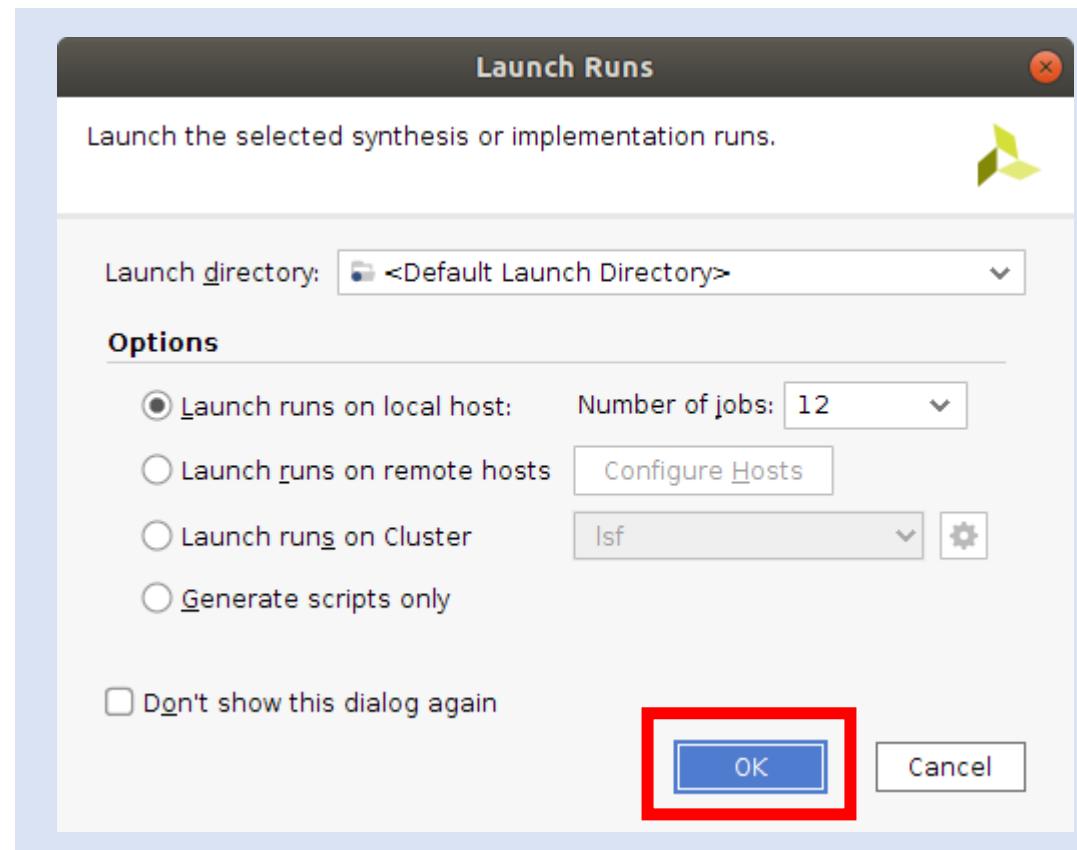
**Step 35 –Run the Implementation, rerun synthesis if you get an out of date warning.**



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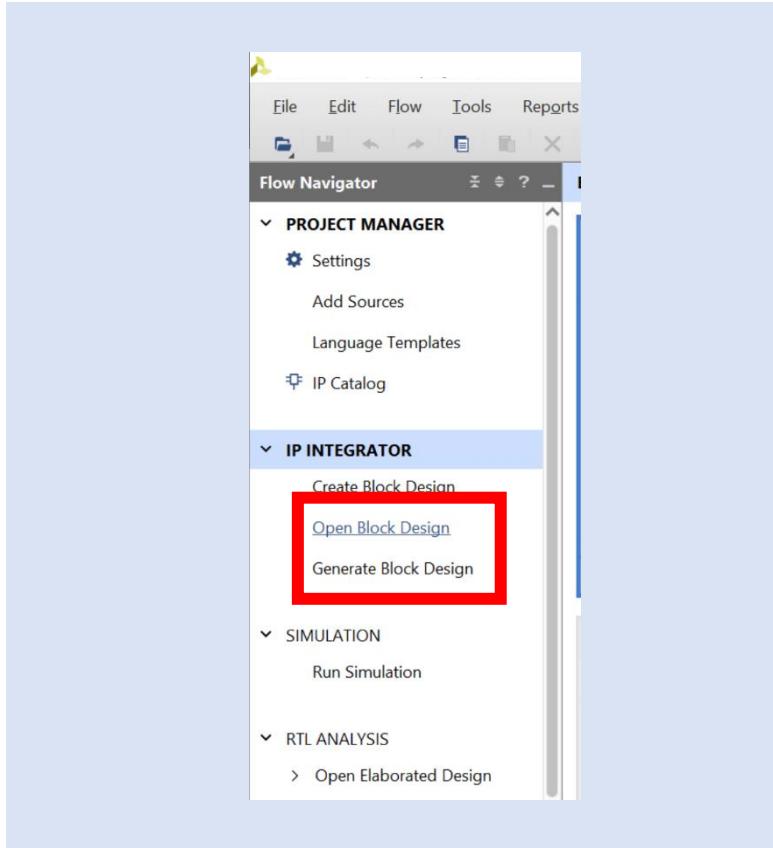
**Step 36 – Click OK to run the implementation.**



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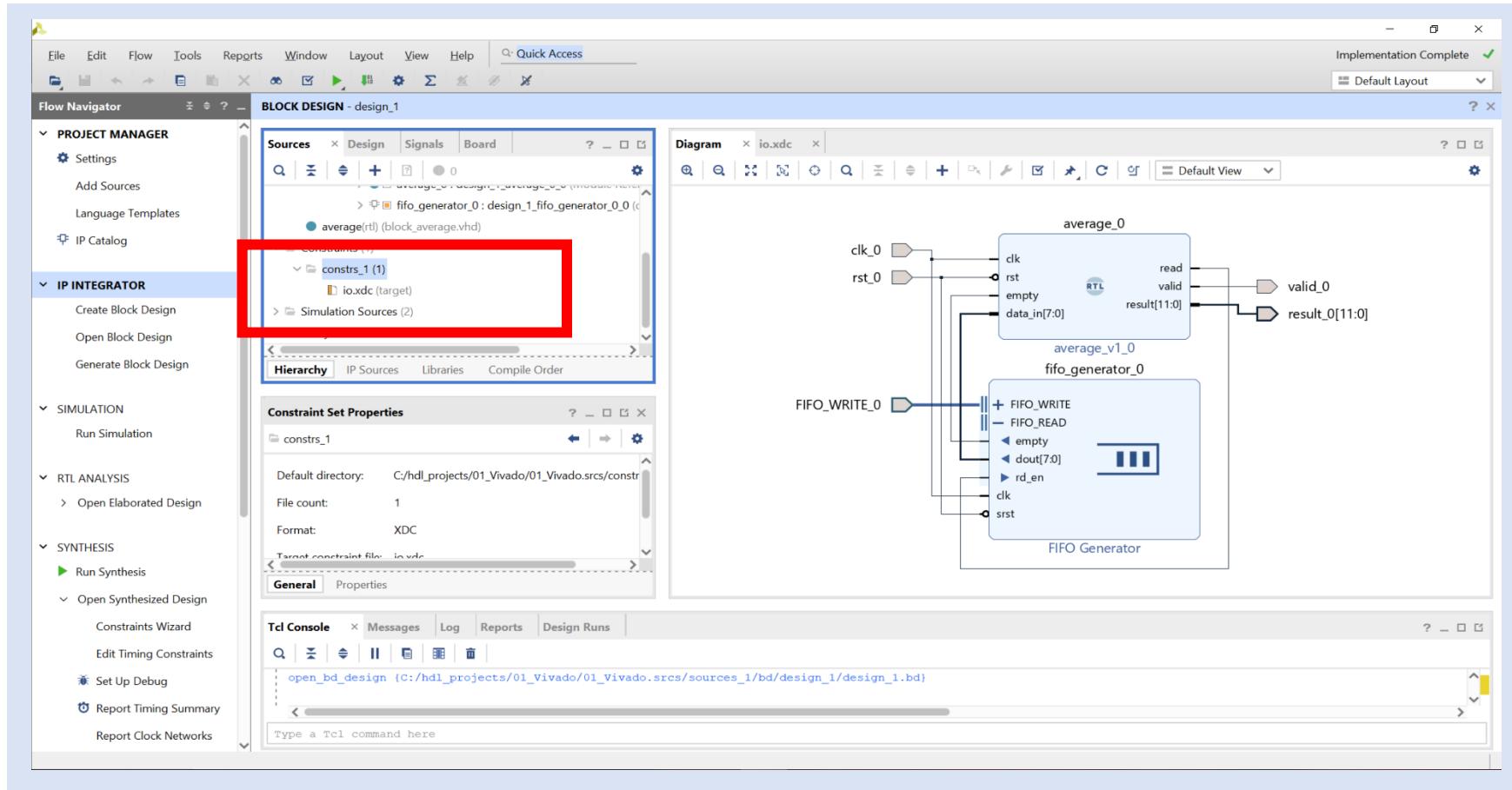
**Step 37 – Open the Block Design when design has built.**



