4-Bit Arithmetic Logic Unit

DE Lab Project Report

Submitted By

Aakash Kumar Boity (18BCS6002)

Devansh Duggal (18BCS6010)

Karan Trehan (18BCS6033)

Under the Guidance of

Mr. Anshul Sharma

Mr. Divneet Singh Kapoor

Mr. Khushal Thakur

Assistant Professors, Academic Unit – 1

Academic Unit-1

Chandigarh University

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1. Problem Identification

An arithmetic logic unit (ALU) is a major component of the central processing unit of a computer system. It does all processes related to arithmetic and logic operations that need to be done on instruction words. In some microprocessor architectures, the ALU is divided into the arithmetic unit (AU) and the logic unit (LU).

Basic Purpose behind designing a 4-Bit ALU is to perform faster computations. The time taken by the ALU to provide the output is very less which is a very good feature as a human mind might take seconds to perform any calculation or computation (either simple or complex) but the ALU does it in fraction of seconds.

Moreover , this 4-Bit ALU equips us with the power to perform and solve eight different kind of problem statements namely:

1. Addition.
2. Subtraction.
3. Increment of a number.
4. Decrement of a number.
5. Bitwise AND operation.
6. Bitwise OR operation.
7. Right Shift Operation.
8. Rotate Left Operation.

In addition to it , ALU holds the capability of processing large amount of instructions in very less time.

2. Features

Capabilities of 4-Bit ALU

It performs basic arithmetic and bitwise logic operations which are commonly supported by ALUs. The basic arithmetic and logical operations are:-

Arithmetic Operations :-

- **ADD:** A and B are the 4 bit binary numbers which are summed and the sum appears at the output.
- **SUBTRACT:** A and B are the 4 bit binary numbers in which B is subtracted from A and the difference appears at the output.
- **Increment:** A is increased by one and the resulting value appears at the output.
- **Decrement:** A is decreased by one and the resulting value appears at the output.

Bitwise logical operations:-

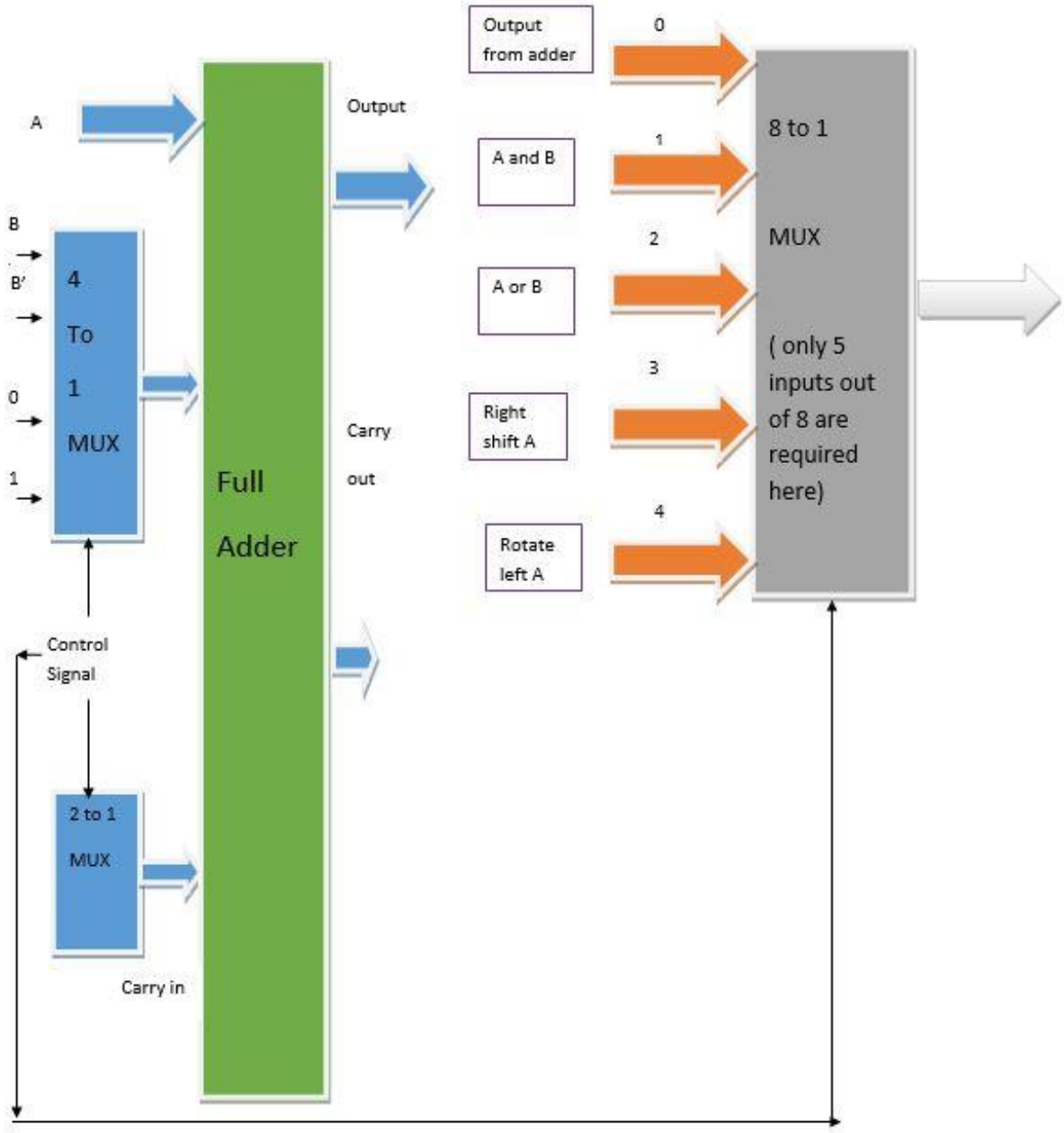
- **AND:** The bitwise AND of A and B appears at Y.
- **OR:** The bitwise OR of A and B appears at Y.
- **Right Shift:** The Right Shift operation is applied on A and the output is produced accordingly.
- **Rotate Left :** The Rotate Left operation is applied on A and the output is produced accordingly.

