Report on Calculator Design & Implementation

A Project of Digital Electronics Lab (EEE 4308)

Submitted by : ALPHA HELIX

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Acknowledgment

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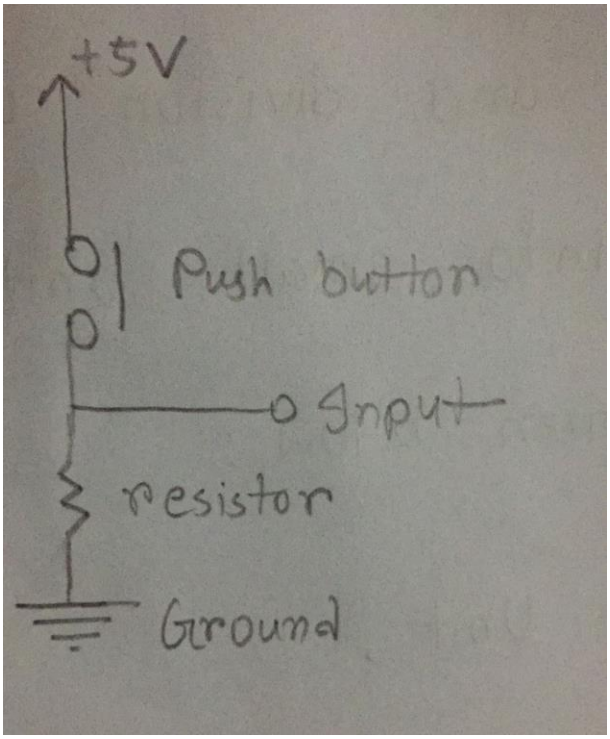
Objective :

This project is mainly based on the basic gates and their operations . Using the gates , we created a two byte decimal calculator where the two inputs are one byte decimal each . We applied our theoretical knowledge of sum , subtraction , multiplication and division using gates . The experiment is divided into small units . the name of the units are given below :

1. Button Unit
2. Memory Unit
3. Adder & Subtraction Unit
4. Multiplication Unit
5. Division Unit
6. Selection Unit
7. Display Unit

1. Button Unit :

In this unit , the button for decimal input are given . The button for different operations and the clear button for clearing all the memory unit used in the calculator . The circuit for each button is given below :



When we press the push button , the input will get 5V or we can say 1 , otherwise it will be grounded or 0 .

Components :

Push Button

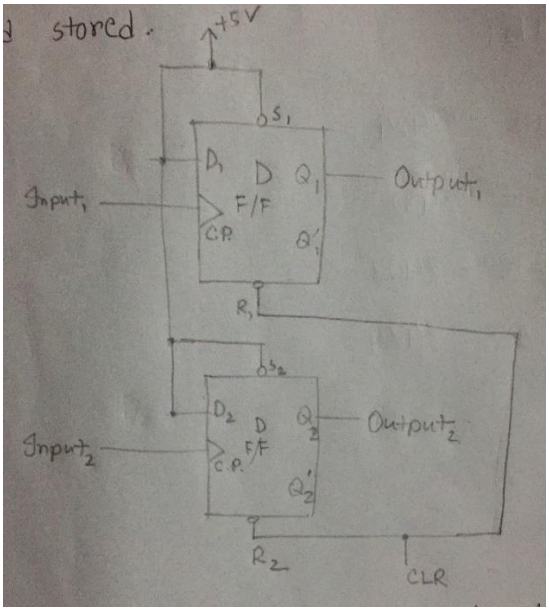
Resistor (1k ohm)

TBlock

Arduino

2. Memory Unit :

In this unit , the output from button section will come . They are converted to binary with logic gates . Then the binary bytes are stored in D flip-flop . This is done for the operations in the next units . The input of decimal is converted and stored .



We used clock-pulse as inputs . And we set D & S always high . We shorted all the R , so that we can clear all the memory input at a moment . The stored unit passes to Adder & Subtractor section , Multiplier and Divider units individually . The operations are done at the same time in other units .

Components :

NOT Gate (7404)

OR Gate (7432)

AND Gate (7408)

Flip-Flop (7474)

2 . Adder & Subtraction Unit :

