Calculator

Vivado VHDL

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***Abstract*—** This final project was to build an interactive calculator capable of performing addition, subtraction, multiplication, division, and squaring using the Vivado VHDL format and a Nexys 4 DDR FPGA board**.** The primary motivation for this project was that a calculator was a unique way to incorporate all the practices learned throughout lab. Things that became apparent during the designing process was to create an easy input method that allowed the user access easily and a way for the user to view the results of their calculations. This simple calculator will allow for the quick input and output of the simple calculator functions described above, which has numerous applications throughout one's education and in everyday activities. The main takeaways are how one is able to implement information learned throughout lab into a project.

I. Introduction

This report will cover the details and methodology of simple calculator functions in VHDL. The scope of this project was to design a fully functioning calculator performing addition, subtraction, multiplication, division, and squaring. This design made use of several components covered during the lab portion of class including full adders, shift registers, multiplexers, finite state machines, and counters. The motivation for this aspect is its importance and usage in real life applications, such as various branches of sciences and mathematics and in people's everyday lives. An implication of doing a simple calculator include not having an easier method of number inputs other than binary using the switches on the Nexys-4 board. Topics learned in class that this project covers are binary to BCD, BCD to 7-segment display and basic math functions, such as adding and multiplying. Topics learned outside of class that the project covers are keyboard input and operation controls. The applications of a basic calculator include all forms of education, business and wide ranging use in everyday activities.

II. Methodology

A. Understanding A Simple Calculator

The first step in this project is to understand how a calculator works and the functions in which we are trying to accomplish with this project. A simple calculator functions by placing the input, number, into a calculator and then selecting an operation in which it must compute, resulting in the output. The main aspect of this project is the input of two, four-bit binary numbers using the switches on the Nexys Board, which are then calculated using either of the functions of adding, subtracting, multiplying, dividing or squaring, and then the output is displayed via the seven-segment display.

B. Layout

The layout of this design consists of the following setup as shown in figure 1 of the block diagram below. As shown in the figure the layout consists of two four-bit inputs A and B which are connected to the 5 different modules that consist of the operations to either add, subtract, multiply,

divide or square the input values. The finite state machine is responsible for the division module. All these modules are then connected to an 8 to 1 multiplexer that has a 3 bit select line coming into it. The select line is responsible for controlling the operation in which the user selects. Not picking a select line puts it in the addition operation, where the first select switch is the subtraction operation followed by multiplication, division and squaring respectively. From here the mux then converts from hex to decimal and is outputted using the seven-segment display.

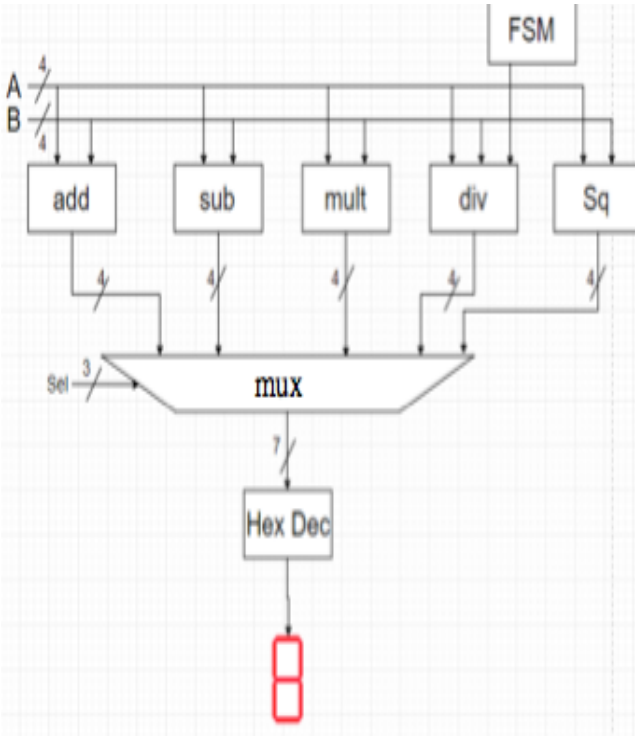

Fig. 1

The controls of the Nexys 4 DDR board can be shown below in figure 2 as they were described. The first four switches represent input A for the first number and the next four switches represent input B. From here switches nine, ten and eleven represent the select line in which the operation the operator must select to perform on the input numbers. The seven-segment display is used to display the final result of the operation the user selects. The reset button was used to simply reset the division allowing the user to input new numbers to have a new problem to solve, then after re-enabling to get a new result.

