Logic Circuits and Digital Design

Project #2

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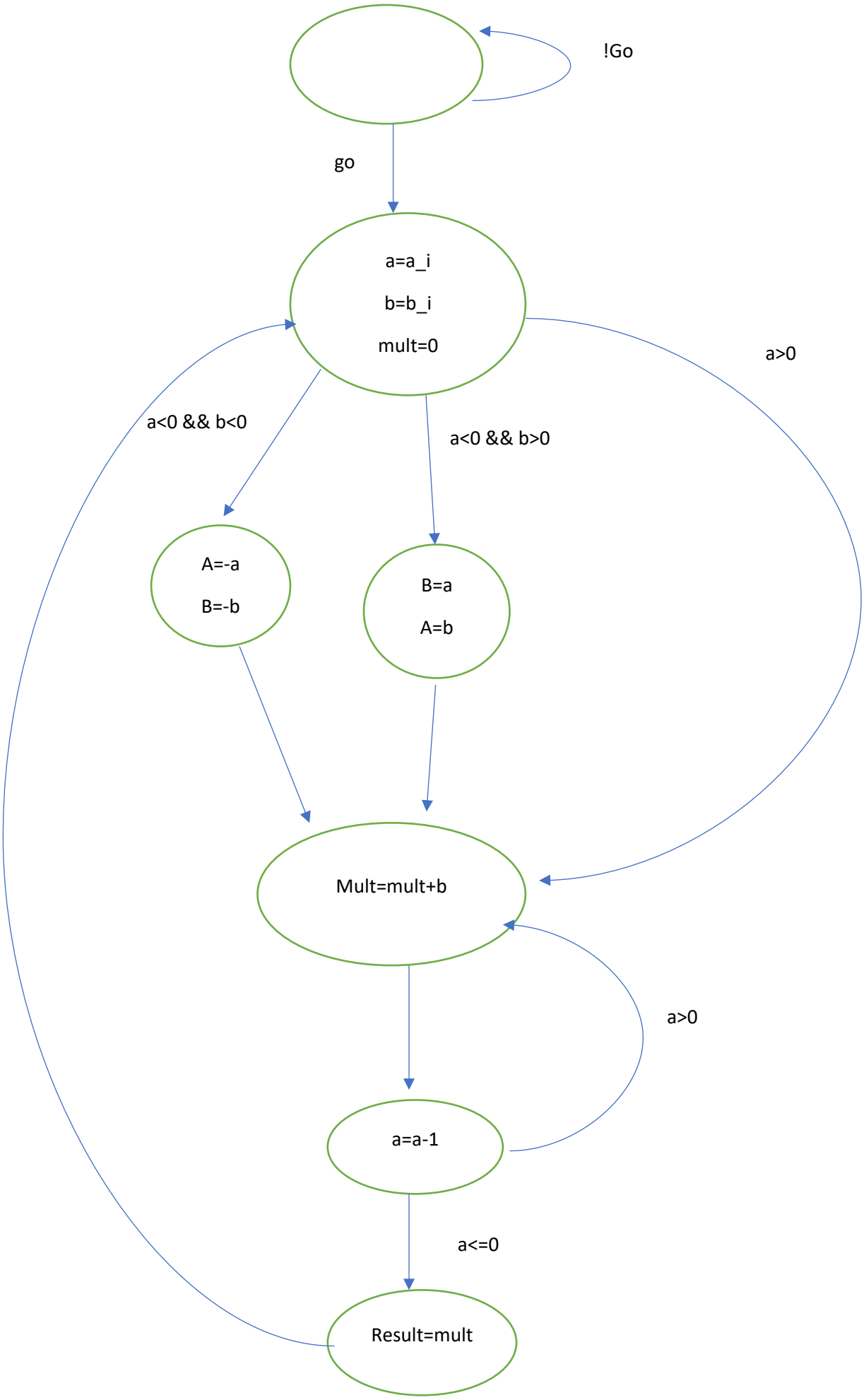
C code of multiplication that I implement:

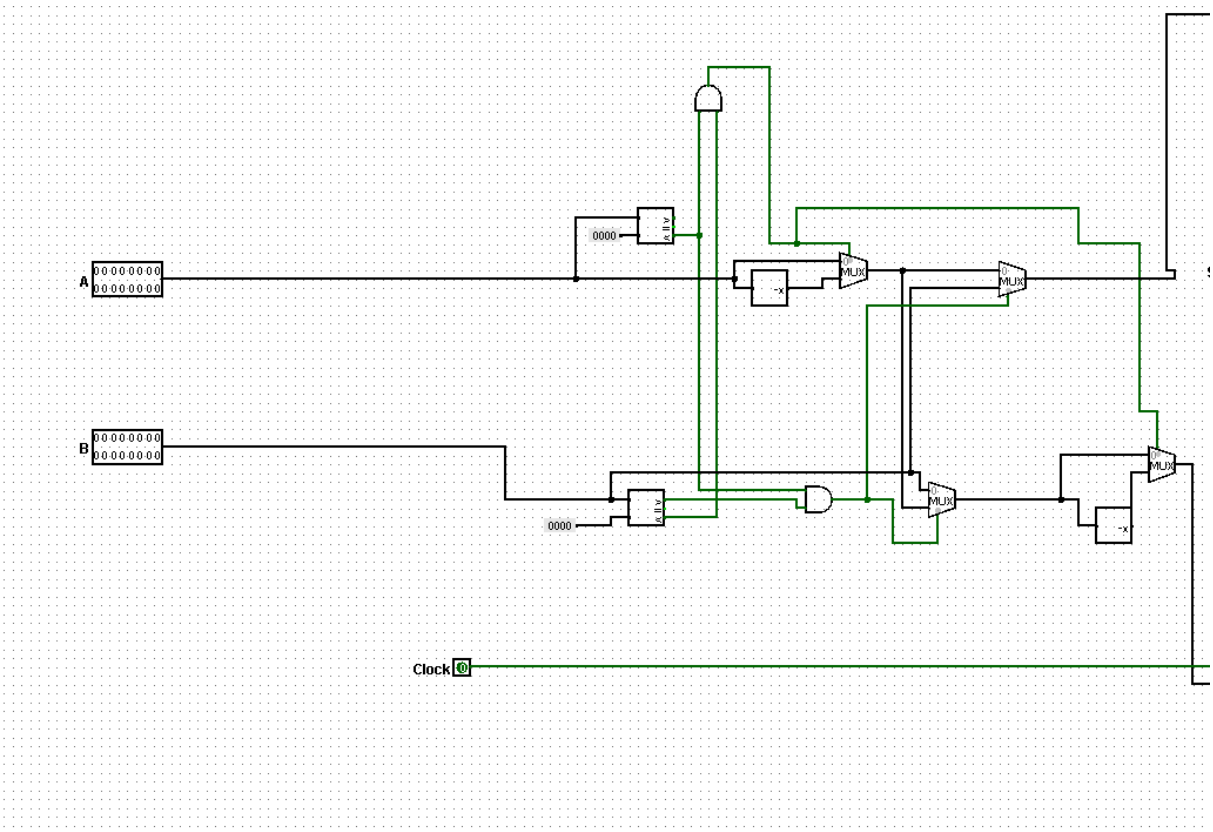
```
If(a<0 && b<0){
        a=-a;
        b=-b;
}
If(a<0 && b>0){
        temp=a;
        a=b;
        b=temp;
}
mult=0;
While(a>0){
        mult=mult+b;
        a=a-1;
}
```

Finite State Machine

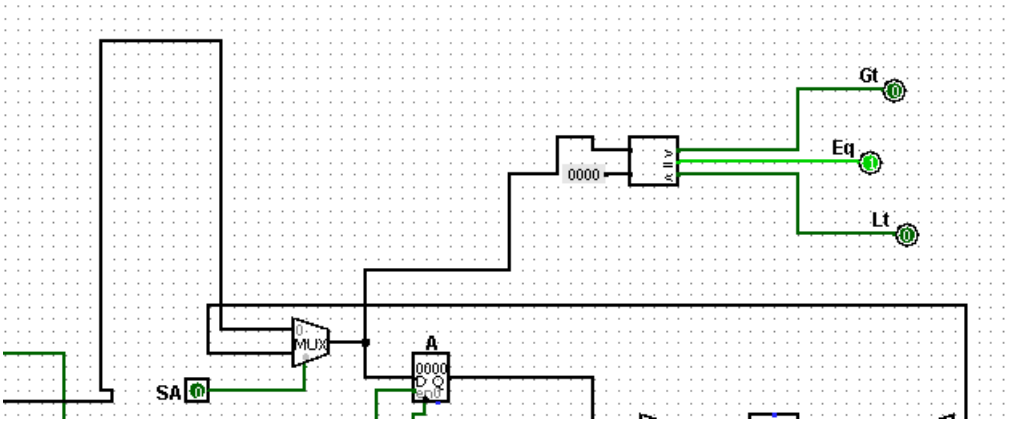

!Go
go
a=a_i
b=b_i
mult=0
a>0
a<0 && b<0
a<0 && b>0
A=-a
B=-b
B=a
A=b
Mult=mult+b
a>0
a=a-1
a<=0
Result=mult