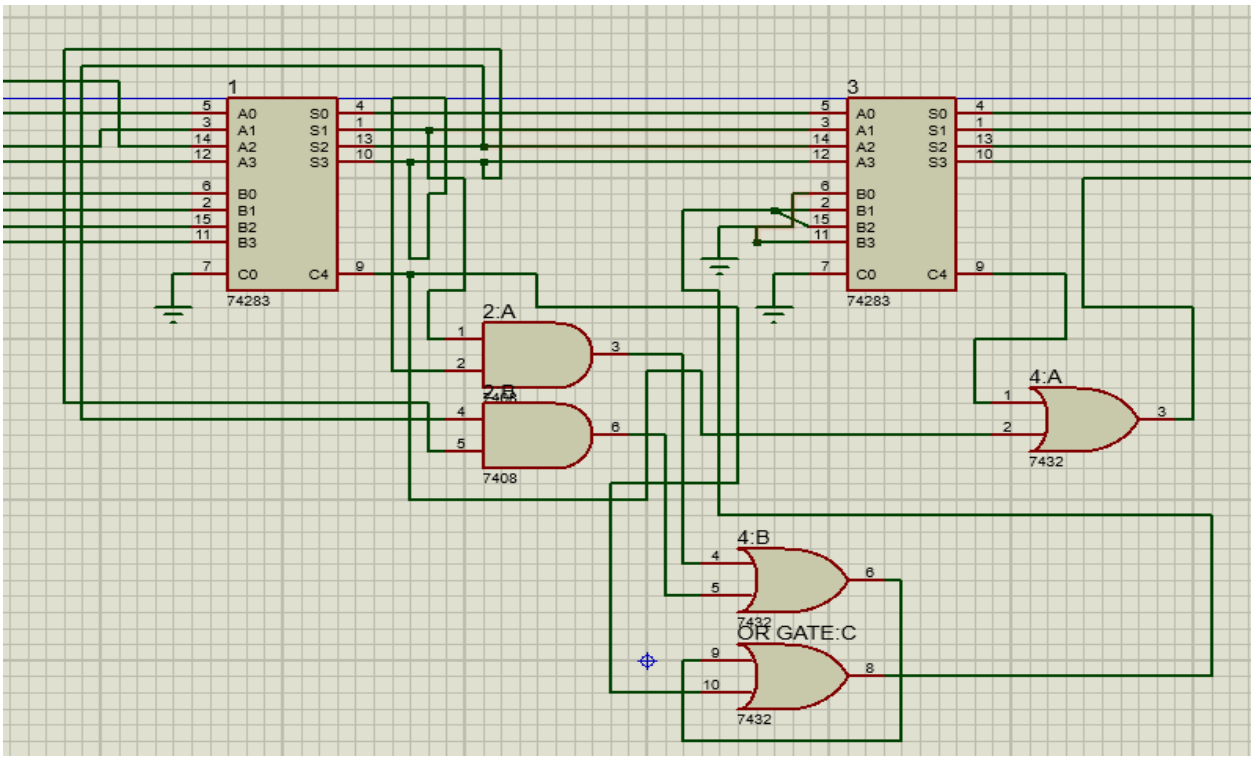
Adder:

In this unit A & B are adder with a 4-bit Full Adder IC(74LS283). As we are showing the output in decimal number so we need to convert the binary number into decimal or BCD output. So we need to check if the number is BCD or not. So we added a checker circuit here. Which number are binary and BCD and which are not are given below:

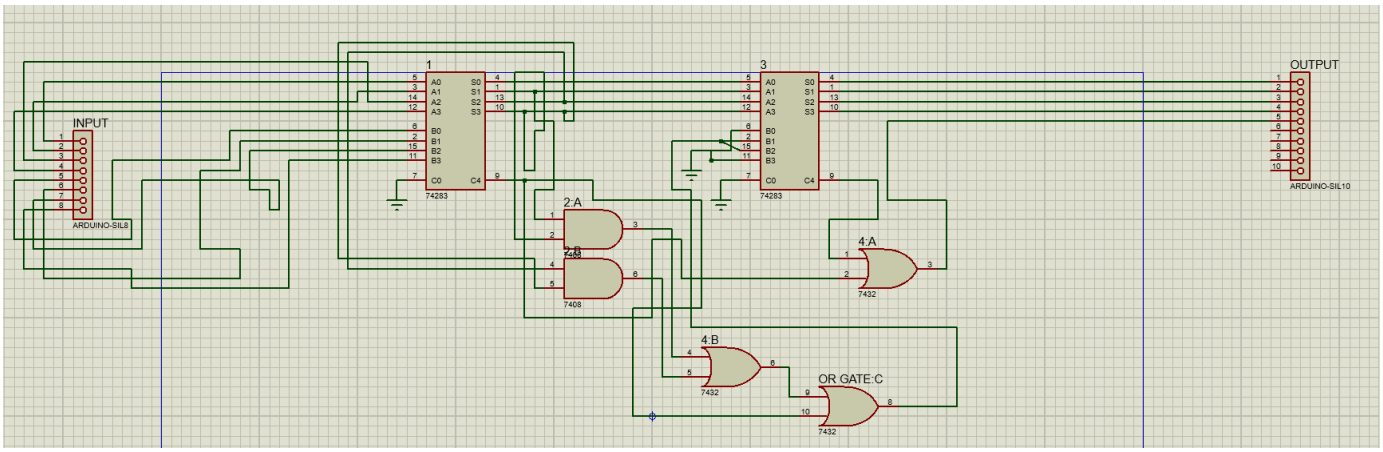
	C_{OUT}	S_3	S_2	S_1	S_0	C_{1OUT}	D_3	D_2	D_1	D_0
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	1
2	0	0	0	1	0	0	0	0	1	0
3	0	0	0	1	1	0	0	0	1	1
4	0	0	1	0	0	0	0	1	0	0
5	0	0	1	0	1	0	0	1	0	1
6	0	0	1	1	0	0	0	1	1	0
7	0	0	1	1	1	0	0	1	1	1
8	0	1	0	0	0	0	1	0	0	0
9	0	1	0	0	1	0	1	0	0	1
10	0	1	0	1	0	1	0	0	0	0
11	0	1	0	1	1	1	0	0	0	1
12	0	1	1	0	0	1	0	0	1	0
13	0	1	1	0	1	1	0	0	1	1
14	0	1	1	1	0	1	0	1	0	0
15	0	1	1	1	1	1	0	1	0	1
16	1	0	0	0	0	1	0	1	1	0
17	1	0	0	0	1	1	0	1	1	1
18	1	0	0	1	0	1	1	0	0	0
19	1	0	0	1	1	1	1	0	0	1