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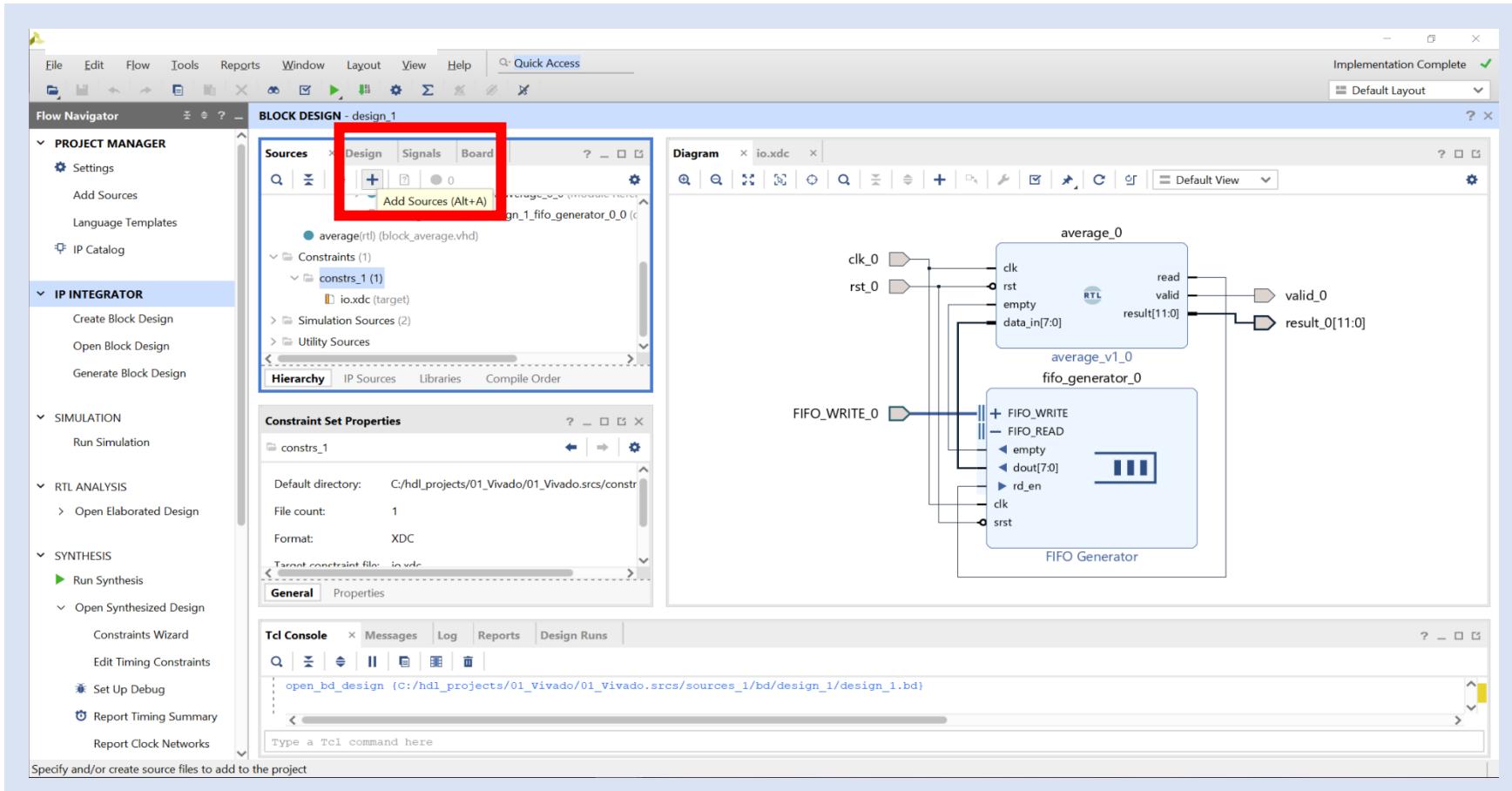
## Step 38 – Select Constraints under Design Sources.



