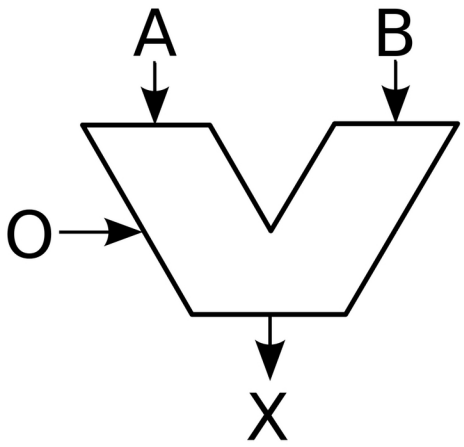
ALU3000

What is ALU3000?

-ALU3000 (Arithmetic Logic Unit 3000) is a well designed modern combinational digital electronic that performs arithmetic and logic operations. Construction of ALU3000 is shown below.



ALU (image 1.1)

-What components does ALU3000 have?

ALU3000 is a combinational circuit which consists of PIPO registers, arithmetic unit, logic unit and multiplexer.

What operations can ALU perform?

- It depends on how ALU is designed. ALU3000 can perform 4 Arithmetic and 4 Logic operations which are shown in table.

Operation list table(table 1.1)

Sel	**Operation**	Type
000	**A + B**	Arithmetic Unit
001	**A - B**	
010	**A + 1**	
011	**max(A,B)**	
100	**A AND B**	Logic Unit
101	**A OR B**	
110	**NOT A**	
111	**A XOR B**	

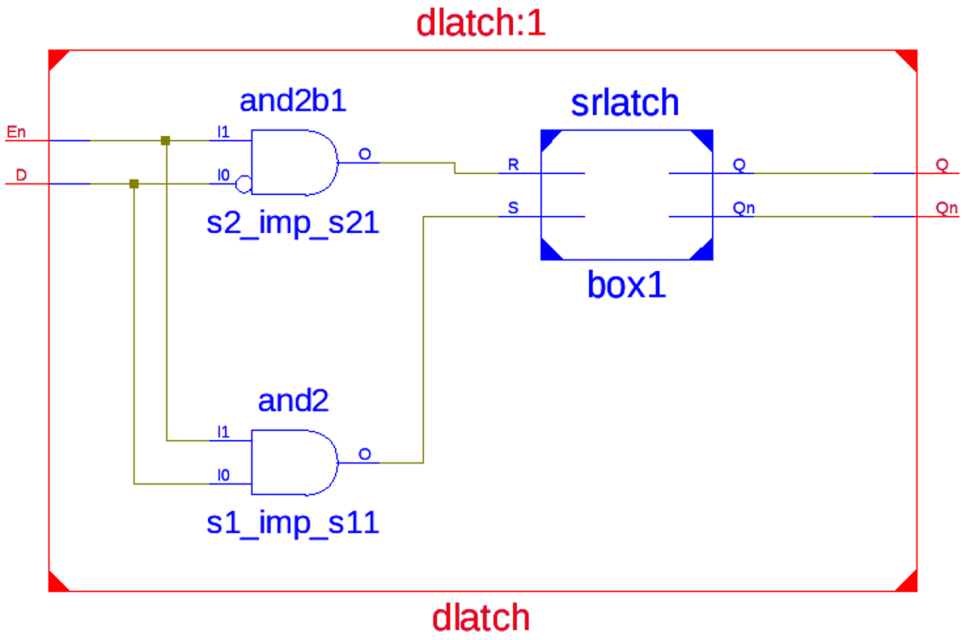
**Magnitude comparison part will be examined in page 6.*

D-LATCH

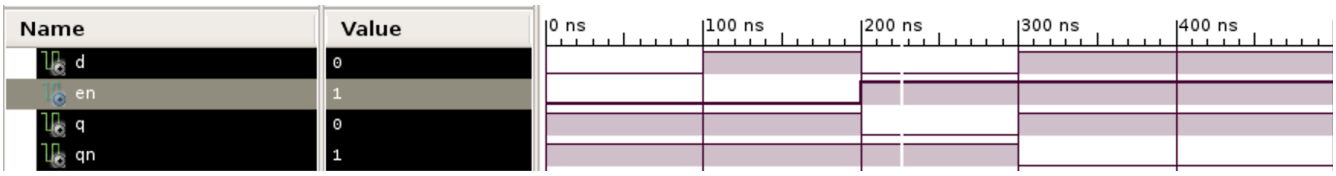
What is D-Latch?