As the inputs cannot exceed 9, the highest output will be 19.

So we put the checker circuit as below to check the binary number if it is BCD or not. If it is not BCD then we will convert it into BCD by adding 6(0110) with it. So it will be converted into BCD

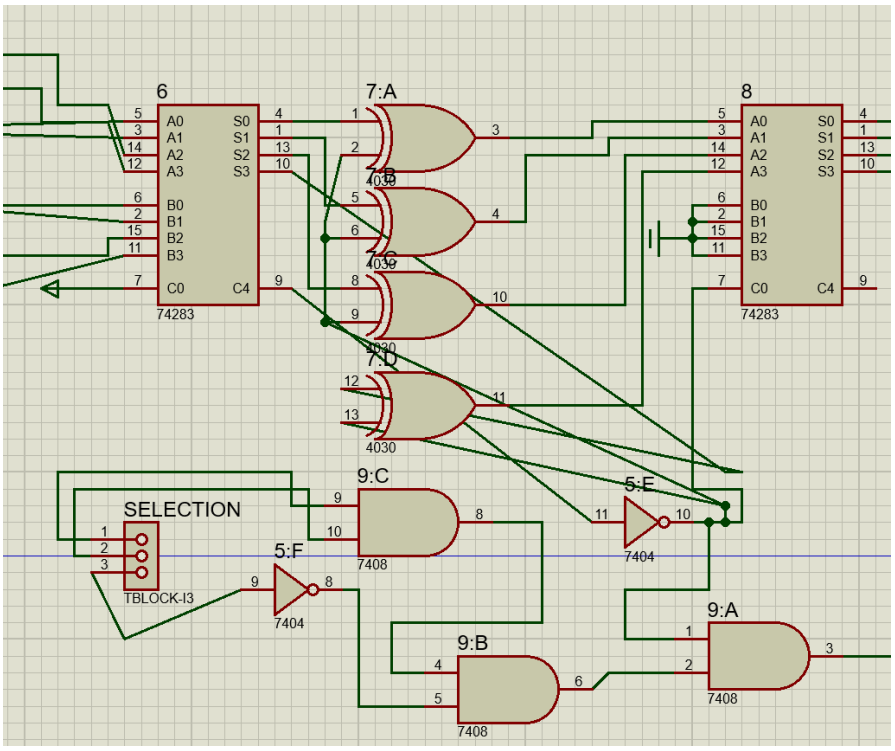


The full circuit is given below:



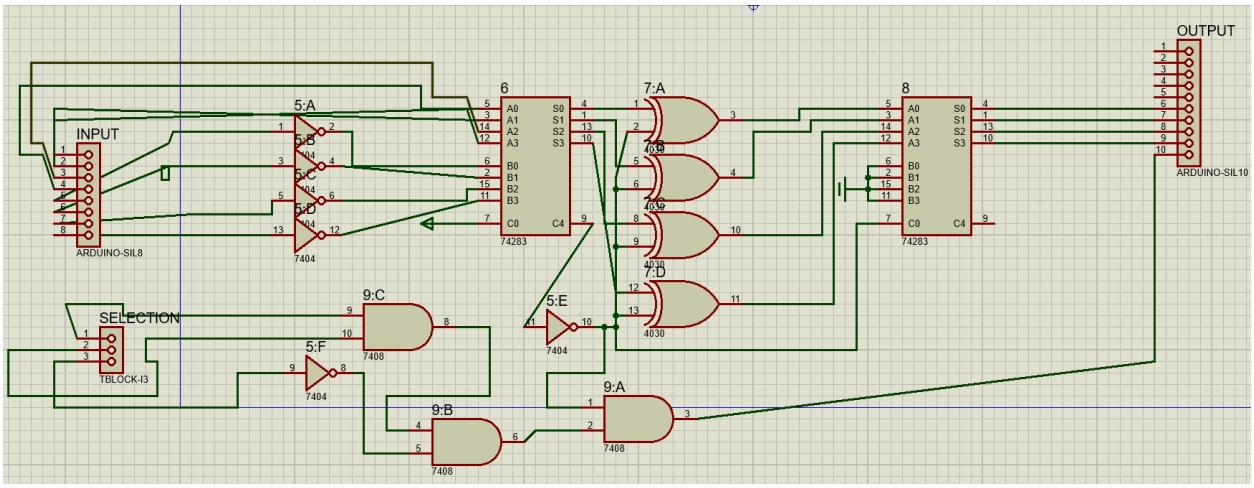
Subtraction :

Here we used 2's complement for subtraction. As the 2's complement inverts one number and adds 1, then added with the other number. If the Cout is 1 the answer is positive and if the Cout is 0 then the number is negative. We need to 2's complement is again and put a minus sign in front of that. So we made a circuit for that sign. When the selection bit will be 011 and the number is negative then we show minus sign for it. So for this the circuit we made is given below:



When the output of 9:A is high ‘-‘ will appear else 0.