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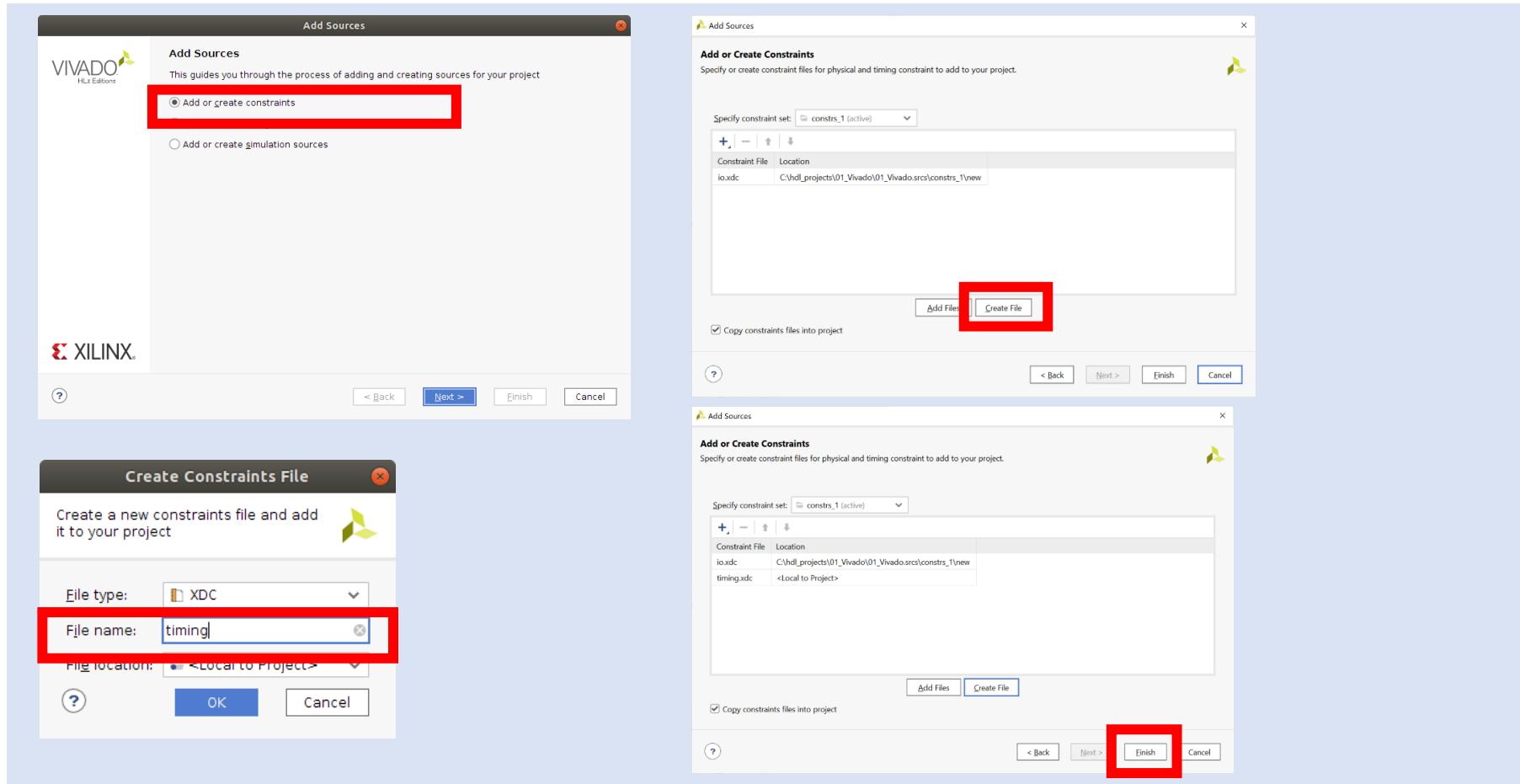
Step 39 – Click on the Add Source button.



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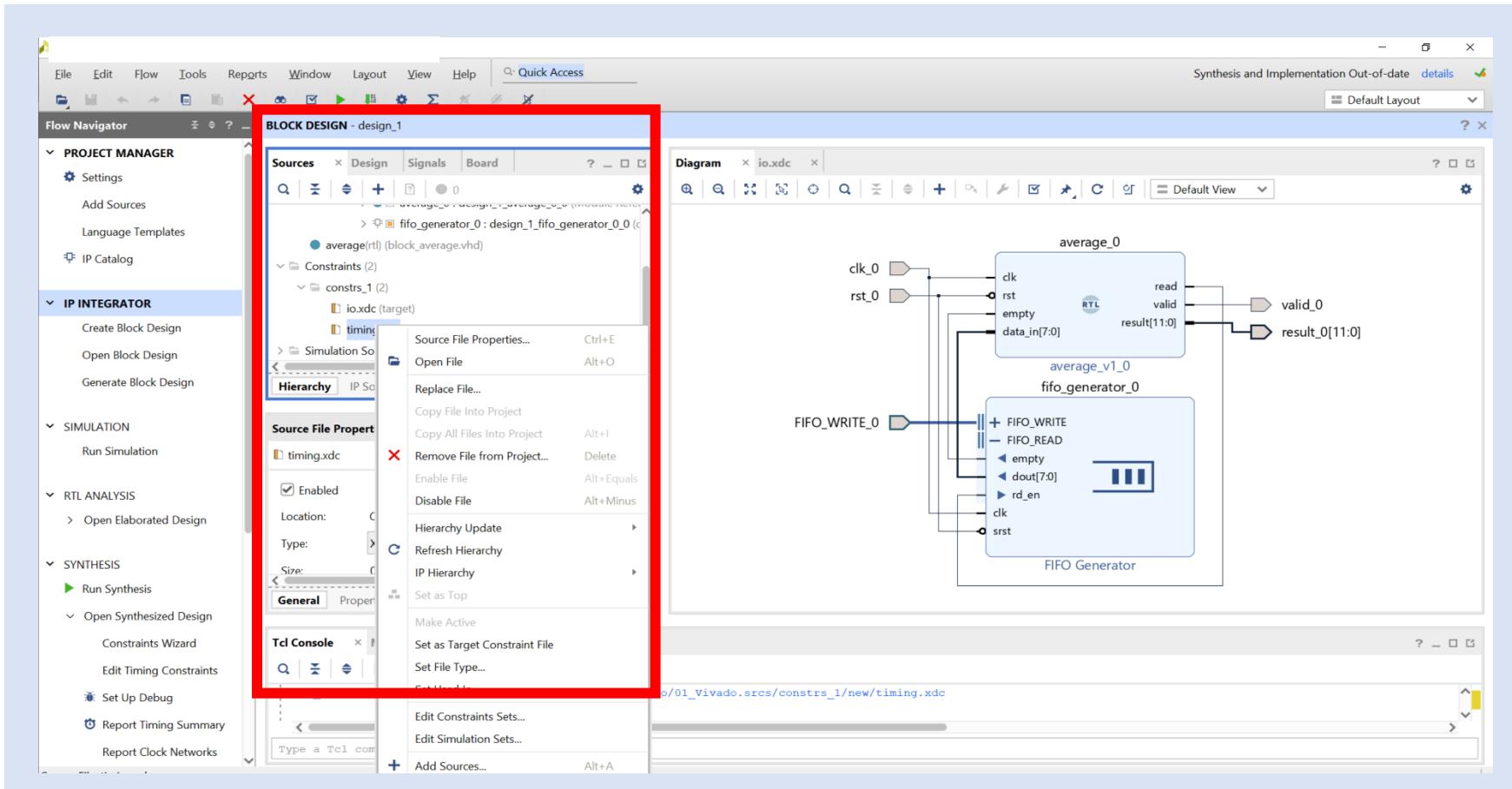
**Step 40 – Select Add or Create Constraints. Then Create File, enter the name “timing” for the file, and click Finish.**



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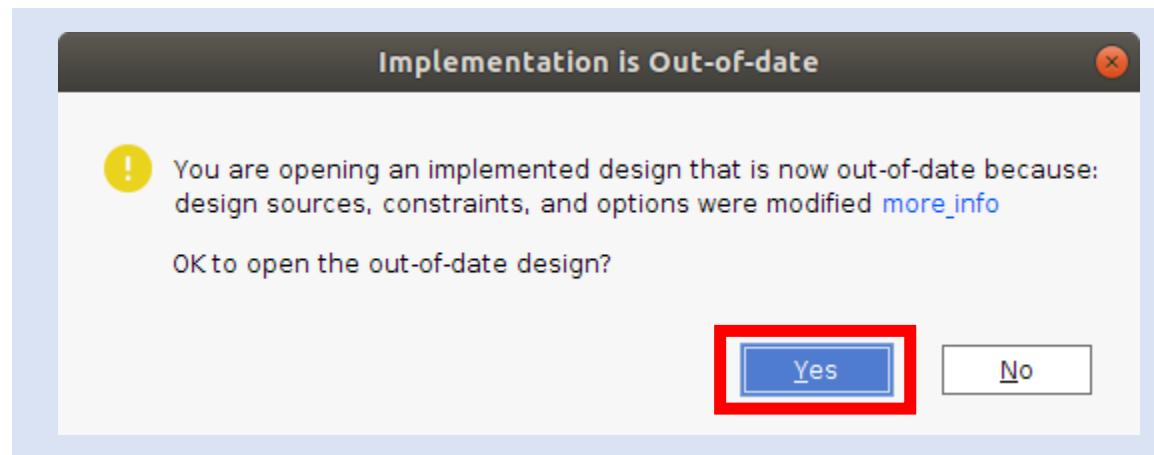
**Step 41 – Right click on the newly created constraint file and select Set as Target Constraints File.**