- D-Latch is electronic circuit that can be used to store 1 bit data.

RTL



Test Bench Result



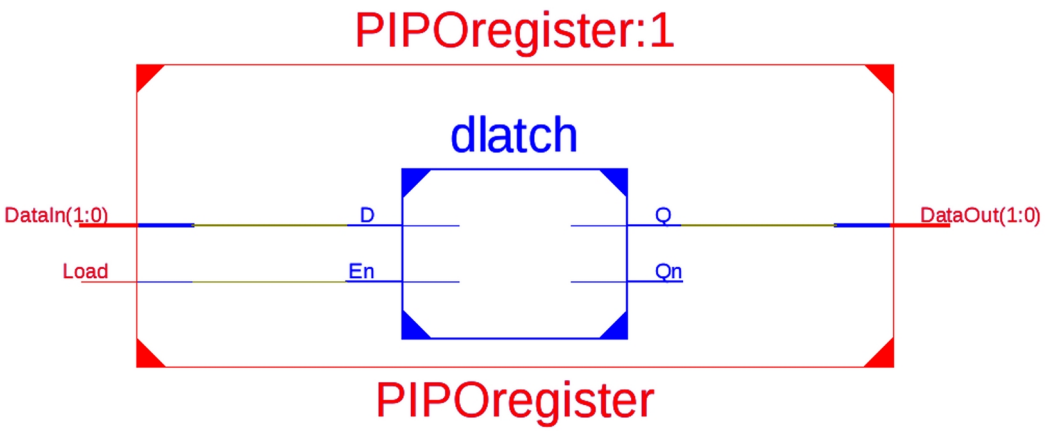
D	En	Q	Qn
0	0	X	X
1	0	X	X
0	1	0	0
1	1	1	0

D-Latch truth table (table2.1)

PIPO REGISTER

PIPO Register (Parallel Input Parallel Output Register) is data storage device that perform data loading in parallel mode.