Limitations of 4-Bit ALU

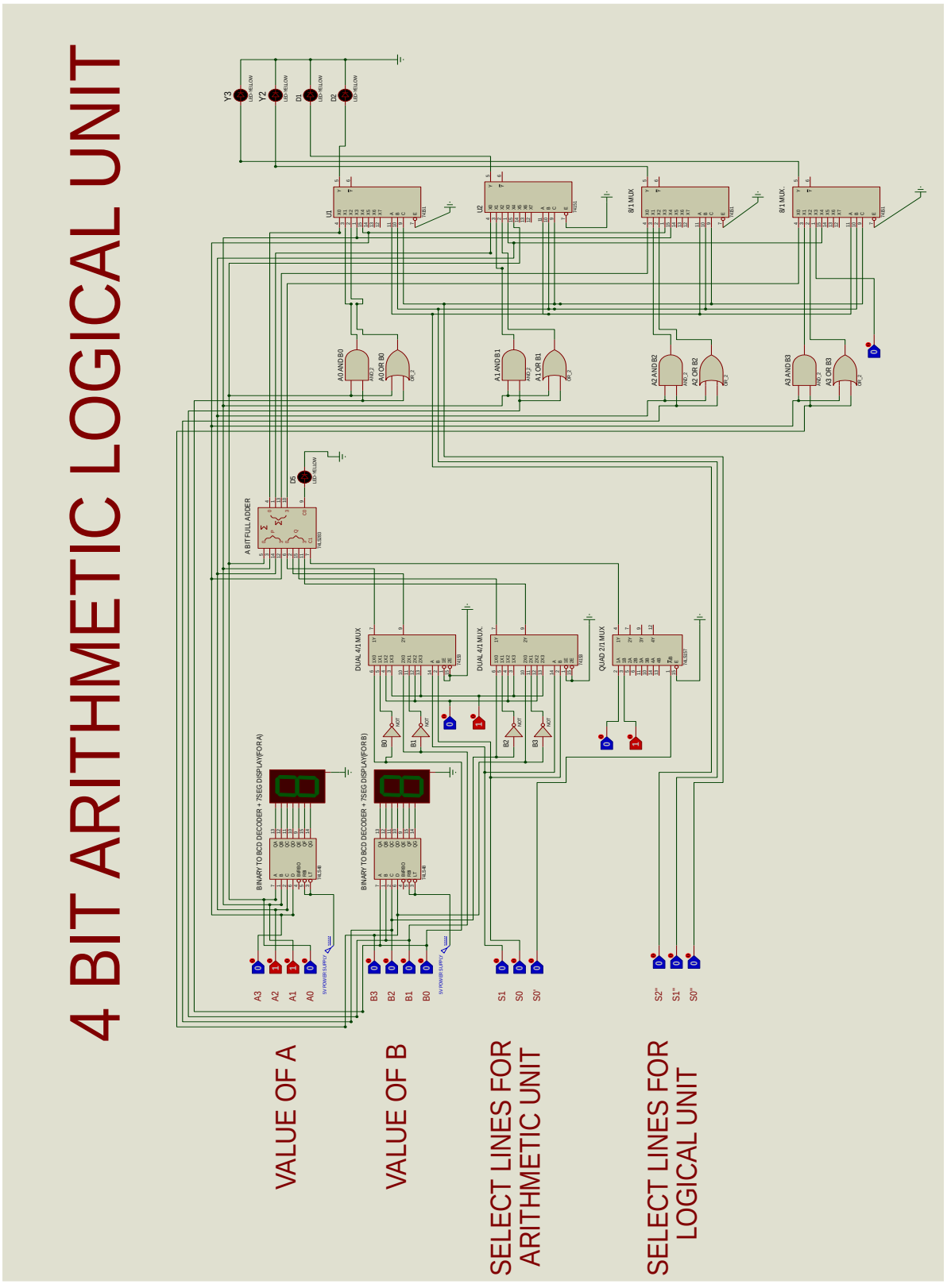
- As the operations become more complex, the ALU also becomes more expensive.
- The basic idea for ALU design presented here is not suitable for complex operations such as multiplication, division, and floating-point operations.
- Cannot perform operations on numbers greater than 4-Bit numbers, and hence hess less usability.