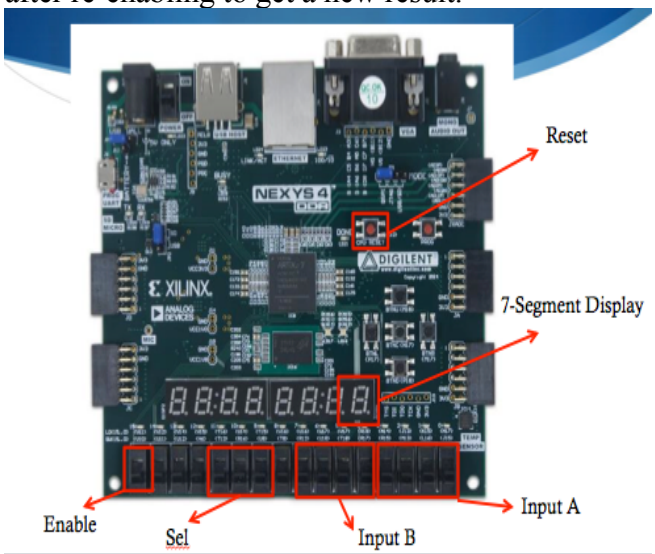

Fig. 2

III. EXPERIMENTAL SETUP

Vivado 2017 was used to create, synthesize and implement the project design to the Nexys 4 DDR board. The setup and testing followed what was done in lab procedure. Every component of the project was designed and simulated to ensure it was in working order. As soon as the timing and behavioral simulations functioned as anticipated, the code was then implemented into the overall structure. The overall testing was done in chunks as there were multiple different kinds of files. This was done in order to troubleshoot problems instantly as they may appear.

Using the test bench, several different operations were established as modules, and from there, the top file was established to combine the operations. From the timing and behavioral diagrams, it was possible to see if any mistakes were in the code or if the logic made sense. In addition, some of the code used and ideas were implemented from previous labs and examples presented by Dr. Llamocca and help from the TA's.

The projected results were that the switches could be capable of inputting digits into the seven-segment display. Another expectation was that all five operations functioned as they were supposed

to. Overall, the results of the project lined up with the expected results from the very beginning.

IV. Results

The results obtained from this project were how to create a simple calculator with operations used in various forms of calculations. New and creative problem-solving techniques were also developed, such as how to create an interface for the project. As a result, we found that our design and implementation was functional and worked for what we planned. The basic operation of inputting two numbers along with selecting a simple mathematical operation and receiving an output was accomplished. Following the results of this project we determined that various improvements could have been made, for example using more seven-segment displays to display greater values than 15 (F). Another improvement can be made by using a different user interface method for example, a keypad or number control method that would allow for easier and more practical uses of a calculator using VHDL as oppose to the switches. This would allow for a more efficient use of an input and output method for a calculator. Overall the project was successful in terms of applying our knowledge to calculate basic problems using a simple VHDL calculator.

V. Conclusions

In conclusion, the group has come to a better understanding of the functions of a simple calculator and coding using VHDL and the Vivado platform. The design was successful in that we were able to input two 4-bit binary numbers select a simple mathematical operation and receive an output. The main operation of this design was done successfully but improvements that were discussed before could be done to further improve the user experience and interaction with the simple calculator.

VI. References

[1] Nexys 4 DDR Keyboard Demo. Digilent Inc., n.d. Web. 15 Mar. 2017.

[2] Llamocca, Daniel. “VHDL Coding for FPGA’s.” Reconfigureable Computing Research Laboratory. N.p., n.d. Web. 8 Dec 2017. file:///C:/Users/joshm/Downloads/Unit%206.pdf

[3] Daniel Llamocca, Notes-Unit 3, “Implementation Technology”, Fall 2017.

[4] Daniel Llamocca, Notes-Unit 7, “Introduction to Digital System Design”, Fall 2017