RTL



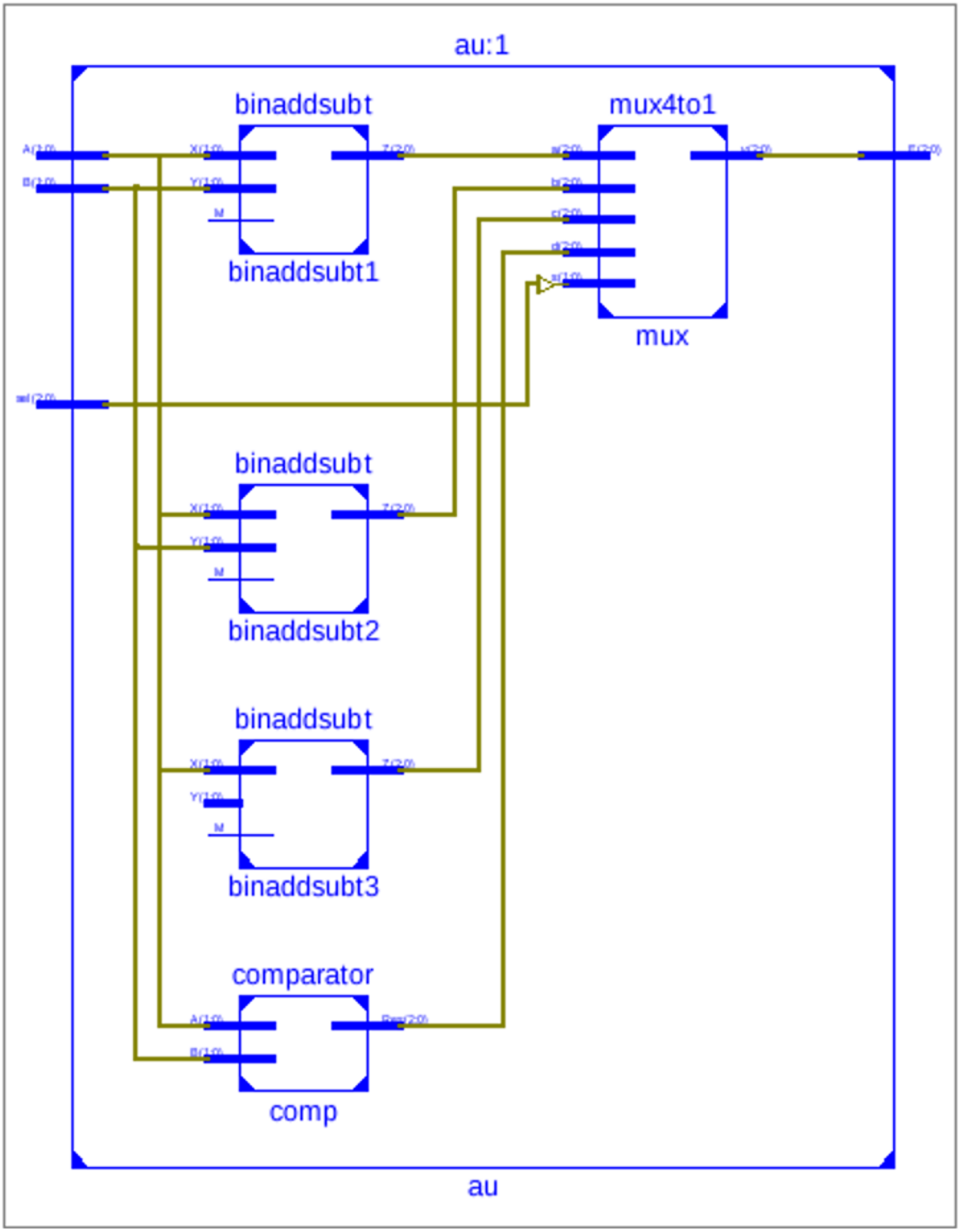
Test Bench Graph

- Pipo register loads when load bit is ‘1’.

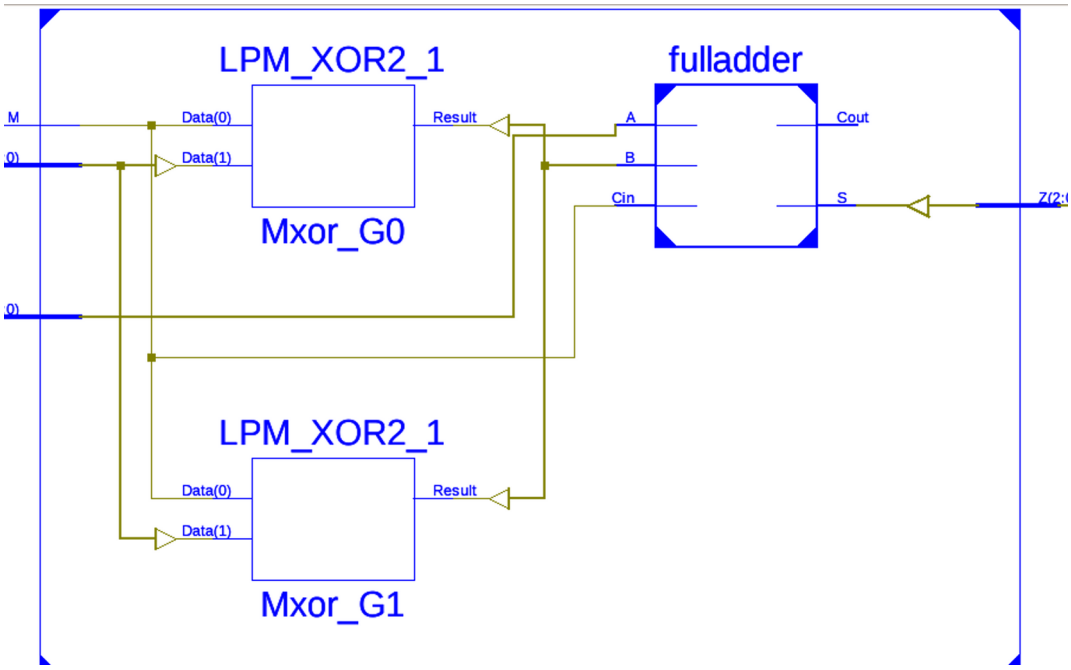
ARITHMETIC UNIT

Arithmetic Unit consists of 3 binary adder subtractor, a 4 to 1 Mux and a magnitude comparator.