3. Design Flow

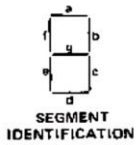
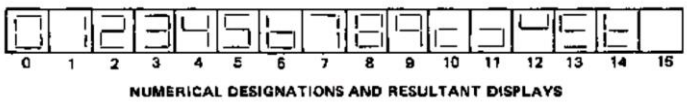
Block Diagram



Circuit Diagram



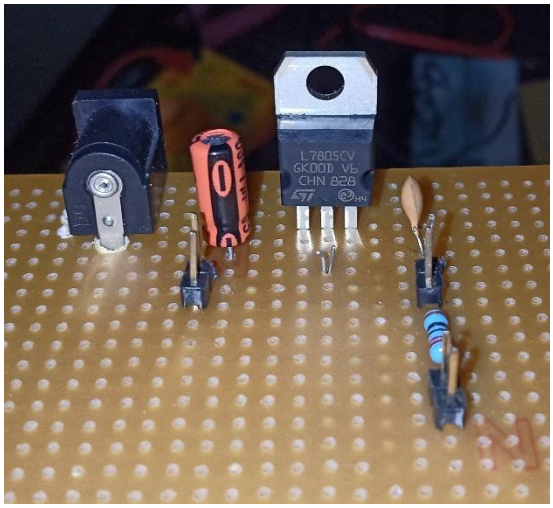
Materials

Materials	Specification
Perf Board	The perf board gives the surface area to the electronic components so that they can be put and joined together at a single place. The size of the perf board is 6” x 4”.
Resistors	Two values of resistors are used, 10kΩ (as a pull down resistor) and 220Ω(as a resistance to whole of the circuit.
DIP Switches	These switches help us in providing the circuit with logic 0 or logic 1.
74LS48	These are BCD to 7 Segment Display Decoder used to show the given binary input in decimal format. It takes a 4 bit binary number , decodes it to decimal number and then displays the converted number on the 7 Segment Display. Operating Voltage Range: 4.5 V to 5.5 V.
74HC04	NOT Gates are used to invert the bits of B. Operating Voltage Range: 2.0 V to 6.0 V.
7 Segment Display	In this Case , it is used to depict the binary inputs in decimal format.  SEGMENT IDENTIFICATION  0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 NUMERICAL DESIGNATIONS AND RESULTANT DISPLAYS
74LS157	Quad 2:1 Mux , used to provide the carry in to the full adder. Operating Voltage Range: 4.5 V to 5.5 V.
74HCT153	Dual 4:1 Mux , used for selecting the operation from a given set of operations. Operating Voltage Range: 2.0 V to 6.0 V.
74LS283N	4-Bit Full Adder , used to perform all the arithmetic operations Operating Voltage Range: 4.5 V to 5.5 V.

