Digital VLSI Design
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A Basic Approach a Simple Calculator

Project Proposal

Group Members

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Motivation

This project intends to be an introduction to first hand embedded system design. Considering the group has not done Verilog in some time, as well as the time constraints of the semester, it was unanimously decided to reconstruct a basic calculator. Should time permit, more functions, such as those found on a financial calculator, will be added.

High Level Description

The very basics of a calculator consists of the four (arithmetic logic unit) operations of addition, subtraction, multiplication, and division, which is the primary focus of the project. The data and the results are to be displayed on an LCD screen, specifically, the HD44780U.

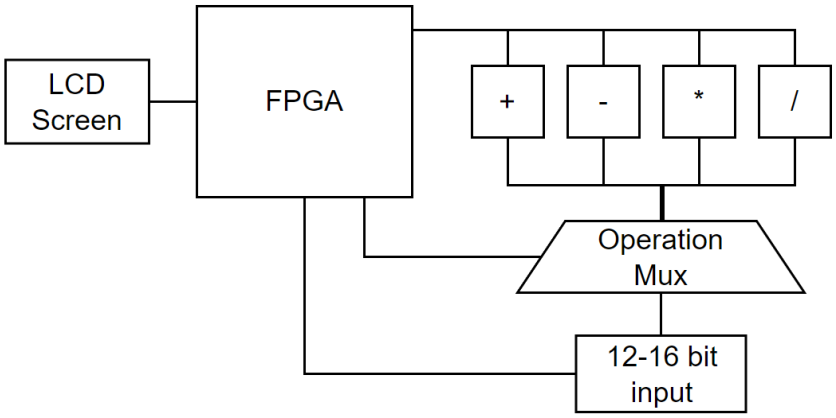

Figure 1: Block diagram of the circuit based on examples from [1] and [2]. Spec sheet of the LCD screen can be found in [3].

The circuit and the LCD screen will be connected to an FPGA. The switches/push buttons on the FPGA will be programmed to simulate a numeric keyboard for the inputs, similar to the project found in [4]. The project will work under the constraints of 12-16 bit numbers in 2's complement.

The project will start with an addition calculator that outputs to the screen. Once synthesis and testing is verified, the calculator will be added onto with subtraction, followed by multiplication and division. Clearing the contents of the screen can be done by a simple reset, although that will also clear the history, if there is one.

Testing

Before tapeout, each ALU will be tested as they are added to ensure they work as intended (i.e., output of a calculation is as one would expect, pressing different buttons for operators switches the MUX operator accordingly). The simulation of the entire circuit will be tested in the testbench and ModelSim for correctness.

After tapout, testing will consist of hooking up the components together and making sure the push buttons are correctly read and the chosen operation is selected properly. For the LCD screen, the connection will be first tested by being able to display any sort of graphic. After the individual components are tested to work as expected, the last test will be to make sure the calculator as a whole works as expected.

The required pins are as follows: *Clock, Reset, Source, Ground,* 12-16 pins each for *Input* and *Output*, and 2-3 pins to control the *Operation* MUX. Additional inputs or variables such as switches may be included later, which increase the pin count. At minimum, we will have roughly 30-40 pins.

Roles

At the start of the project, the group will work together to review Verilog skills. Afterwards, the rest of the project will be split up according to level of comfort for each member.

Fabrication

At the time of this proposal, there is no intention of fabricating the design.

References

[1] Tanshi, Foghor & Bello, N., “A Basic Approach to Designing Embedded Systems Using a Simple Calculator and C Programming Language” in Nigerian Journal of Technology, Jul. 2014. [Online]. Available: https://www.researchgate.net/figure/Simple-Calculator-Circuit-Diagram_fig1_287865276

[2] NJIT. “Lab 8: Design Project–4-bit RPN Calculator.” ecelabs.njit.edu. http://ecelabs.njit.edu/ece394/lab8.php (Accessed: September 29th).

[3] Hitachi. “HD44780U (LCD-II).” SparkFun. https://www.sparkfun.com/datasheets/LCD/HD44780.pdf (Accessed: September 27th).

[4] J. Skelly & D. Flores. “Four-Function Calculator with 8-bit Output.” http://cmosedu.com/jbaker/students/james_s/Calculator.pdf (Accessed: September 26th).

[5] https://documentation-rp-test.readthedocs.io/en/latest/fpgaexample01.html

[6] LCD screen product page: https://www.adafruit.com/product/1447?gclid=CjwKCAjw4c-ZBhAEEiwAZ105RQlXSKimUptlJU_f2rqVXlHqzTlTesp9L9-aLvBaubxtXWWkALgh8RoCXjwQAvD_BwE