RTL

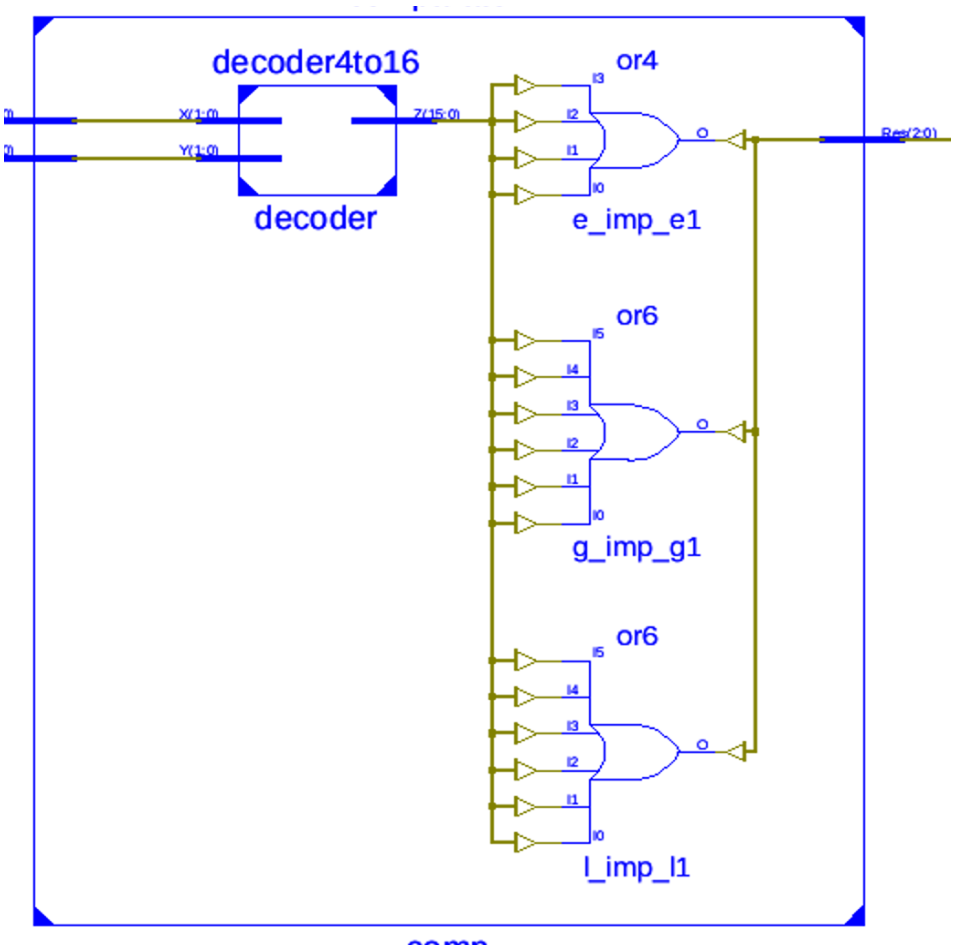


Binary Adder Subtractor



- Binary adder subtractor gets 3 input and give 1 output.
- 2 inputs for data and 1 input for selection bit.
- Selection bit allows adder subtractor to perform allow/subtract operation.

Magnitude Comparator

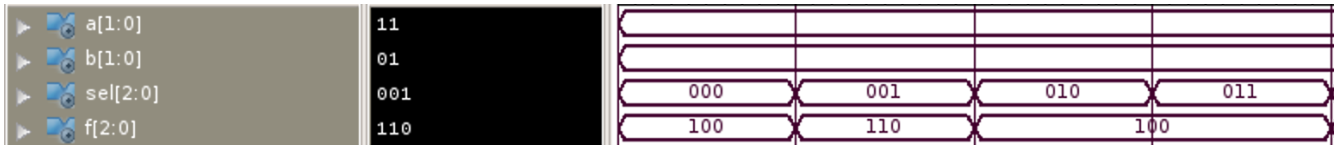


- Magnitude comparator gets 2 inputs and gives 1 output.
- The size of the output is 3 and it is in order of “GEL”
- Which means;