The whole circuit for subtraction is given below:



Components :

Full Adder (74LS283)

NOT Gate (7404)

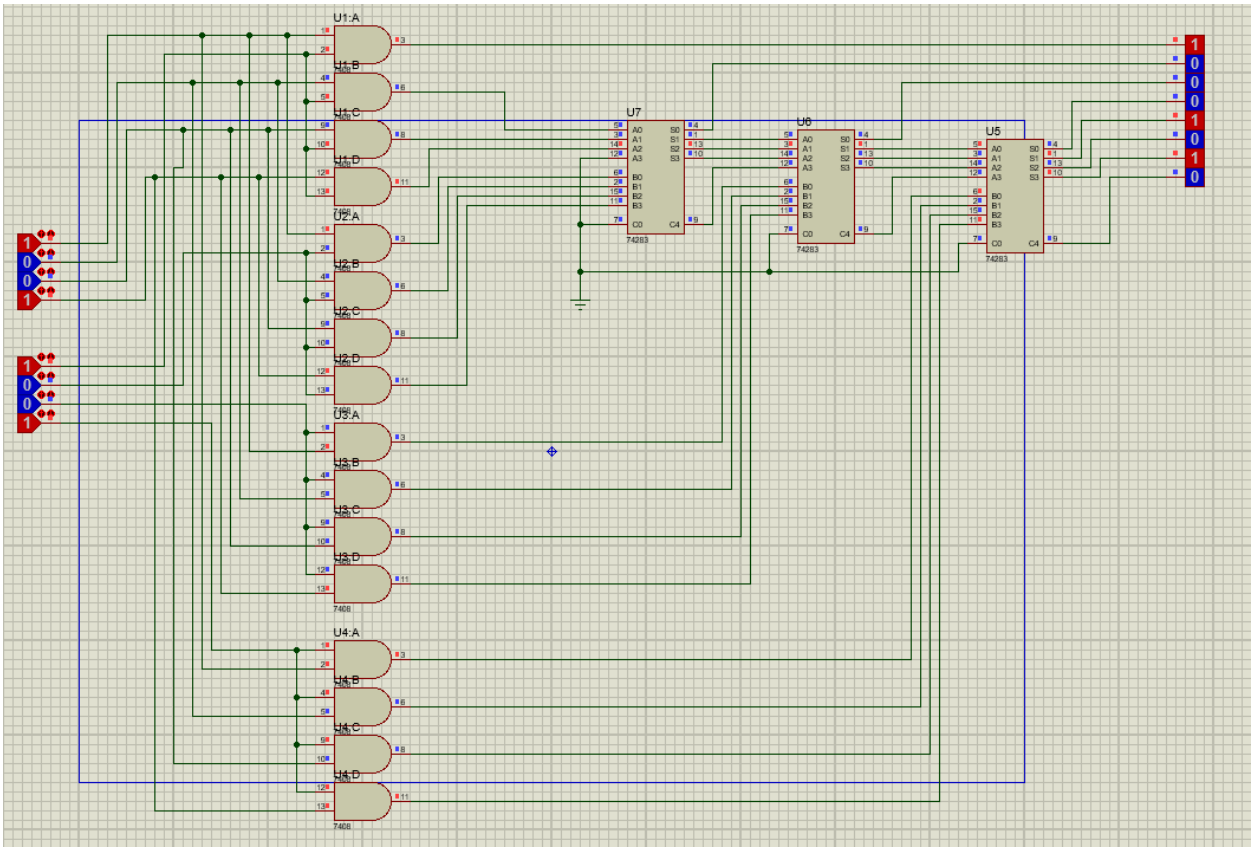
AND Gate (7408)

XOR Gate (4030)