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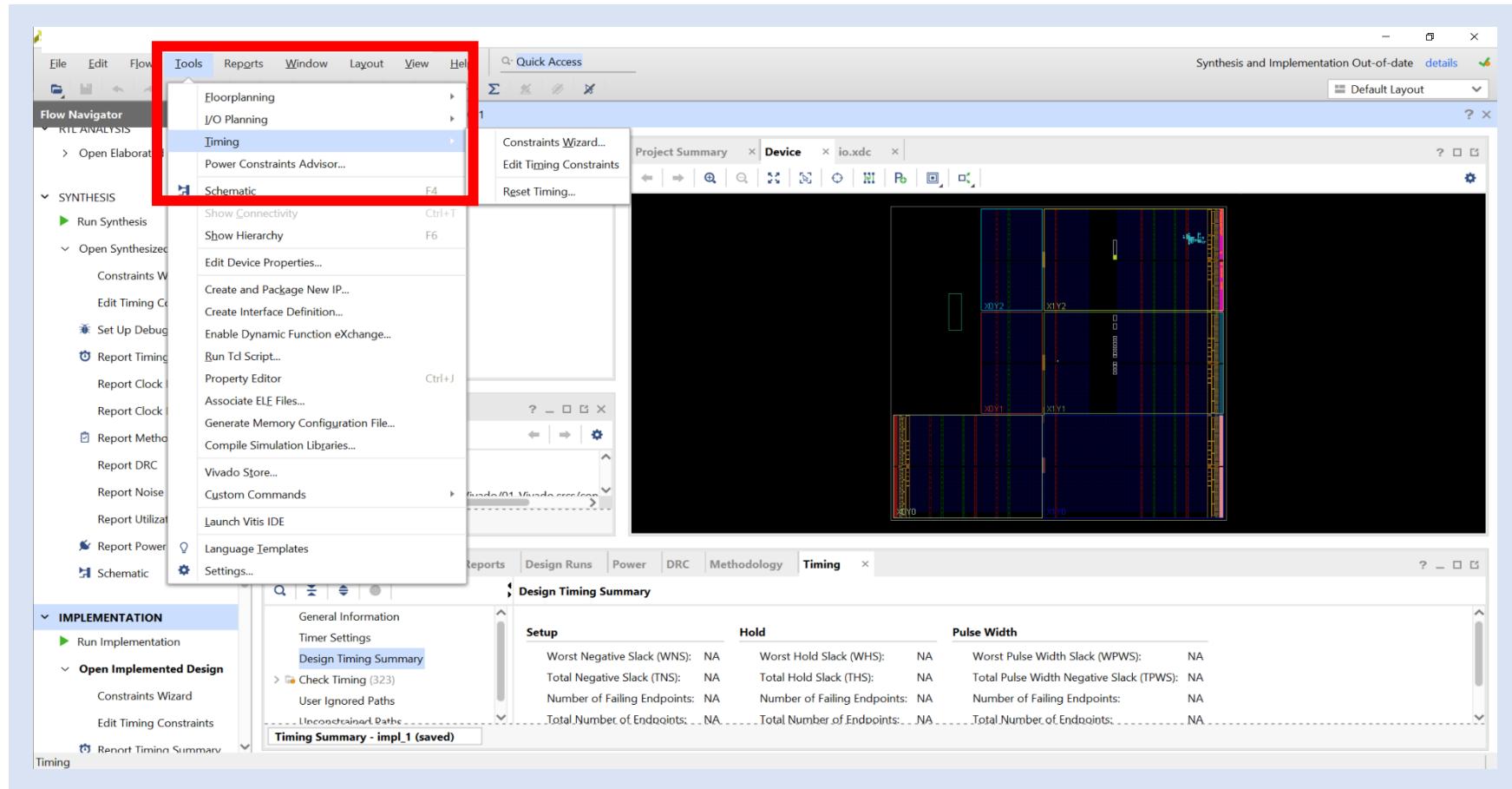
# Lab: Intermediate AMD Vivado™

**Step 42 – Open the implemented design. If you see the warning below click **OK**.**



# Lab: Intermediate AMD Vivado™

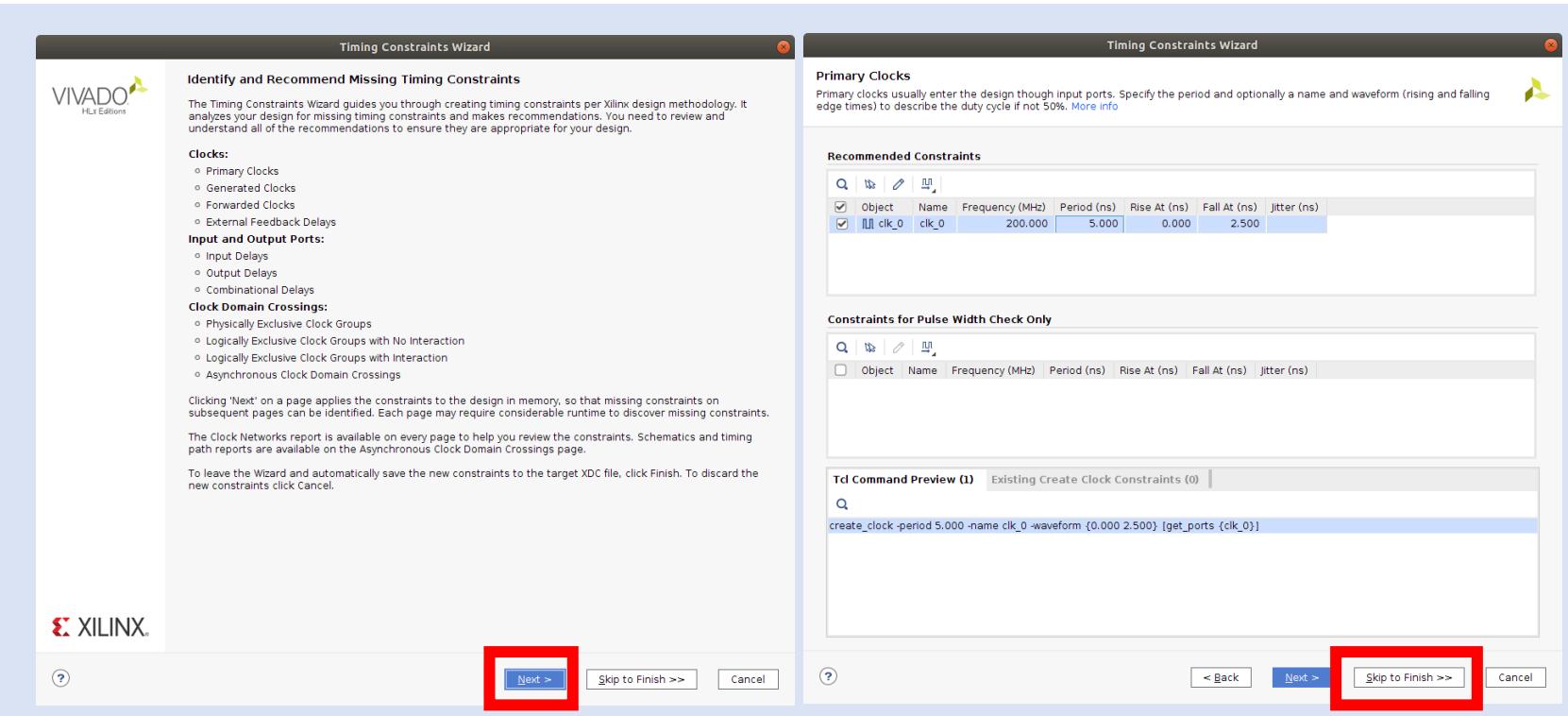
Step 43 – From the Tools menu, select Timing -> Constraints Wizard.