A >B => “100”
A=B => “010”
A<B => “001”

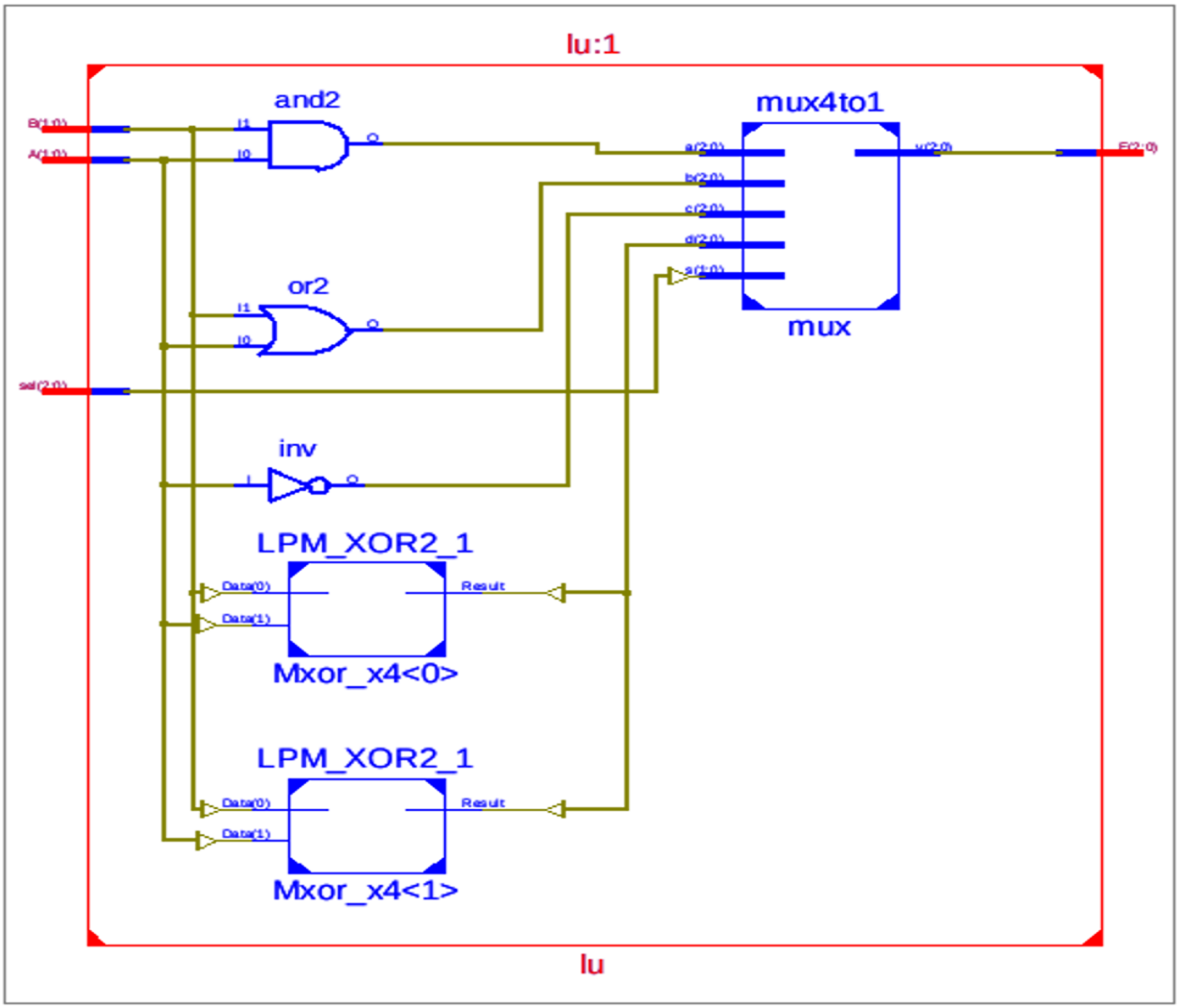
Test Bench Result

A+B A-B A+1 max(A,B)