4. Multiplication Unit:

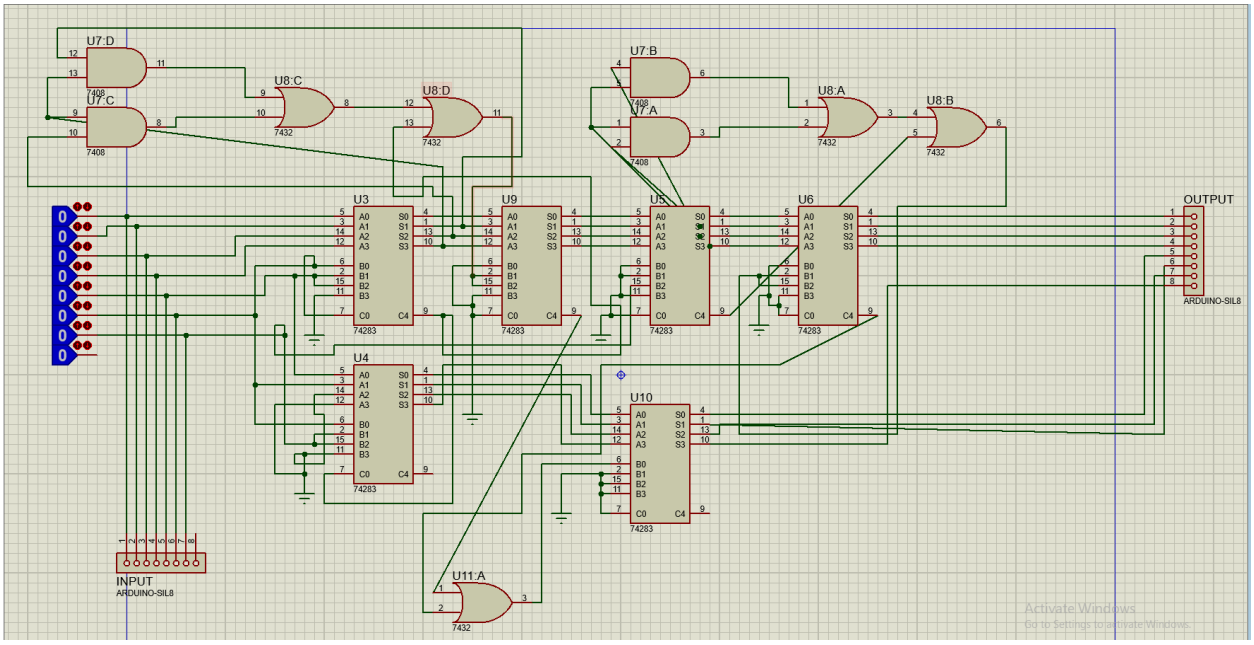
Binary Multiplier:

In this unit we just multiplied two binary number as we multiply two decimal number with each other. The output of the multiplier comes in binary. The circuit is given below:



Binary To BCD Converter:

The input of this segment is the output of the BCD multiplier. We built an 8 bit binary to 4 bit 4 bit BCD number. As we know in binary if there is 1 we add the value with the rest of the 1 to convert it into decimal number. As example if the number is 01010000 in binary the equal number in decimal will be 128*0+64*1+32*0+16*1+8*0+4*0+2*0+1*0=80. We applied this method in circuit. We added those numbers with the help of 4 bit binary adder(74LS283). After adding we checked if it is BCD or not. IF it is not BCD we converted it into BCD as we did in the Addition Section. The circuit for this is given below:



Components :

Full Adder (74LS283)

AND Gate (7408)

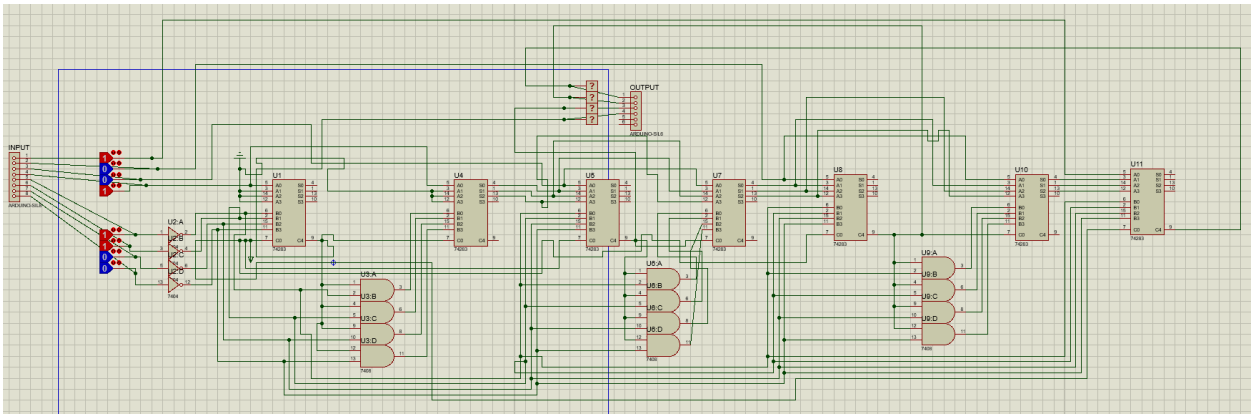
OR Gate (7432)

5. Divider :

The arithmetic operation of division was carried out using a process that involves subtraction and addition. In the first step, the denominator is subtracted from the MSB of the numerator. The MSB of this result is then complemented (1's complement), and forms the MSB of the result of the division. It also serves as a checkpoint to determine the next step. If the value of the complement is 0, then the next step involves addition, and subtraction if the complemented value is 1. In the second step, the second MSB of the numerator is taken, forming the LSB of the input to the next adder, with the three bits other than the MSB from the previous subtracted stage forming the other three digits. The value of the previous complement determines whether the denominator is added to, or subtracted from this value. The complement forms the required carry in for

this step. The MSB of the resulting operation is again complemented, and forms the second MSB of the division operation as well as the checkpoint for the next step. Thus, this procedure continues until the LSB of the numerator is reached. The division procedure is shown below with an example.

