Course Name: Embedded Systems Design

Course Number and Section: 14:332:493:02

Lab 2 - The only time you have to do math

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Purpose:

- ***What is the intent of the lab? (To design, test, or implement a/an xyz?)***

The intent of this lab is to design a single bit full adder with inputs A, B, Cin and outputs S and Cout and with this, design a ripple carry adder, which consists of full adders together.

Also, to design an ALU using unsigned operands and implement it and test it in the Zybo using buttons, LEDs and Switches.

For each part of the Lab:

<u>Part 1:</u>

- ***Theory of Operation:***

  ➔ ***How will or should the circuit behave?***

The circuit should behave like a 4-bit ripple carry adder, which consists of 4 full adders.

  ➔ ***What do you expect to happen?***

I expect to get an output, which is the SUM of the inputs, and a Carry Out output.

- ***Schematic Diagram (as desired)***

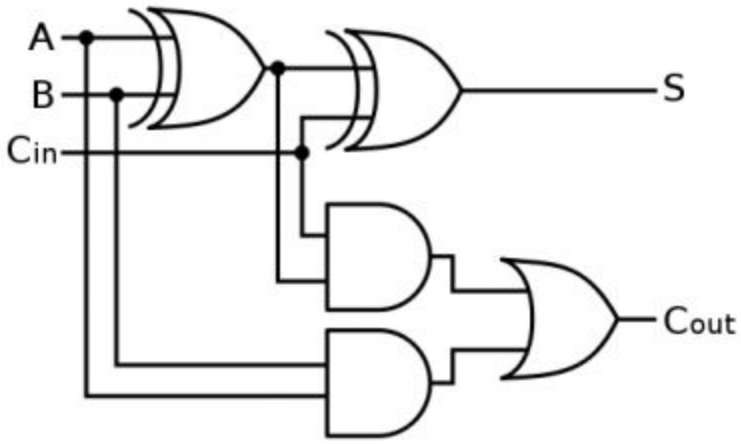


Figure 2.1: Single-Bit Full Adder Gate Diagram [1]

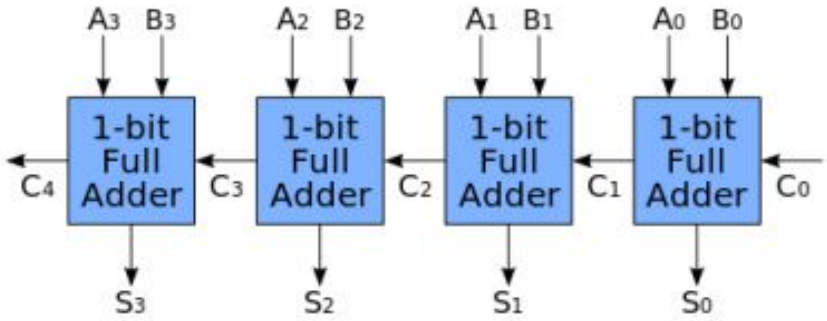
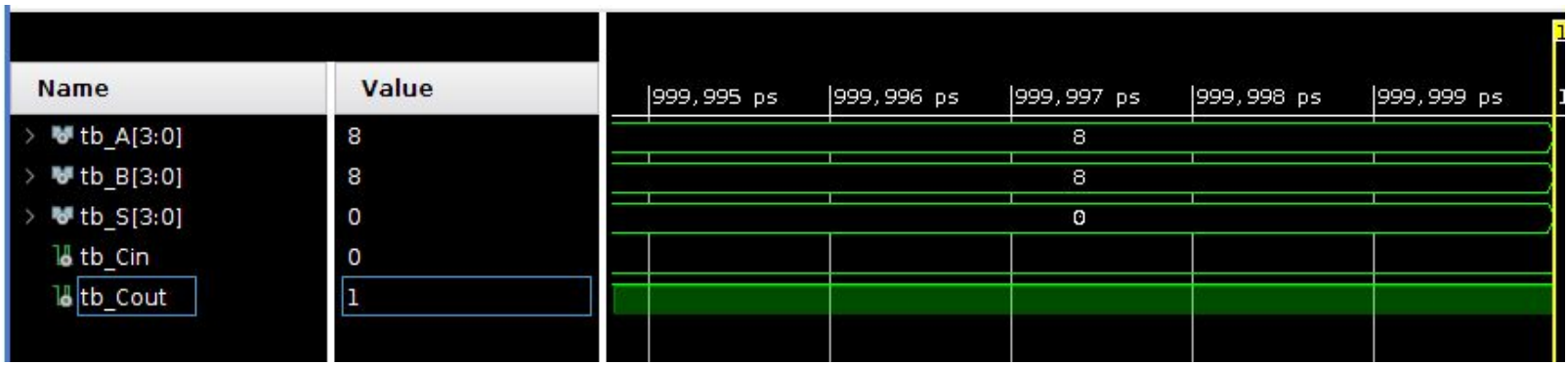