LOGIC UNIT

Logic Unit is the unit which process logic functions, such as AND, OR, XOR, NOT.RTL



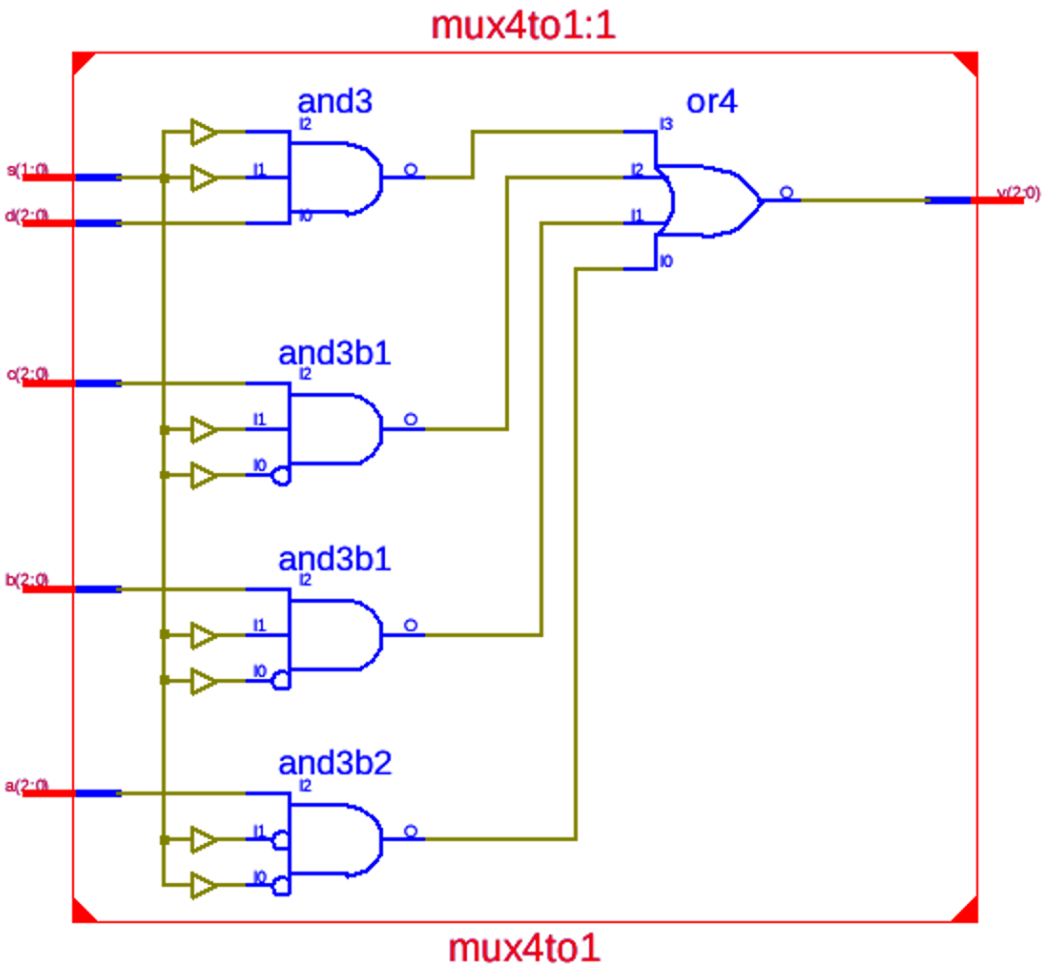
Test Bench Result

AND OR NOT A XOR

4x1 MUX

-4x1 mux allows us to choose which operation to perform in logical unit and arithmetic unit by Sel(1:0) “last 2 bit of Selection signal”

