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School of Sciences and Engineering

Fall 2021

CSCE2301 Digital Design 1

Calculator

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30/11/2021

The program’s main purpose is to construct a calculator that can handle basic arithmetic and mathematical operations. Operations supported are the basic four operations: addition, subtraction, multiplication, and integer division. It adjusts two numbers entered by the user through a set of buttons two control each digit of the two numbers. Each number is two digits. Finally the calculator performs the operation selected by the user through another set of buttons.

This program is designed to take the input numbers from 4 push buttons, one button to adjust each digit of the 4 digits of the 2 numbers. However, the operations are taken from 5 toggle switches. The first switch is for addition, the second is for subtraction, the third is for multiplication, the fourth is for division, and the fifth and final button is to display the two original numbers before doing any operations on them. The priority of the operation is in the following order original display, addition, subtraction, multiplication, division.

The signals from each button and switch is stabilized through a debouncer and synchronizer to match the input correctly with the clock. Then they are passed to a rising edge detector to capture input changes instants not to cause multiple presses at a single press. Then the detected edges are passed as parameters to two modules that handle these edges. One module is to handle incrementing and adjusting the digits, the tens of the first and second number and the units of the first and second number. Then the tens and units of each number are combined to single decimal number, i.e. A and B. And the other module is to handle which operation to perform.

Then these two numbers (A and B) and the specified operation is passed to a module that performs the operation on the given input and calculates the result. The addition, multiplication, and division are performed normally. The subtraction must take into account negative results as Verilog performs unsigned operations only. So first it compares A and B. if B is greater, it subtracts A from B and send a negative flag, otherwise it performs subtraction normally.

|  |  |
| --- | --- |
| Addition | A+B |
| Subtraction | (A>=B) 🡪 A-B |
| (B>A) 🡪 B-A |
| Multiplication | A\*B |
| Division | A/B |
| Display | A.B |

Then the result which is at most 4 decimal digits long is passed to another module that breaks the number into individual digits to be able to send one digit display in the FPGA. In the case there is a negative flag, the left most display in the FPGA is designated for the negative sign. After the breaking, the digits are broken and are ready to be shown and a fast clock divider is used to operate each signal of the display at a time with the correct digit. The digits are mapped to a normal seven segment display, however, in our case it is a 8 segment display in order to turn on the decimal point of the second most significant figure of the FPGA to differentiate between A and B.

**Simulation Results**

**A screenshot of a computer

Description automatically generated with medium confidence**Now, we will demonstrate the results of the simulation (1st test case).

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Definitions:

Figure 1

1-Clock

2-Reset

3-input buttons

4-output of the calculator

5,6,7,8-value of each digit of the four digits

9,10,11,12,13,14,15,16-inputs and outputs respectively for the seven segment display

In figure 1, we were incrementing the numbers until we reach 99 and 99.

A screenshot of a computer

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Display Original

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Figure 2

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In Figure 2 , we applied the required operations and finally displayed the original numbers.