Figure 2.2: Single-Bit Full Adder Gate Diagram [2]

- ***Testing/Simulation***

  ➔ **Screenshots of simulation result/waveforms**

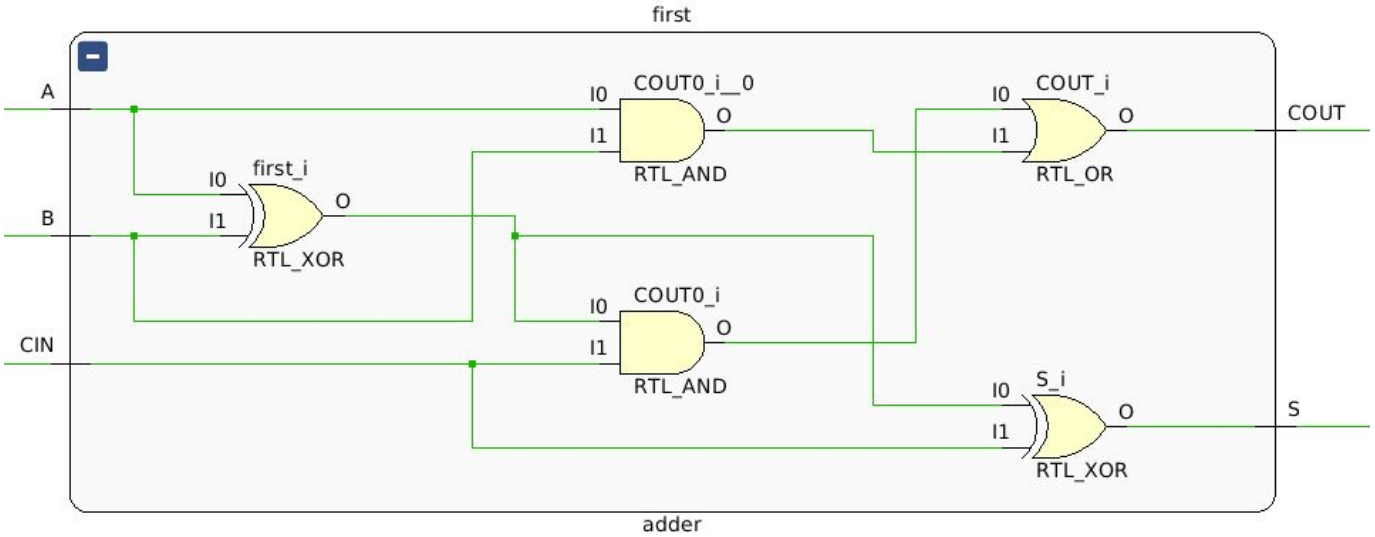
Simulation of 4 bit ripple carry adder:



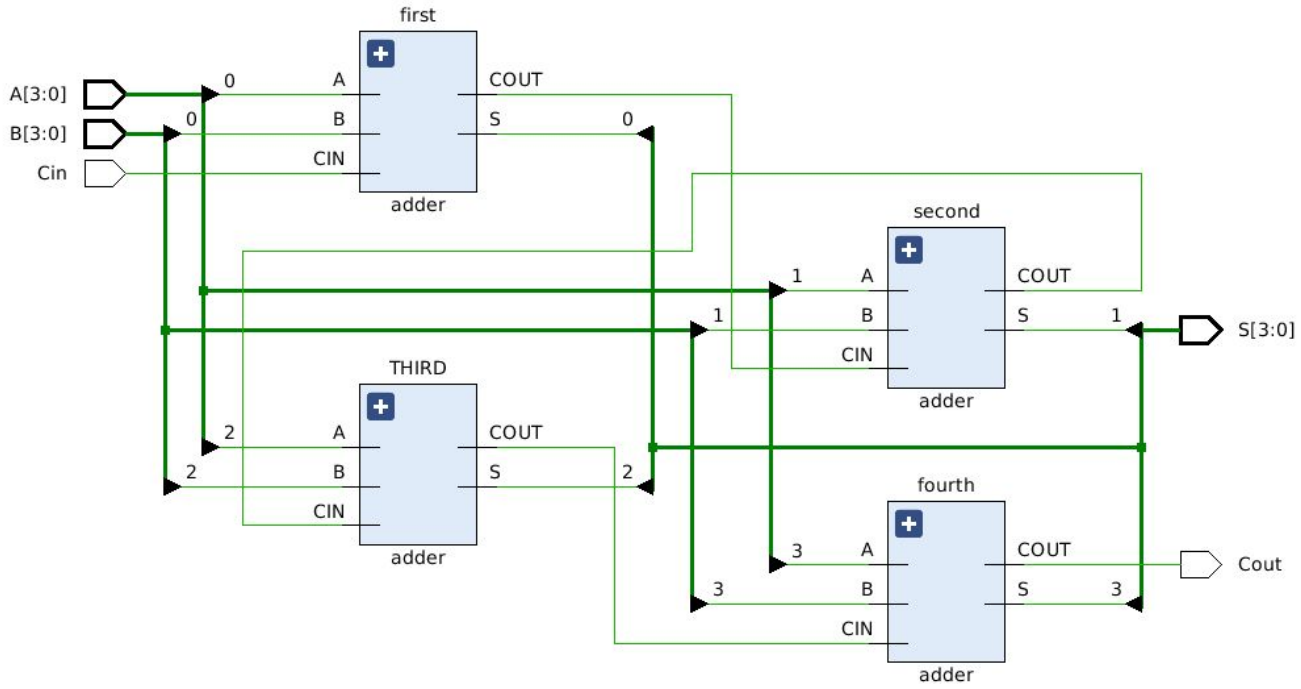
- ***Implementation***

  ➔ ***Vivado Elaboration Schematic***

Elaboration Schematic of Single-Bit Full Adder:

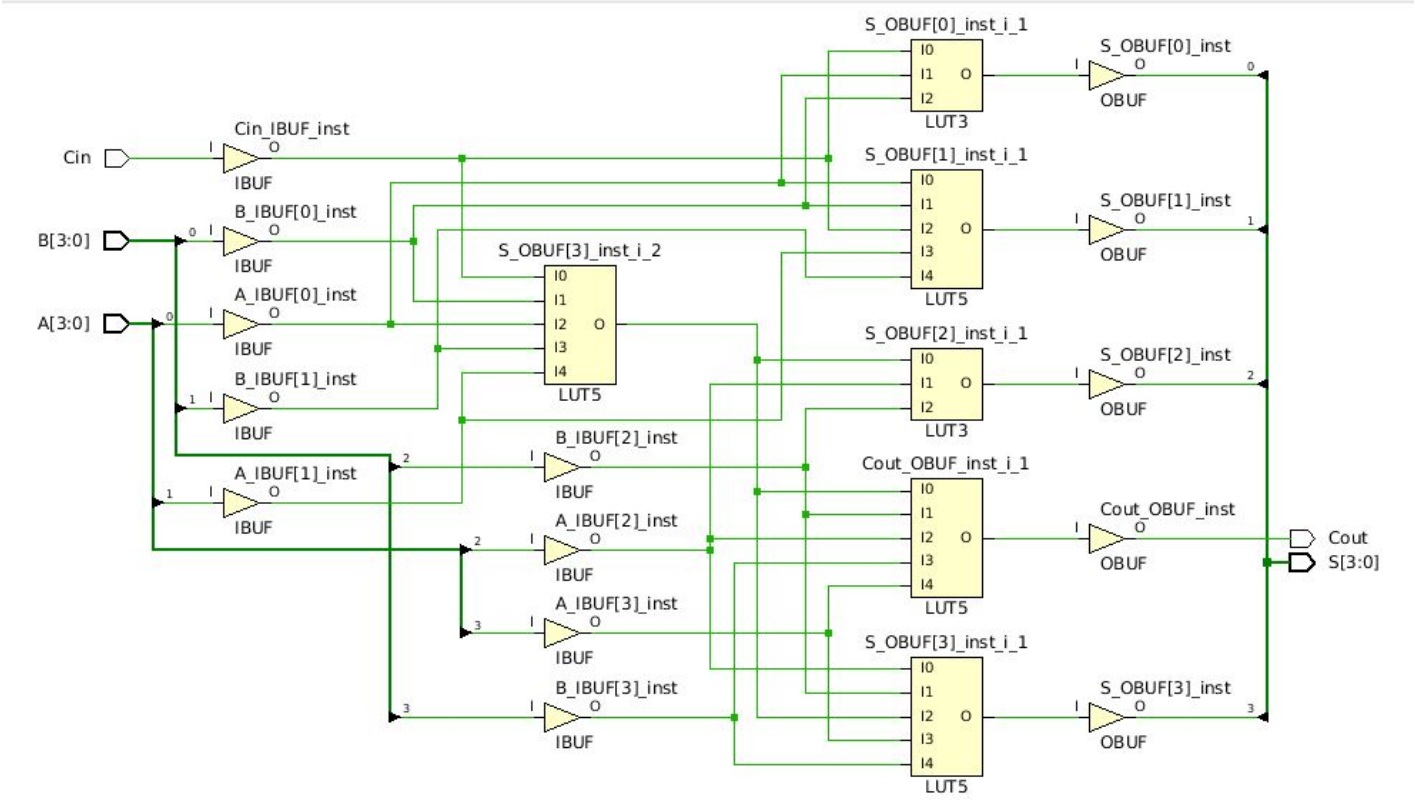


Elaboration Schematic of 4-bit ripple carry adder:



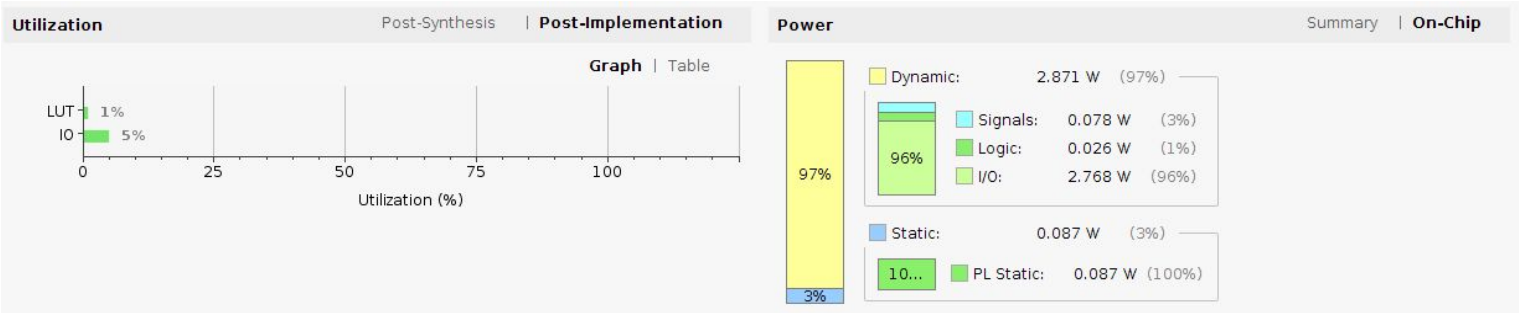
➔ *Vivado Synthesis Schematic*

Synthesis Schematic of 4-bit ripple carry adder:



➔ *Vivado Project Summary Images*

- ❖ *Post Synthesis Utilization Table*
- ❖ *On– Chip Power Graphs*



➔ ***Explain what you had to put in your constraint (.xdc) file and why***

For this part, I didn't have to use it.

<u>Part 2:</u>

- ***Theory of Operation:***

  ➔ ***How will or should the circuit behave?***

The circuit should behave like an ALU, of 16 functions and 4-bits, it should do Arithmetic and Logical functions, then the signals will be sent to physical parts of the Zybo and show the result in the LEDs.

➔ ***What do you expect to happen?***

I expect to get the correct result for all 16 different functions, using my 4 bit inputs and show my results in the LEDs of the Zybo.

- ***Schematic Diagram (as desired)***

opcode	function	opcode	function
x"0"	$A + B$	x"8"	$A >>> 1$ (right shift arithmetic)
x"1"	$A - B$	x"9"	not A
x"2"	$A + 1$	x"A"	A and B
x"3"	$A - 1$	x"B"	A or B
x"4"	$0 - A$	x"C"	A xor B
x"5"	$A > B$ (greater than - see note)	x"D"	A xnor B
x"6"	$A << 1$ (left shift logical)	x"E"	A nand B
x"7"	$A >> 1$ (right shift logical)	x"F"	A nor B