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# Lab: Intermediate AMD Vivado™

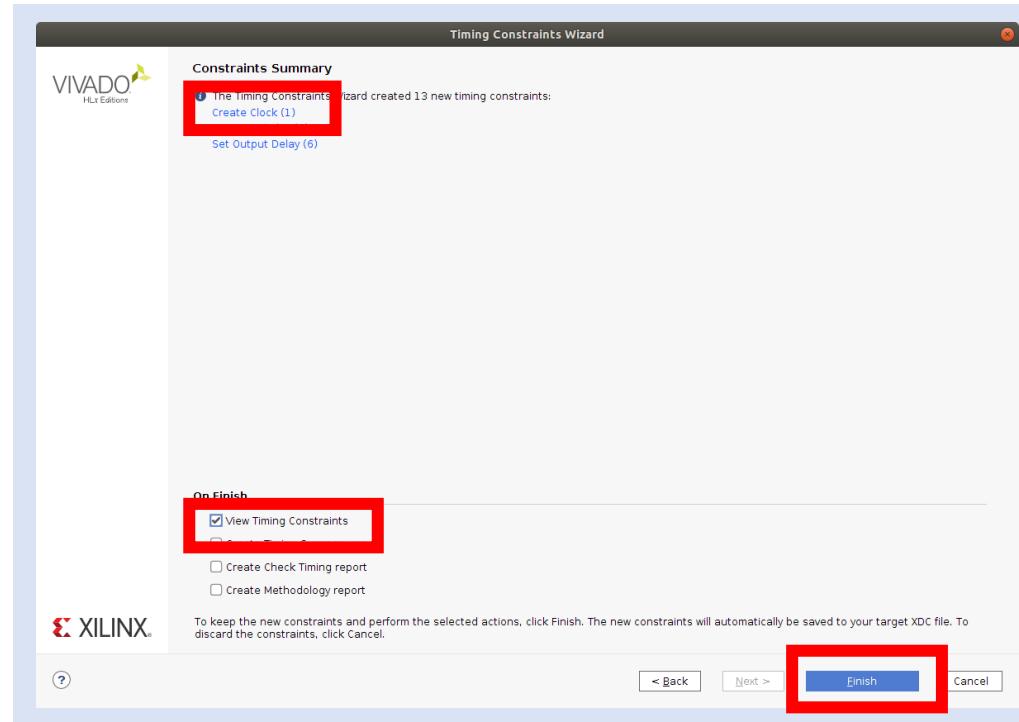
**Step 44 –** On the welcome screen, click **Next** and then enter **200 MHz** for the clock frequency. Once done, select **Skip to Finish**.



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# Lab: Intermediate AMD Vivado™

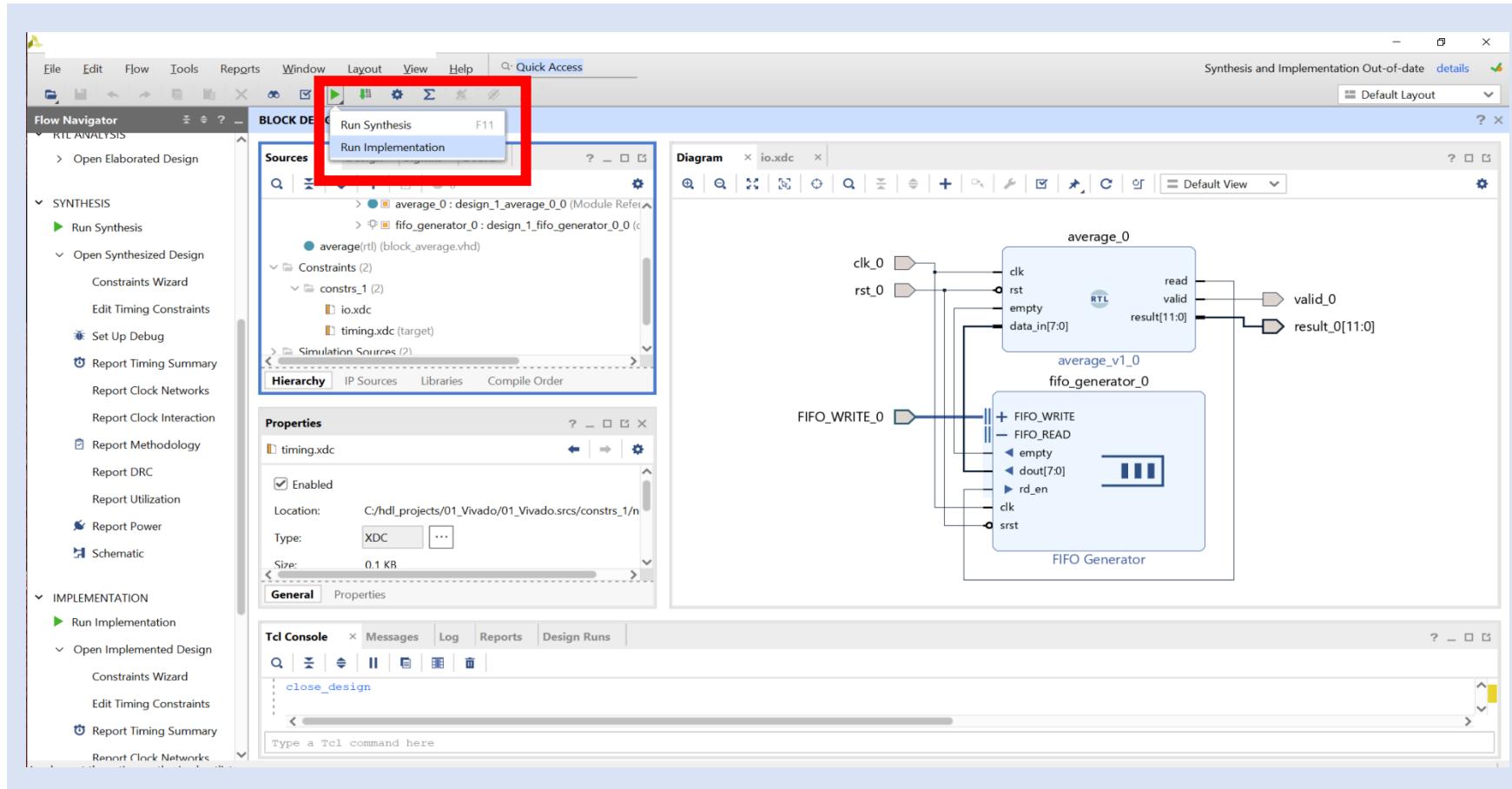
**Step 45 –** On the final page, check that only one constraints is being created, check the **View Timing Constraints**, and click **Finish**.