The circuit diagram is given below:



Components :

Full Adder (74LS283)

NOT Gate (7404)

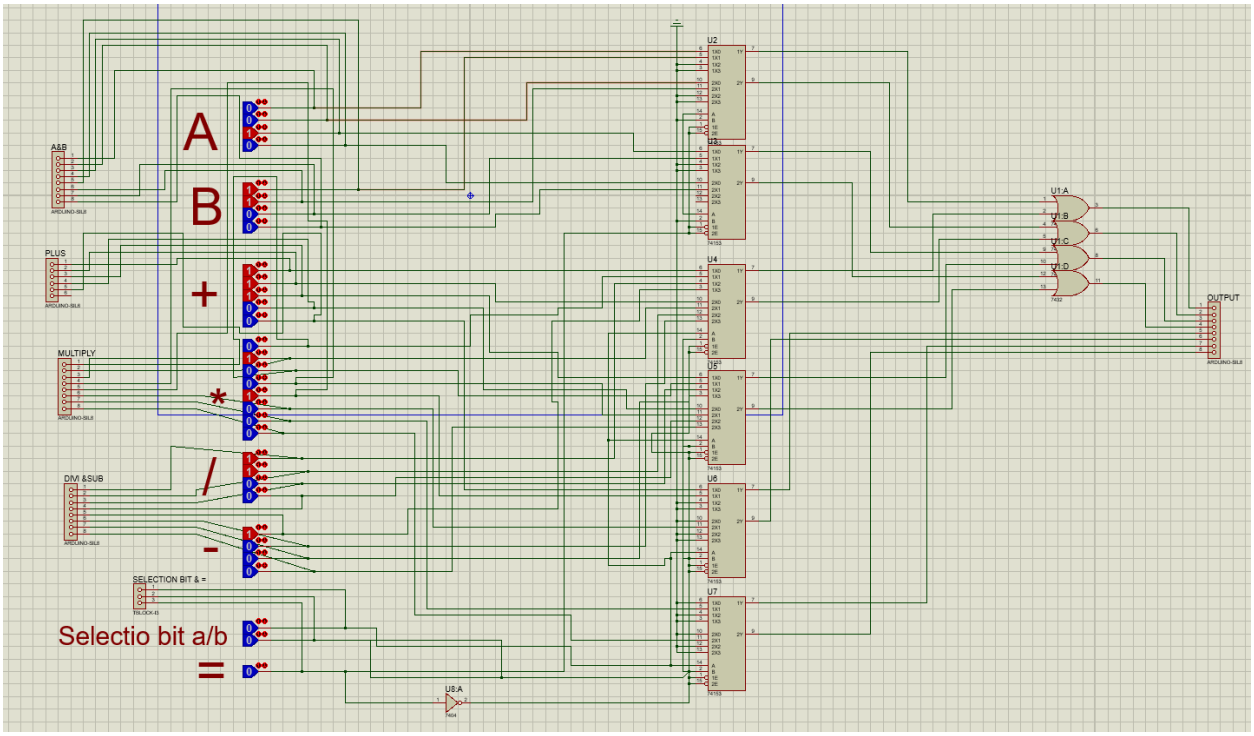
AND Gate (7408)

XOR Gate (4030)

6. Selection Unit:

Here we took all the outputs from Adder& Subtraction, Multiplier, Divider and also A&B. We used 4:1 mux (74LS153) for this. We used a mux for every bit. We used 4 set of mux for A&B and enabled is to '=' and the other 8 mux used for the operational answers where also enabled with it. When u '=' is 0 the mux for A&B are activated and when it is 1 the answers mux are activated.

The circuit for the Selection unit is given below:



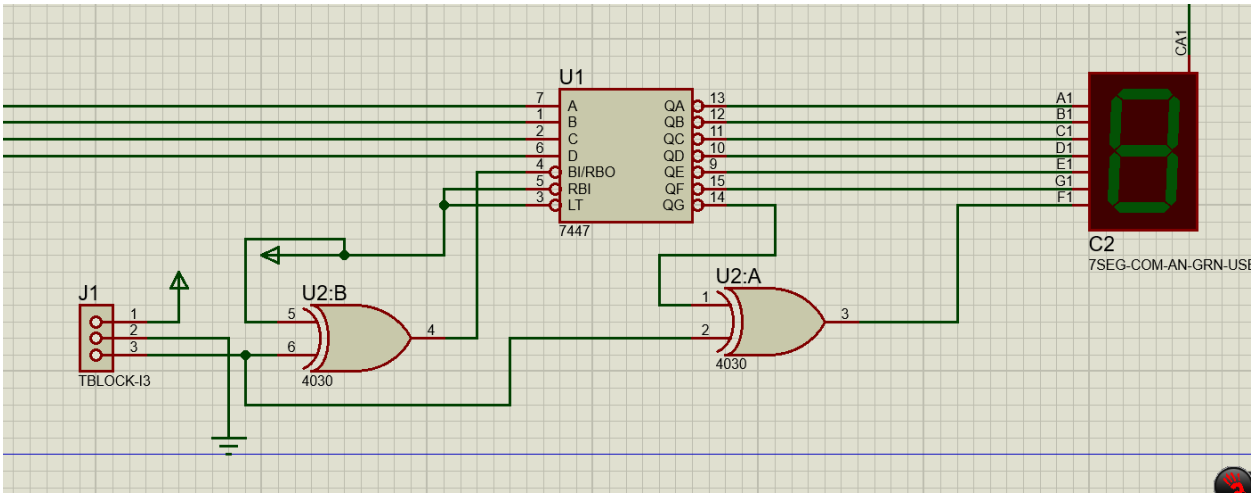
Components :