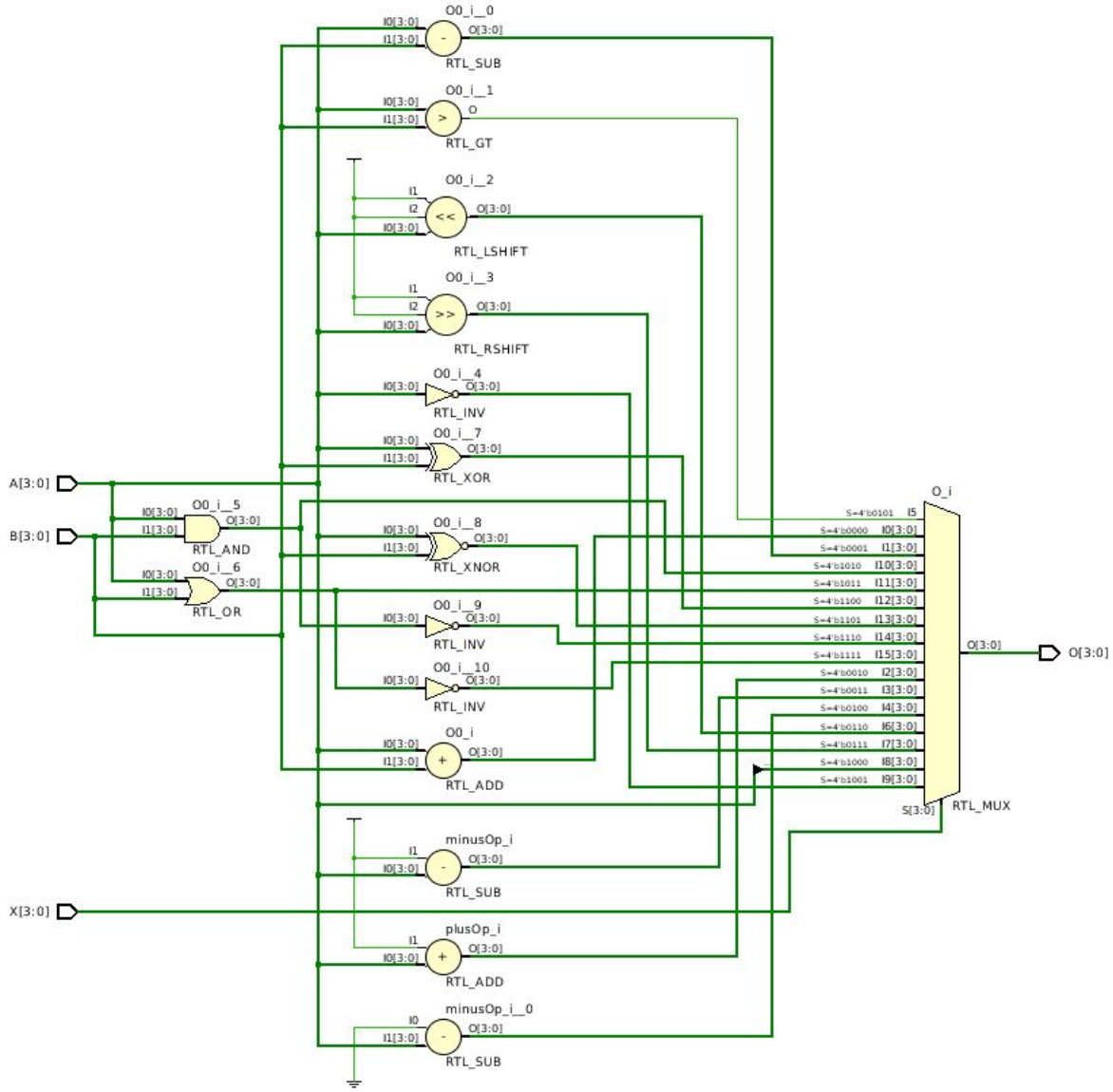
- ***Testing/Simulation*** **(Not needed)**