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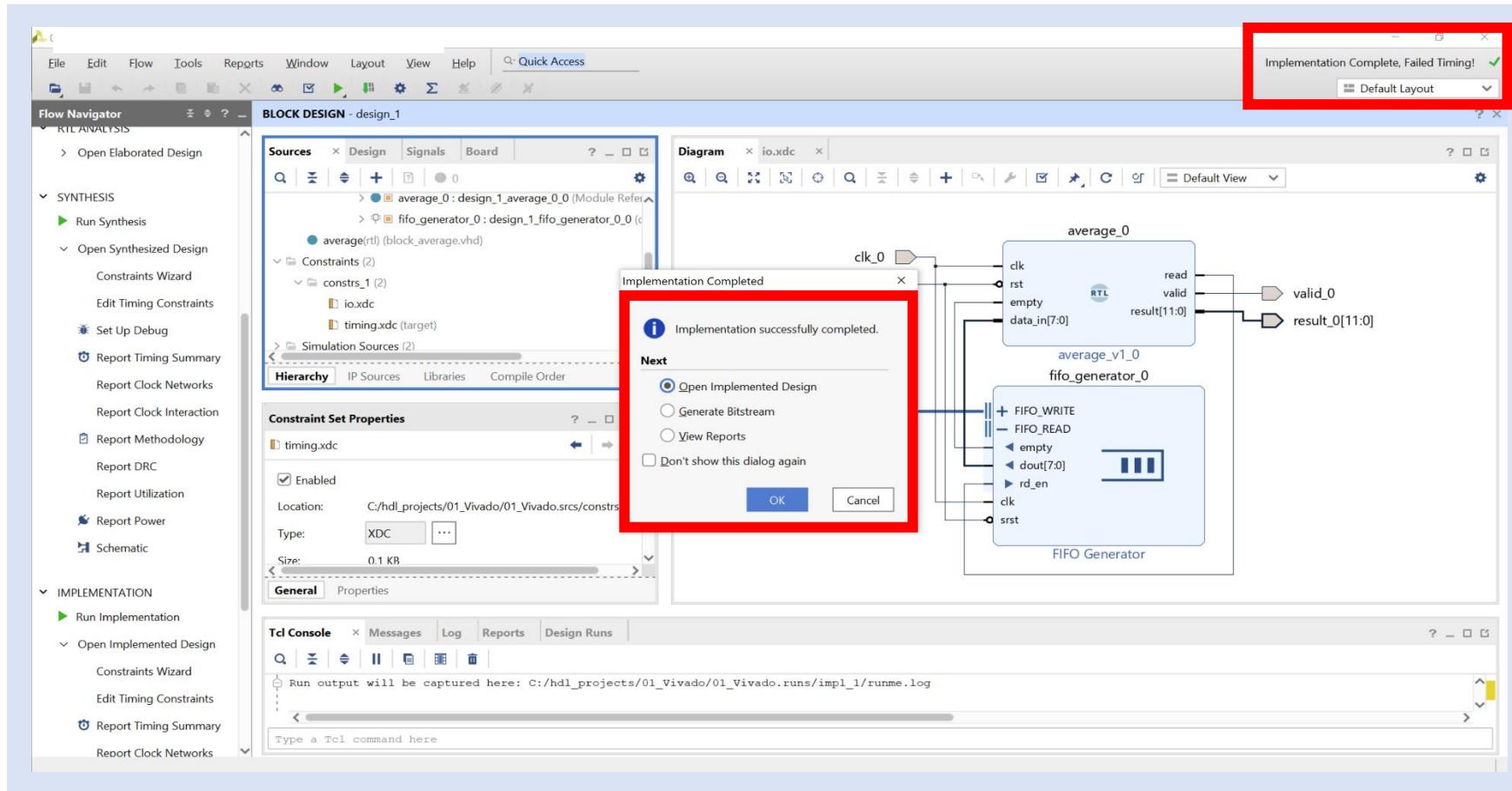
**Step 46 – Close the implementation view and **rerun the implementation**. Run synthesis if you get out of date pop up. Click **OK** on any dialogs which pop up prior to implementation starting.**



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# Lab: Intermediate AMD Vivado™

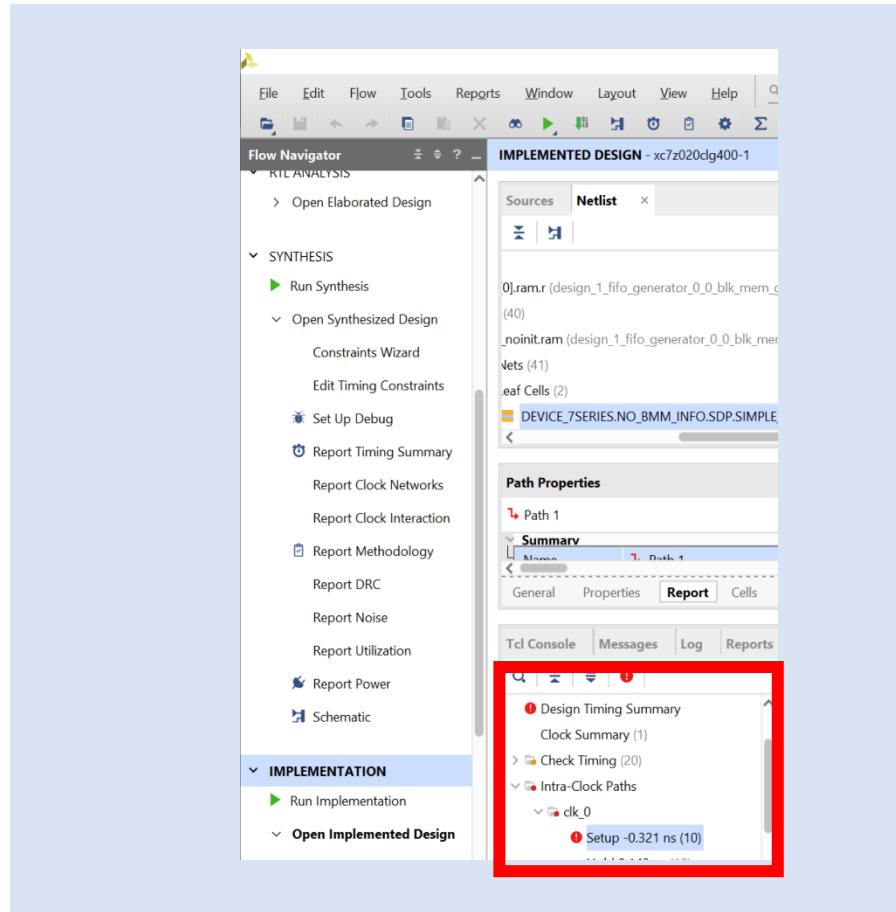
**Step 47 – Once the implementation completes, Timing will fail. Open the Implemented Design.**



