ENGG 125.03 Laboratory Activity 2: Simple ALU

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***Abstract*—The laboratory activity is about making a simple arithmetic logic unit (ALU) using quartus. An ALU is a digital circuit that can do different arithmetic and logic operations. These are also the building blocks of a CPU. In the activity, an ALU was designed such that it can do five operations. These operations are AND, OR, addition, multiplication, and division. These operations can accept two 2-bit inputs. The different operations were simulated, along with different input values for the inputs.**

Keywords - Arduino, Touch Sensor, Ultrasonic Sensor

I. Computations/Solutions

In the activity, the students were required to do multiple operations based on the ALU. These operations are: AND, OR, addition, multiplication, and integer division. In this section, the different outputs from the different operations will be computed. These are the inputs that will be used: A) A = 00B and B = 11B, B) A = 01B and B = 10B, C) A = 10B and B = 01B, D) A = 11B and B = 01B, and E) A = 00B and B = 01B

The equations below are the equations and computations for the AND operation.

A) 00 AND 11 = 00
B) 01 AND 10 = 00
C) 10 AND 01 = 00
D) 11 AND 01 = 01
E) 00 AND 01 = 00

The equations below are the equations and computations for the OR operation.

F) 00 OR 11 = 11
G) 01 OR 10 = 11
H) 10 OR 01 = 11
I) 11 OR 01 = 11
J) 00 OR 01 = 01

The equations below are the equations and computations for the addition operation.

K) 00 + 11 = 11
L) 01 + 10 = 11
M) 10 + 01 = 11
N) 11 + 01 = 100
O) 00 + 01 = 01

The equations below are the equations and computations for the multiplication operation.

P) 00 * 11 = 00
Q) 01 * 10 = 10
R) 10 * 01 = 10
S) 11 * 01 = 11
T) 00 * 01 = 00

The equations below are the equations and computations for the integer division operation.

U) 00 / 11 = 00
V) 01 / 10 = 00
W) 10 / 01 = 10
X) 11 / 01 = 11
Y) 00 / 01 = 00

The values from these equations can be used to verify the results of the simulation.

II. HDL Code

This section shows and explains the code made for the activity.

```
module simple_alu(andOutput, orOutput,
addOutput, mulOutput, divOutput, A, B);

input[1:0] A; // first input
input[1:0] B; // second input
output[2:0] andOutput, orOutput, addOutput,
mulOutput, divOutput; // answer to the
operation

assign andOutput = A & B; // AND
assign orOutput = A | B; // OR
assign addOutput = A + B; // addition
```

```
assign mulOutput = A * B; // multiplication
assign divOutput = A / B; // division

endmodule
```

Fig. 8. Code for the ALU

In the code, five outputs were declared because there are five total operations. The outputs were assigned to be 3 bits because the addition and multiplication operations can produce three bit answers. Two 2-bit inputs were initialized. The assign keyword was used on each of the outputs to save the appropriate operations.

III. Output Circuit

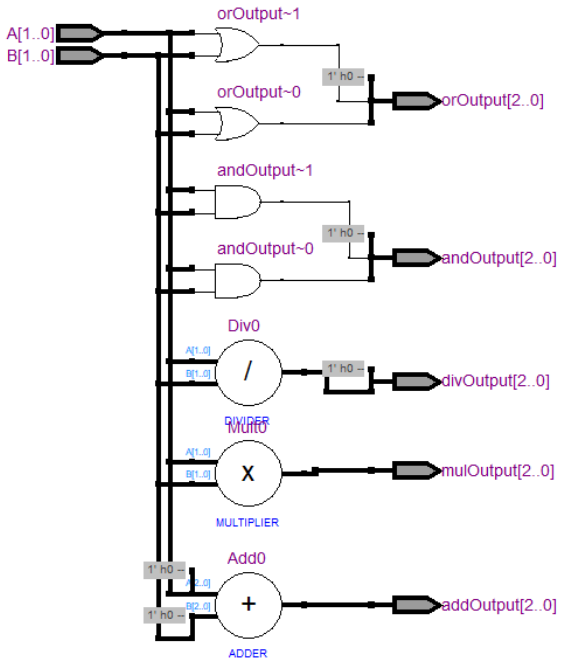

Fig. 10. Circuit for the ALU

The circuit simply follows the code. Two AND gates and OR gates were used in their respective operations since the inputs are 2-bits. Furthermore, an adder, multiplier, and divider were used for their respective operations. Using these gates, the appropriate output can be obtained.

IV. Screenshot(s) of Simulations and VWF file

The screenshots of the simulations are presented below.

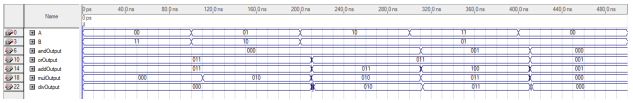

Fig. 12. Simulation for the ALU (Click here for a clearer copy)

As seen in the screenshot, all the answers in the simulation are the same with the answers done in the computations section of the paper. There are, however, some problems with the simulation. Firstly, the result of the outputs is delayed by about 10 ns. This is because of the propagation delay. Secondly, there are unusual figures in the simulation, such as the one around the 210 ns mark. This is most probably due to the inputs not instantaneously changing when transitioning from value to value. However, the correct results are still shown in the simulation. Therefore, it can be concluded that that simulation and activity is successful.