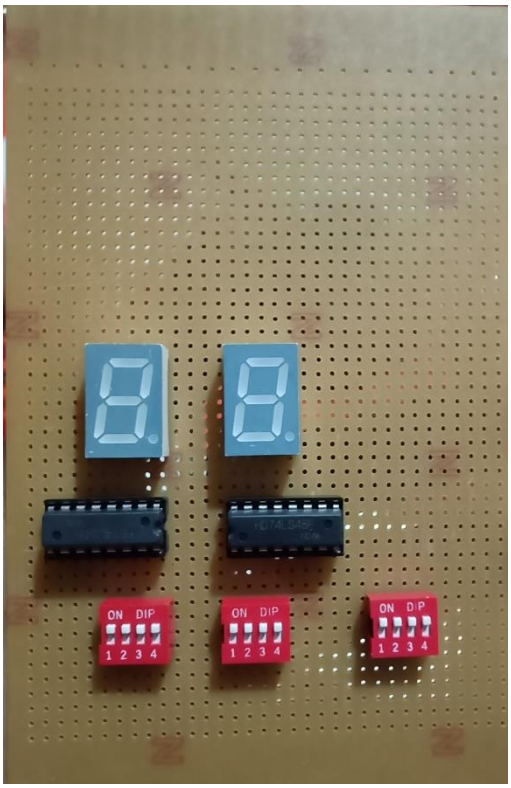
7805	Voltage Regulator. Helps in deriving 5V DV output from 12 DC Input.
74HC08	AND Gate is used to perform bitwise AND operation between A and B. Operating Voltage Range: 2.0 V to 6.0 V.
74HC32	OR Gate is used to perform bitwise OR operation between A and B. Operating Voltage Range: 2.0 V to 6.0 V.
74LS151	8:1 Multiplexers are used in the logic unit. Operating Voltage Range: 4.75 V to 5.25 V.