4:1 mux(74153)

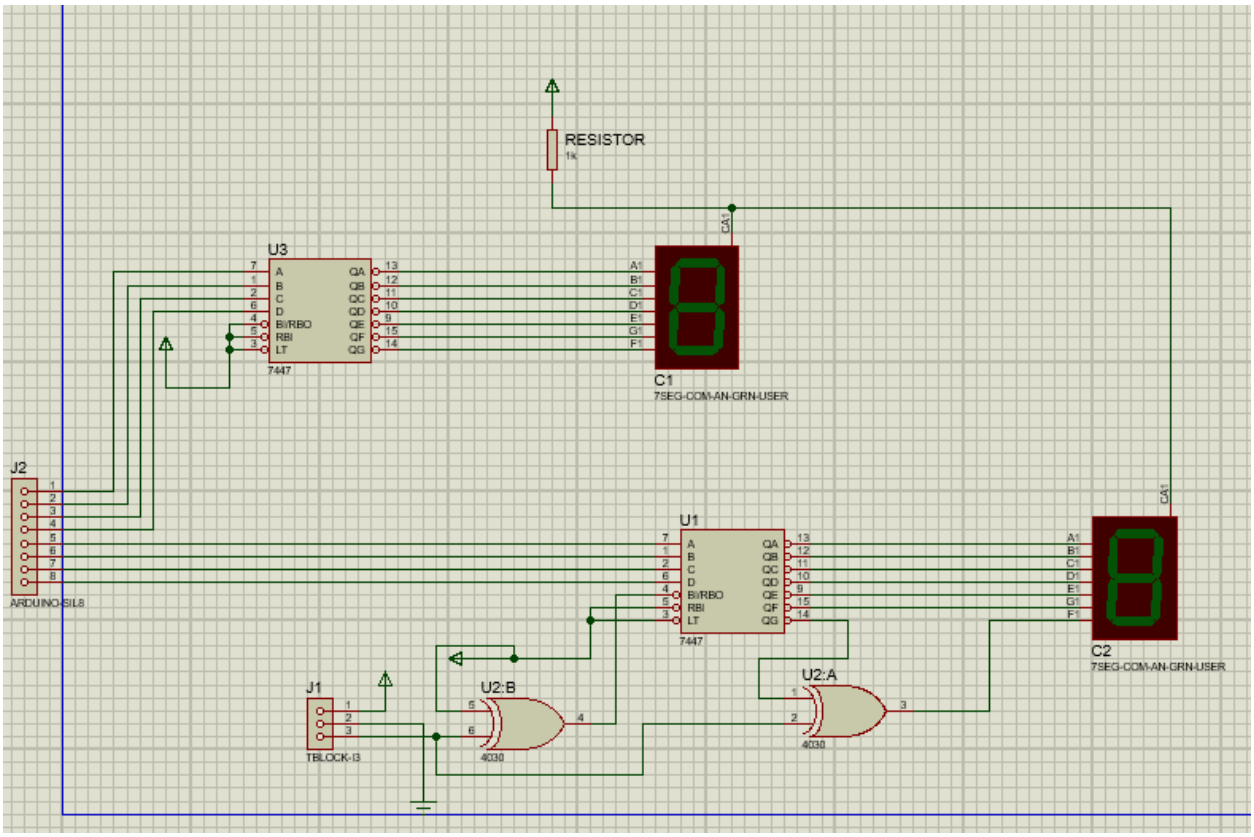
OR Gate(7432)

7.Display:

In the display we used a different kind of method to show both negative sign and the answer at the same time with the help of selection bit. We made a circuit for the negative value checking in the subtraction unit. If the value comes 1 then the display for tens will show minus sign. It will only happen if the selection bit is for minus operation and the value of A is greater than the value of B. This operation is done by giving XOR gates in PIN number 4 (BI/RBO) and in the output side in PIN number 14 .The circuit for this job is given below:



The other connections are as regular. The whole circuit for the Display unit is given below:



All the circuits for the calculator project,PCB design and hardware implementation are given afterwards.