  ➔ **Screenshots of simulation result/waveforms (Not needed)**

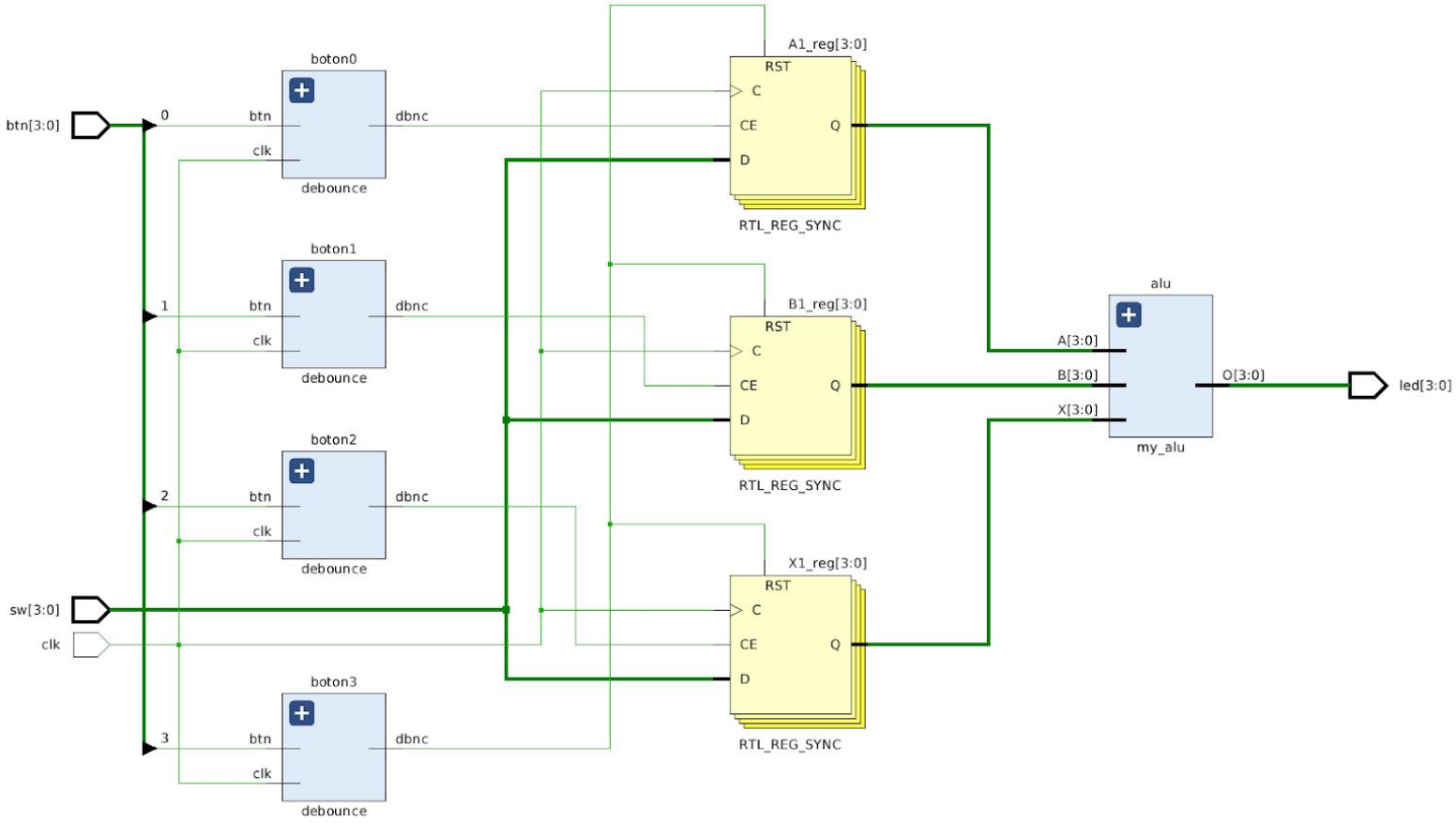
- ***Implementation***

  ➔ ***Vivado Elaboration Schematic***

My_alu Elaboration Schematic:

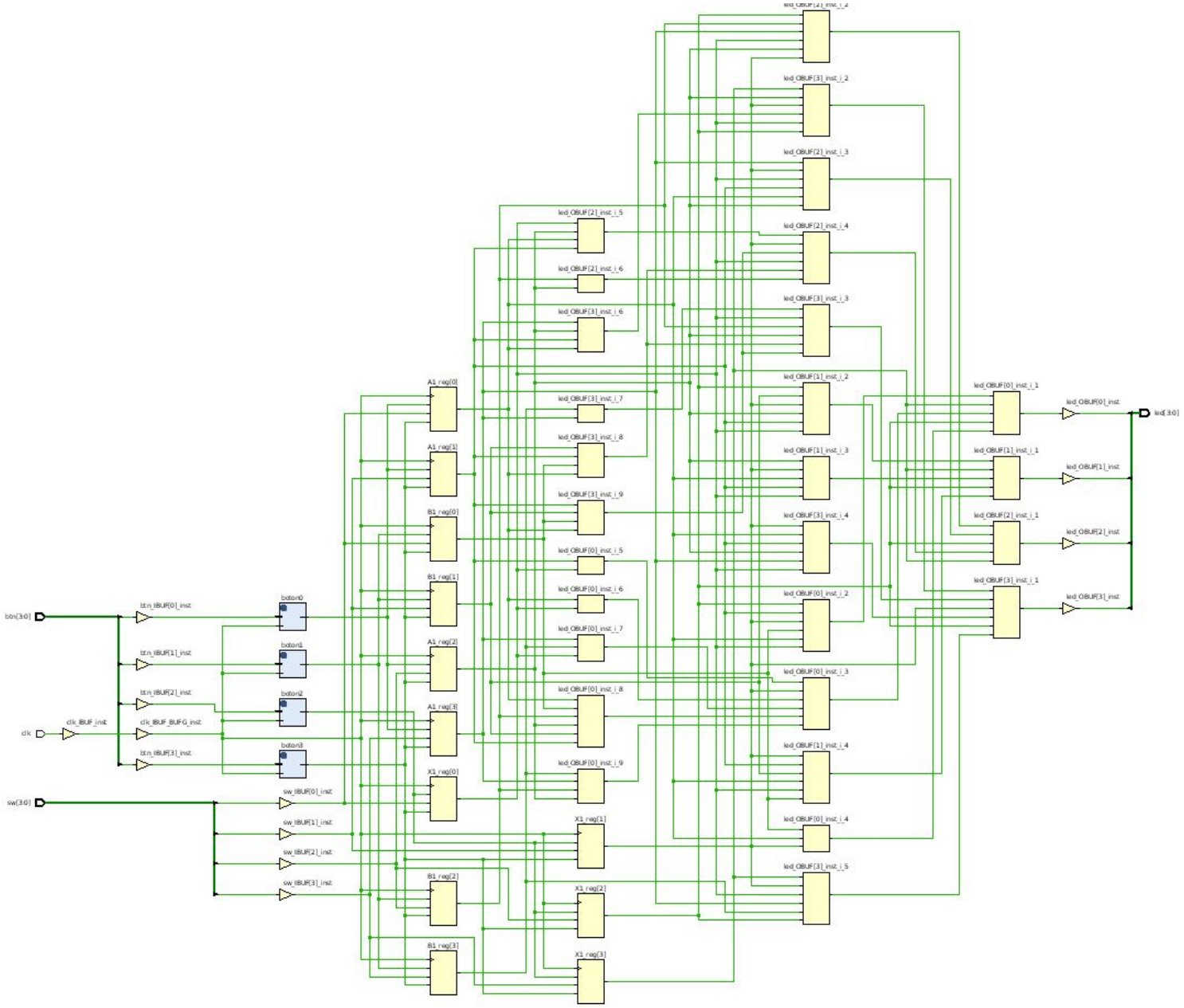


alu_Tester Elaboration Schematic:



➔ ***Vivado Synthesis Schematic***

alu_tester Synthesis Schematic:



➔ ***Vivado Project Summary Images***

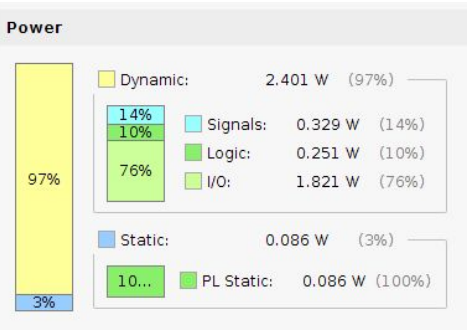
❖ ***Post Synthesis Utilization Table***

❖ ***On – Chip Power Graphs***

Utilization Post-Synthesis | **Post-Implementation**

Graph | **Table**

Resource	Utilization	Available	Utilization %
LUT	67	41000	0.16
FF	112	82000	0.14
IO	13	300	4.33
BUFG	1	32	3.13



➔ ***Explain what you had to put in your constraint (.xdc) file and why***

I had to uncomment all Switches, Buttons and LEDs lines.