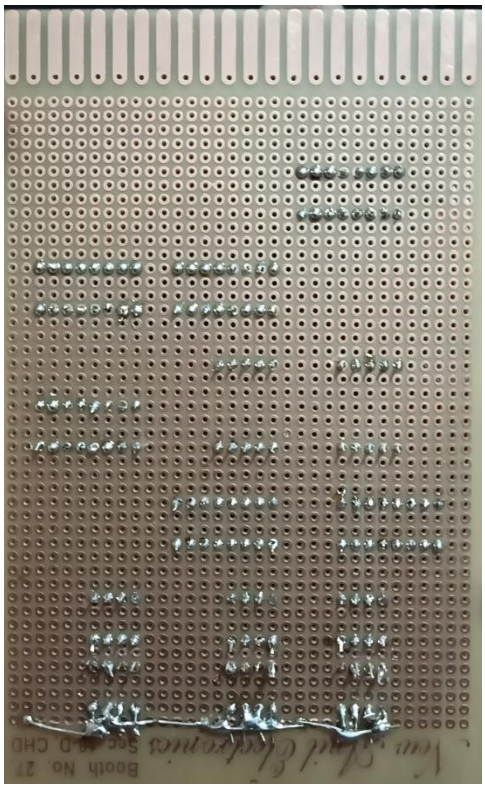
4. Outcome

Steps of Circuit Completion

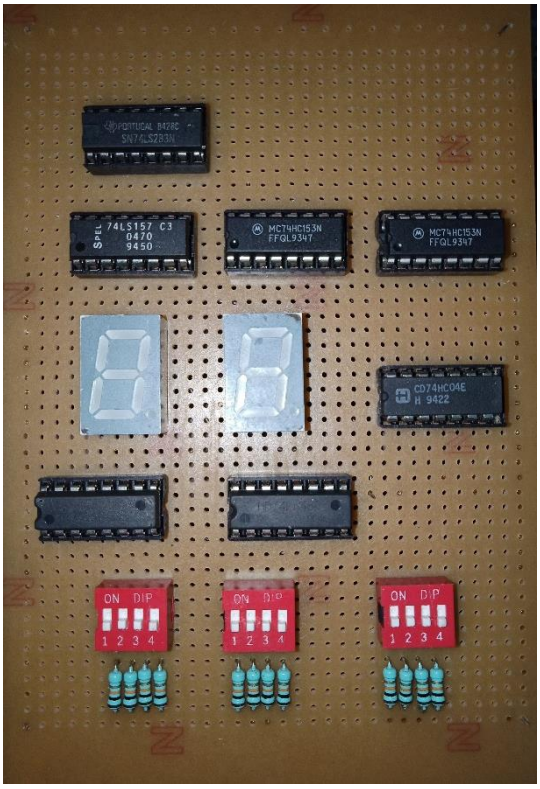


Firstly , the input source was designed which converted 12V DC to 5V DC

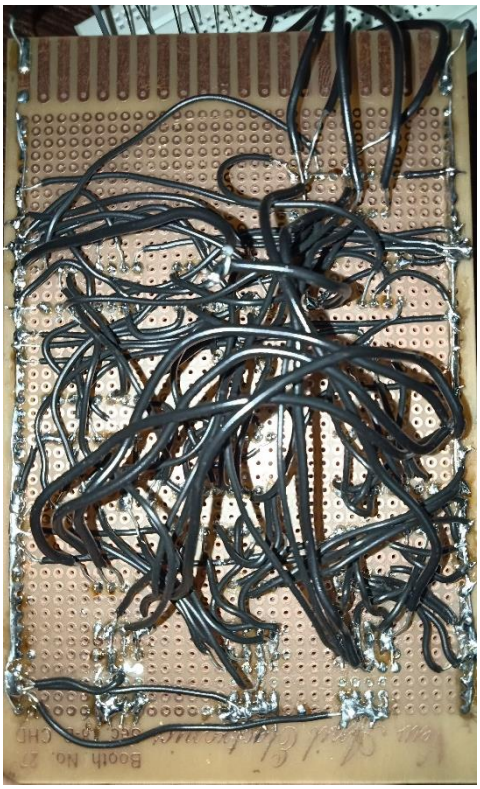




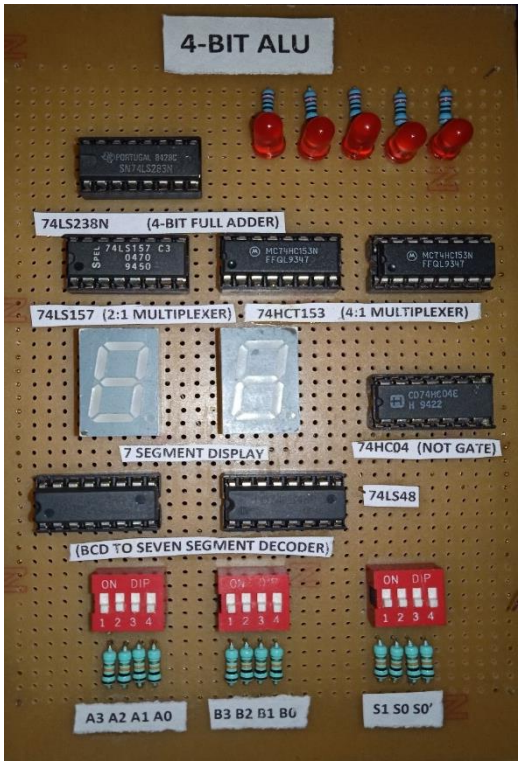
Secondly , All the input components required for the ALU were installed on the perf board and were soldered.