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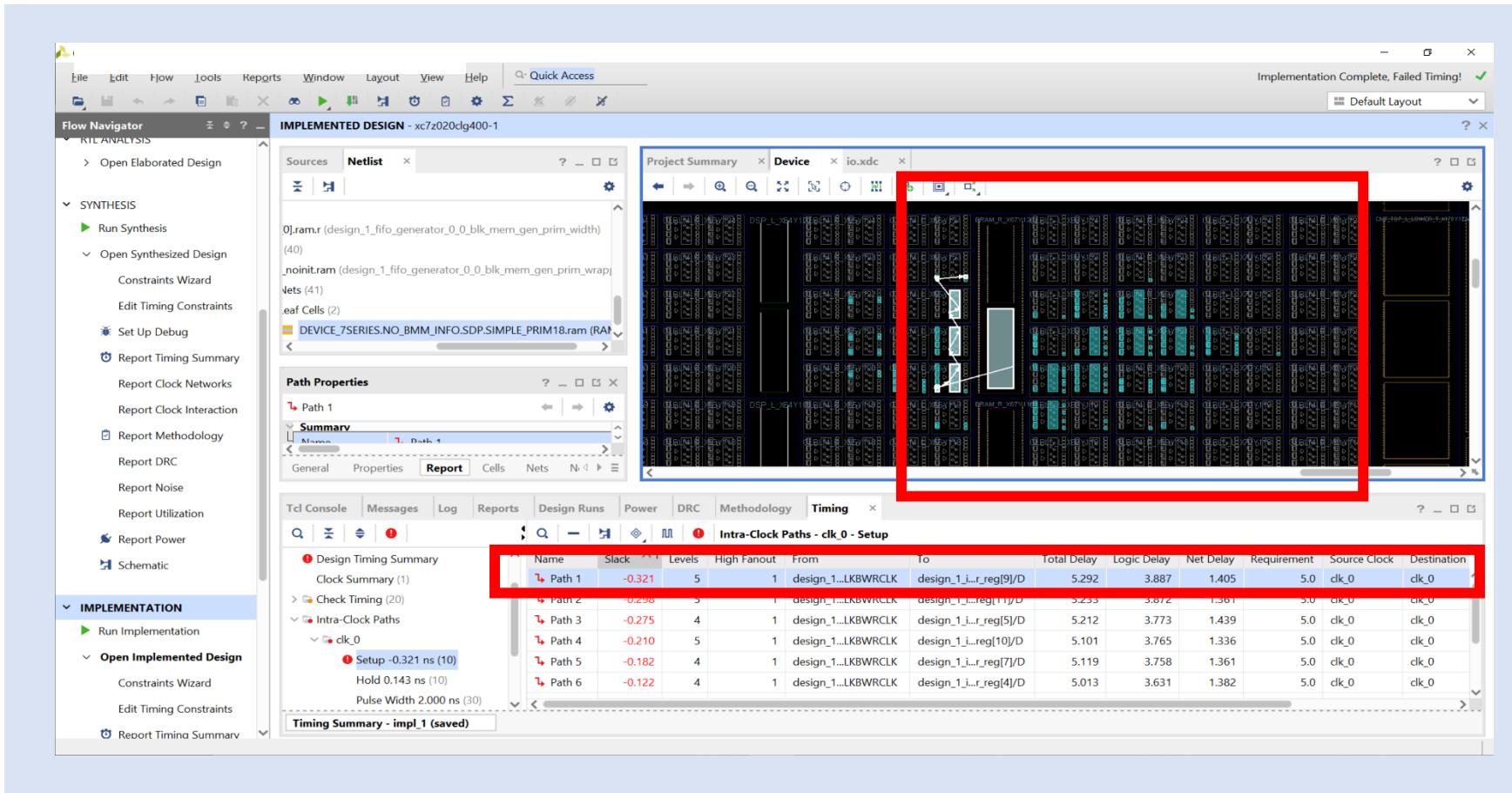
**Step 48 – In the implemented design, select the failing Intra-Clock Paths.**



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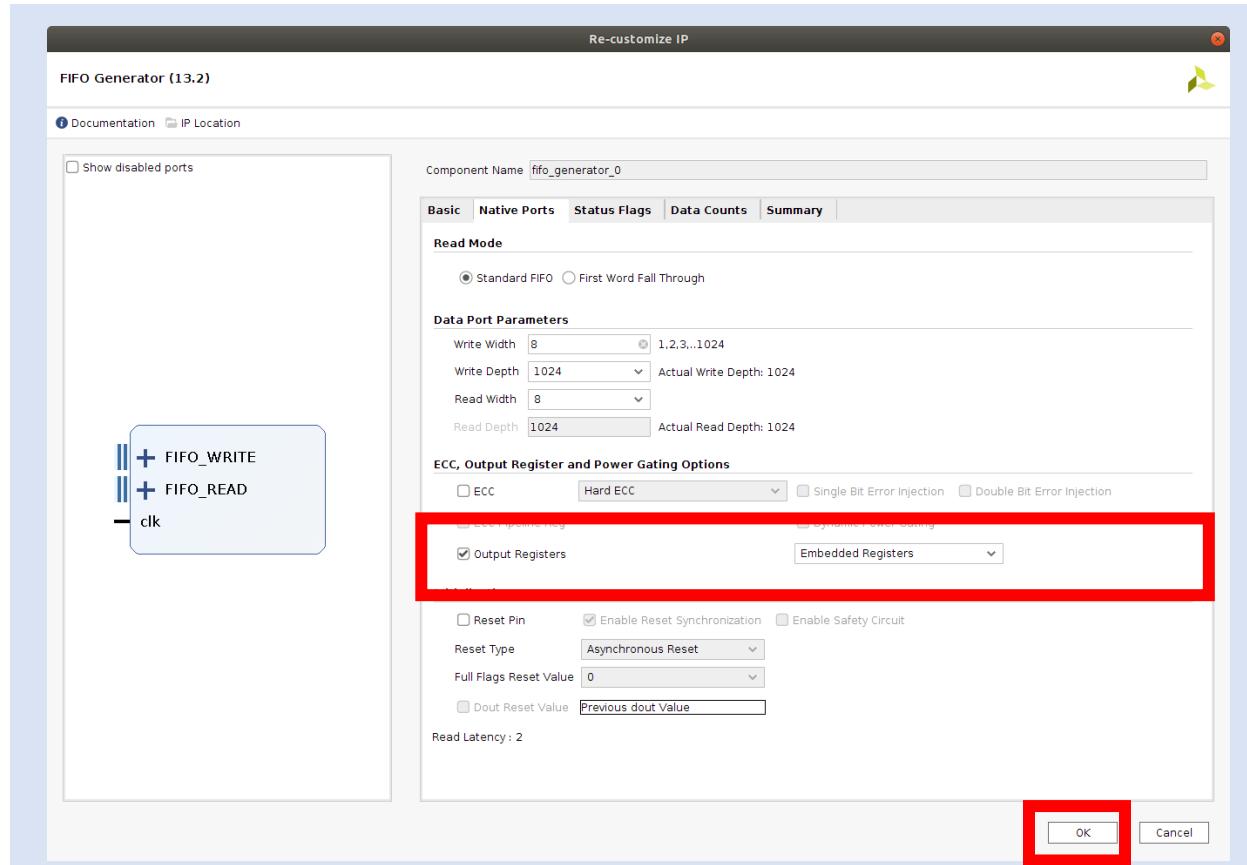
**Step 49 – Select Path 1 and zoom in.** You will see that the FIFO output data passes through LUTs before finally being registered. This path is too long for timing at 200 MHz.