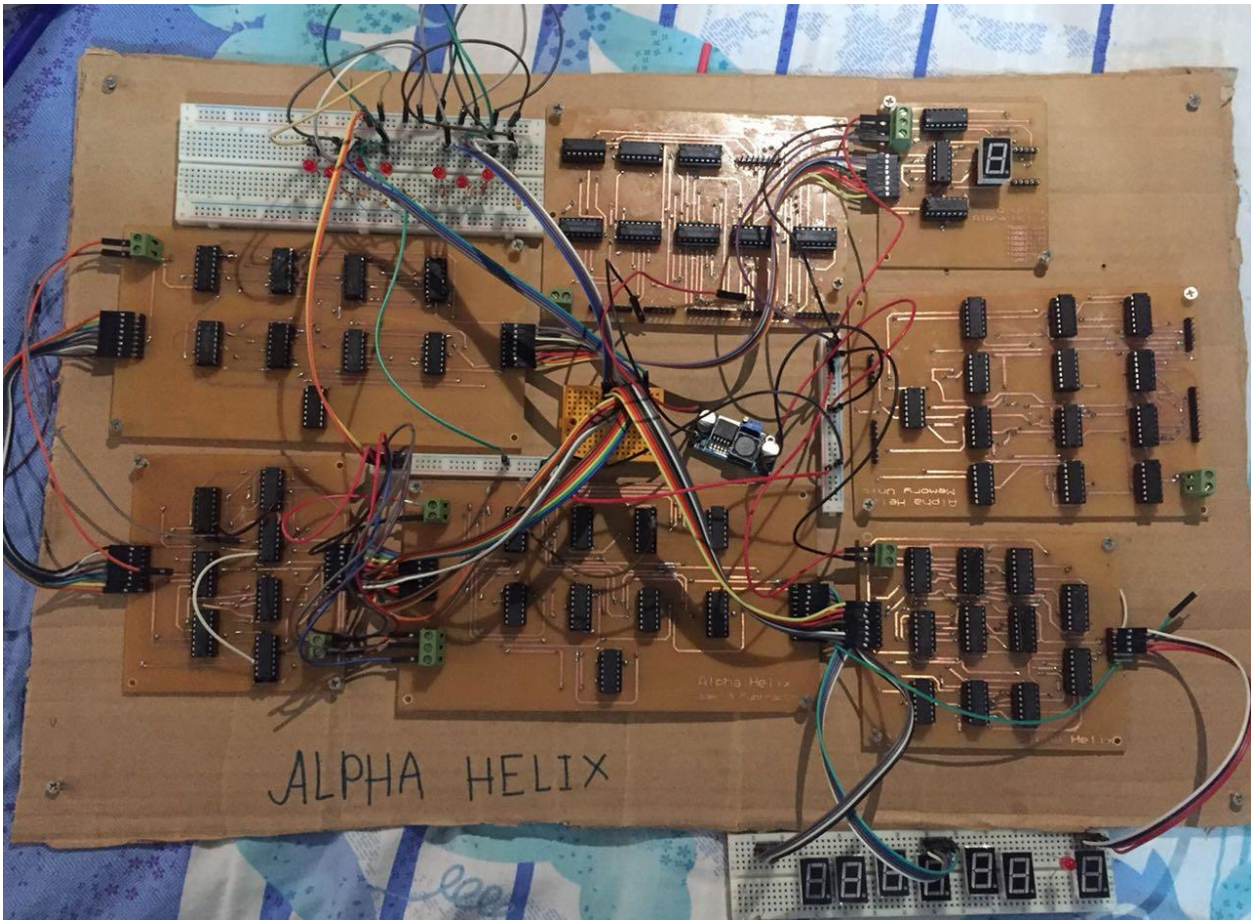


Figure: Overall Calculator

Problems Faced:

1) The first problem we faced in this project was making the PCB. We made the PCB where some IC PIN connection was in top copper. So we need to design and print the PCB again.

2) One we ordered a PCB board and when we got that from the courier the PCB was broken. So we had to print that again.
3) We saw a wrong video on display making. The person guiding the video made a wrong design. We followed that whit out checking. So when we printed that and started to debug we found that the design was fault.
4) In designing the divider. While simulating everything was good. But somehow some connections was deleted. We found out that while debugging. The simulation worked perfectly. So we did not checked that. We solved that by connecting some extra wires in the IC.
5) In selection unit one of our IC was accidentally in DIL 16 instead of DIL 14. Which made a huge impact in our PCB.
6) Out multimeter did not worked on the last day of this project. So our debugging was really very hard.
7) The time was short. We made PCB for Memory unit and selection unit but as could not debug it so I we didn’t add those circuits.

Cost:

- Components:3800/-

- PCB:

    - Adder & Subtraction:
        - First attempt:420/-
        - Second attempt:150/-(Got broken so he took less money.).
        - Third attempt:390/-
    - Multiplier:
        - Binary multiplier:340/-
        - Binary to BCD converter:400/-
    - Divider : 380/-
    - Memory unit : 300/-

    Total Cost : 6520 /-