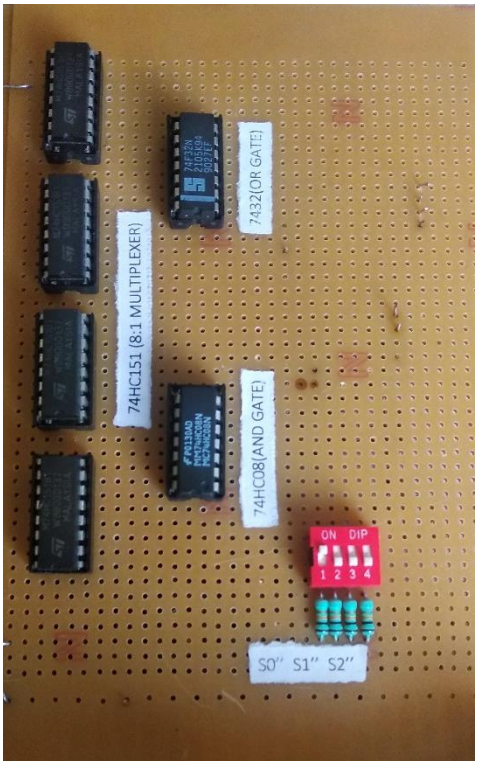
All the components of the Arithmetic Unit were put on the perf board and were soldered.



Necessary Joints were made in the process. All the connections made were successful.

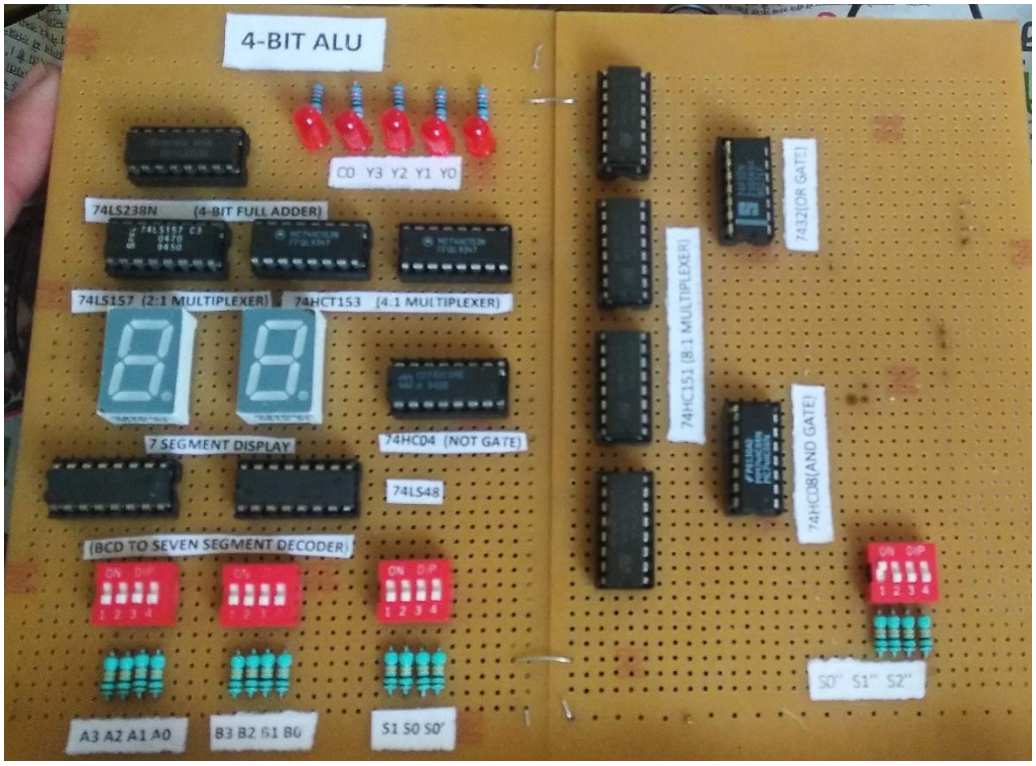


Arithmetic Unit



Logic Unit

Wiring Done On the back of the ALU



Final Look Of The ALU.

5. Cost Analysis

S. No.	Component / Material	Price (in Rs.)
1.	Perf Board(2)	60
2.	Resistors(10k)	5
3.	Resistors(220)	5
4.	4 Bit Dip Switches(3)	30
5.	74LS48(2)	40
6.	7 segment display	10
7.	74HC04	15
8.	74LS157	20
9.	74HCT153(2)	50
10.	4 Bit Full Adder(74LS283N)	120
11.	Wire(6 meters)	30
12.	LEDs(10)	10
13.	D.C. Power Jack	5
14.	1uF and 0.1uF Capacitors	5
15.	7805	20
16.	74HC08	15
17.	74HC32	15
18.	74LS151(4)	80
19.	220 V AC to 12 V DC Adapter	150
Total		685