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# Lab: Intermediate AMD Vivado™

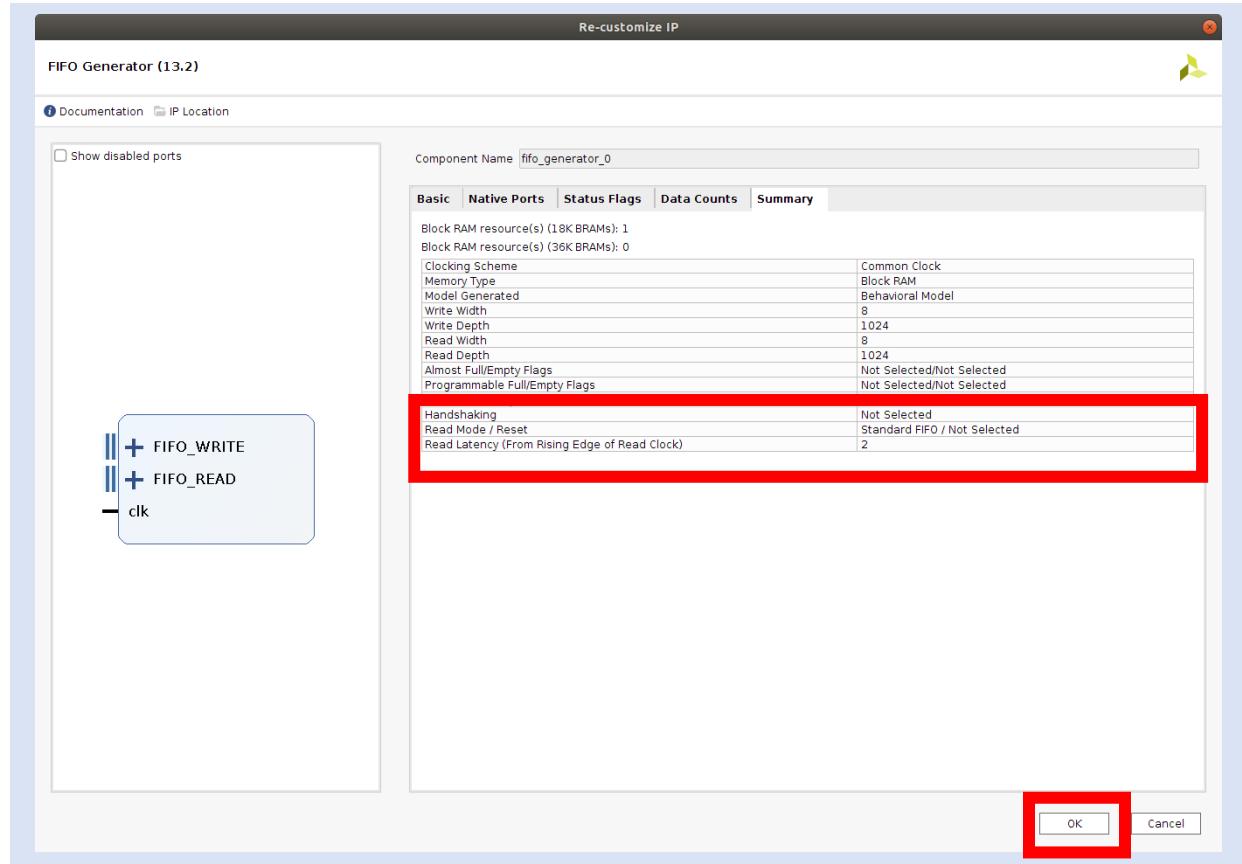
**Step 50 –** To fix this, we need to register the output of the FIFO. Close the implementation view and reopen the block diagram. Double click on the **FIFO** to customize.



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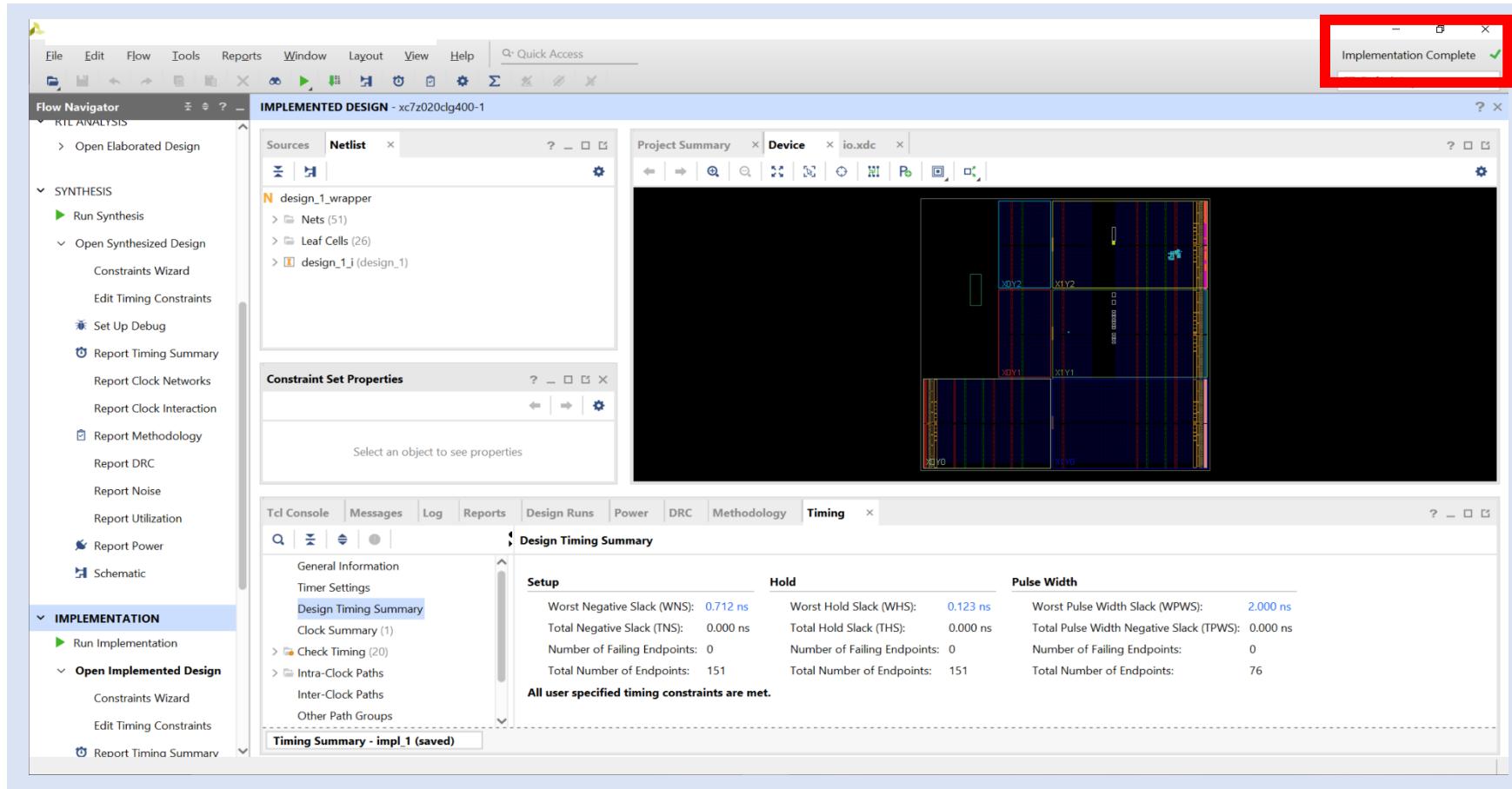
**Step 51** – Note the latency has changed from 1 to 2 clocks. We would need to correct for this in the average block, however, we proceed assuming that we have.



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**Step 52 – Reimplement the design.** When the timing is completed, you should see that the implementation is correct and the timing is met.



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