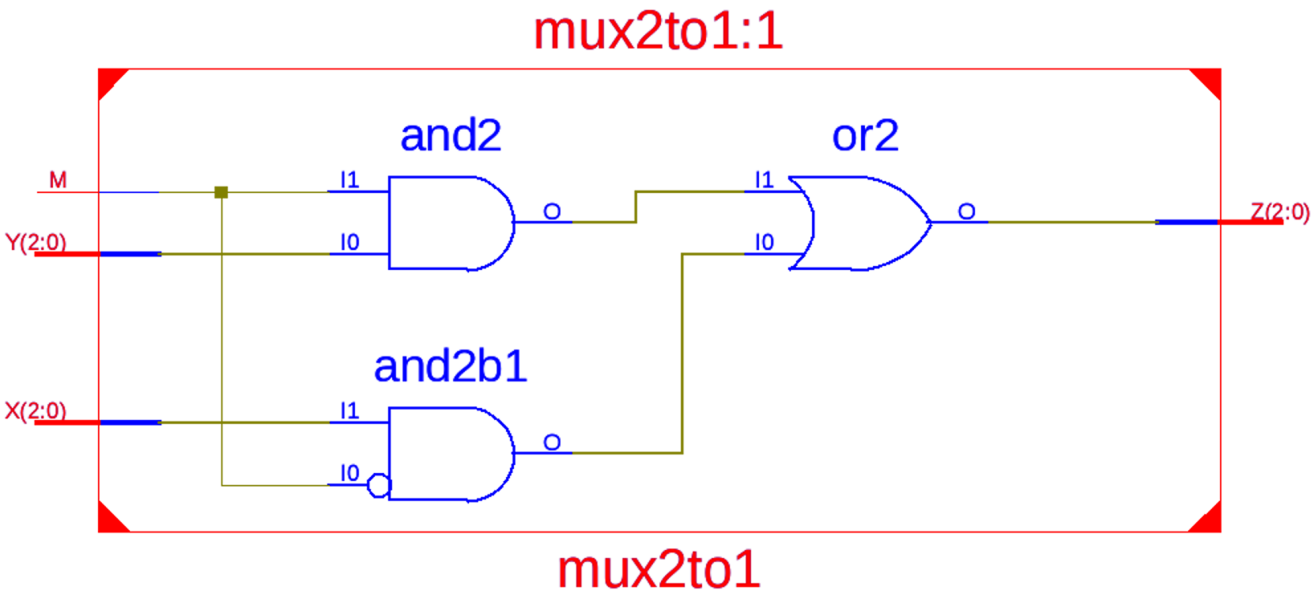
RTL



MUX (2 TO 1)

This MUX takes the output of Arithmetic Unit and Logic Unit as input and msb of ‘sel’ as a selection bit. If msb of ‘sel’ is 1 it gives to corresponded output of Logic Unit, else it gives Arithmetic Unit’s output.