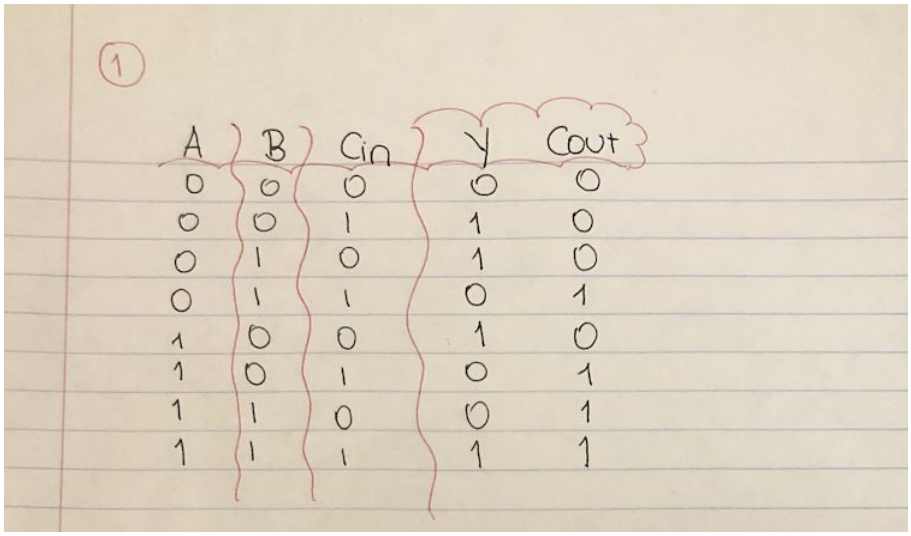
Discussion:

- ***Answer to specific Lab Manual questions:***

<u>Part 1:</u>

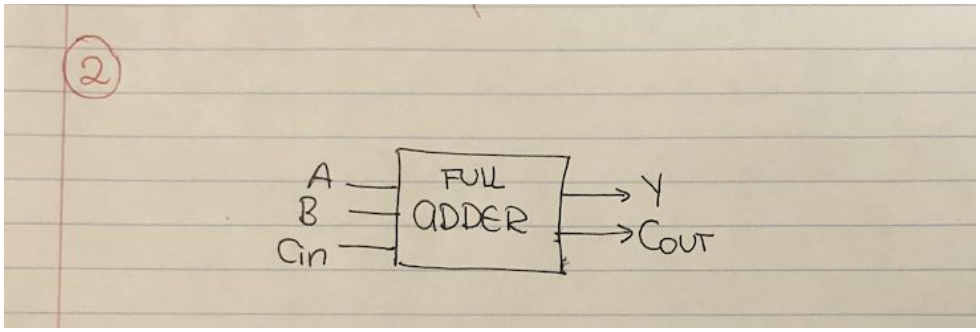
Pre Lab - Operators and Conversions Review

1. ***Write the logic equations for a single bit full adder with inputs A, B, Cin, and outputs Y, Cout.***

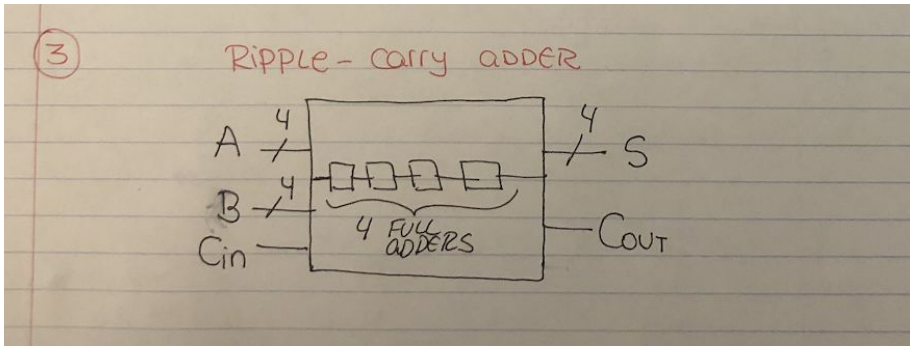


A	B	Cin	Y	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

2. ***Draw a black box diagram for the single bit full adder described above.***



3. ***Draw a block diagram of a 4-bit ripple-carry adder made of single bit full adders, with 4 bit inputs A and B, a single bit input Cin, a 4-bit output S, and a single bit output Cout.***



- ***Observations/Discoveries***

  ➔ ***What did you learn?***

I learned how to design a full adder and a ripple adder. Also, how to use signed and unsigned operands, concatenations, arithmetic and logic functions.

- ***Questions/Follow Up***

  ➔ ***Which concepts do you feel like you completely understand?***

I completely understand the concept of a full adder, what each input and output means. Also, how to create a basic ALU and how these work.

➔ ***Any concept you're unsure of?***

I am unsure of the concept of the Chip Power Graph and the Utilization Table, what exactly they are for.