RTL



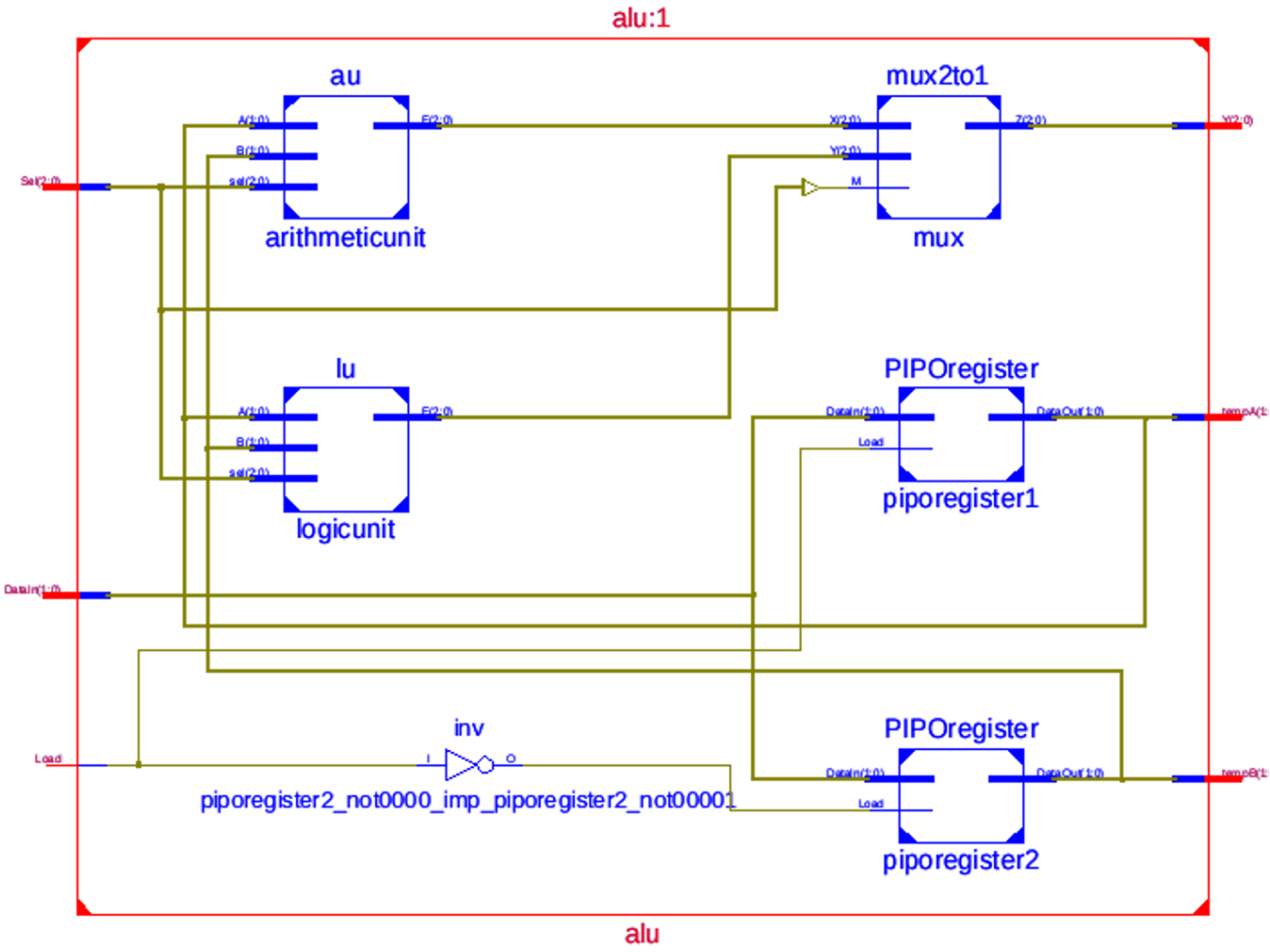
-2x1 multiplexer gets 3 inputs. M is *msb* of selection signal, X is output of arithmetic unit and Y is output of logic unit.
-It allows us to choose whether perform arithmetic or logic operation by the msb of selection input.

Test Bench Resul

**msb = Most significant bit*

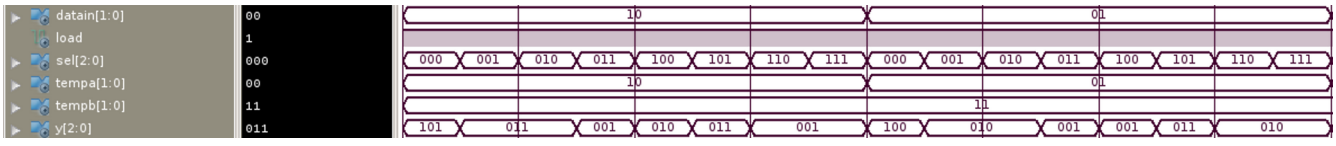
ALU

Rtl



-This is the top module of project.

Test Bench Result



**We can see that it follows the order of table 1.1*

Summary

- ALU is logical components which perform logical and arithmetical operations.
- ALU may consists of different components and it varies by the design of it.
- For ALU3000, magnitude comparator, binary adder subtractor, sr-latch, d-latch, PIPO register etc. used.

Further Improvements

- To improve to ALU 3000 there are three steps that I can take
    1- Expanding the operation list
        - Shifting, rotating etc. can be add
    2- Optimizing the system
        - For me, only way to that is decreasing the total transistor amount.

External Links

- https://www.youtube.com/watch?v=mOVOS9AjgFs *youtube video by Ben Eater about ALU
- https://www.allaboutcircuits.com/projects/how-to-build-your-own-discrete-4-bit-alu/ similar project by Robin Mitchell. August 18,2016.
- https://www.allaboutcircuits.com/projects/how-to-build-your-own-discrete-4-bit-alu/ useful resource by Gojko Babic

Source Code can be found in

https://github.com/itsjustaplant/ALU3000 (by me of course)