Datapath Organization

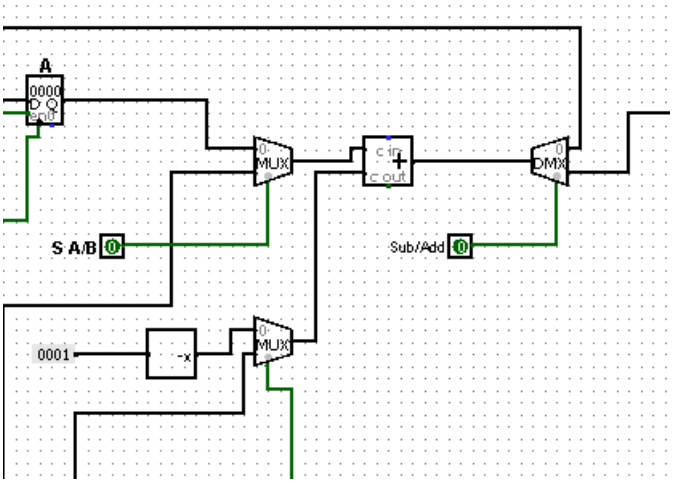
When I make the datapath , Firstly I thought that I should make converter that if two number both are negative then make them to posistive and If a is negative and b is positive then swap elements each other. So In my datapath I did this part firstly.I use 16 bit registers in input and output. Alp Arslan Teacher said that you can ignore results that pass 16 bit numbers.So I design this circuit for 16 bit results.



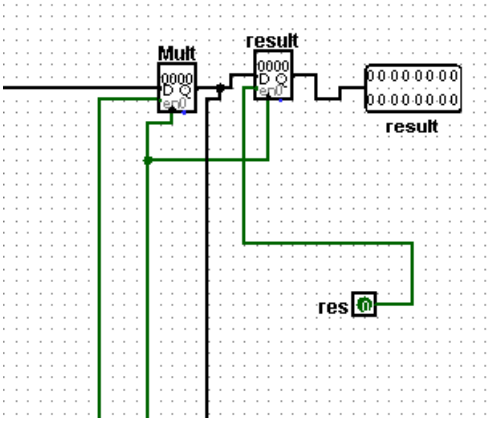
This part is converting negative to positive or swapping elements if It is necessary. Then I use multiplexers to choose numbers that I want.After that I did something that checks the number is equal to 0 or not with comparator.



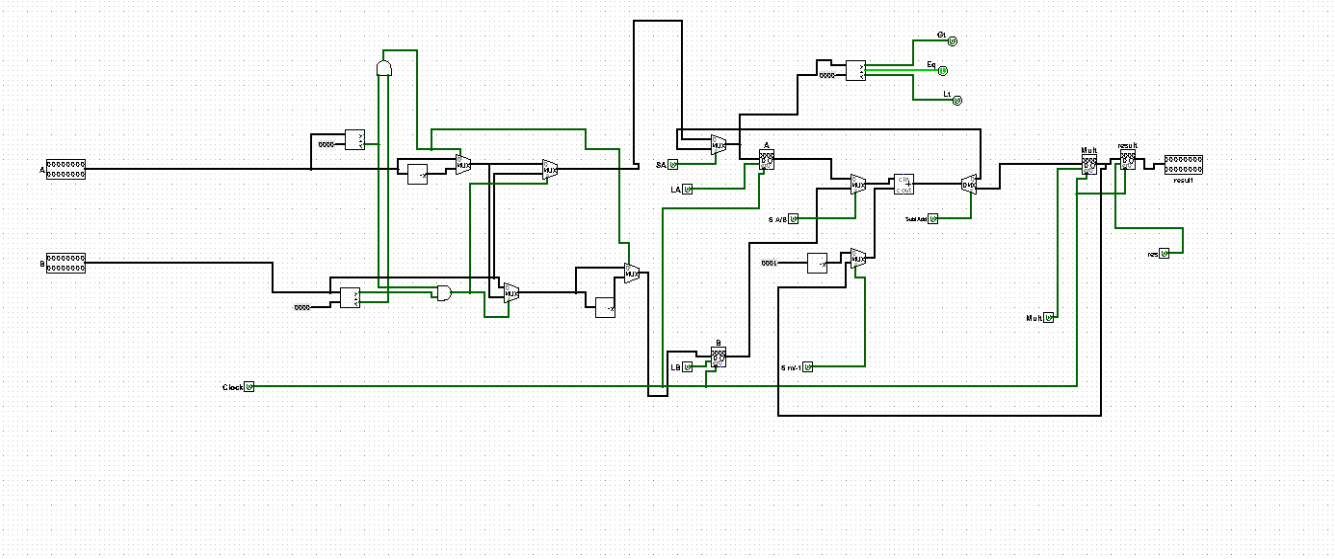
After that , I needed to do subtraction by using adder.So I add -1 to a to do subtraction and I had to do it by using only one adder becouse of Project rule.So I use multiplexer here to choose -1 or mult and a or b .



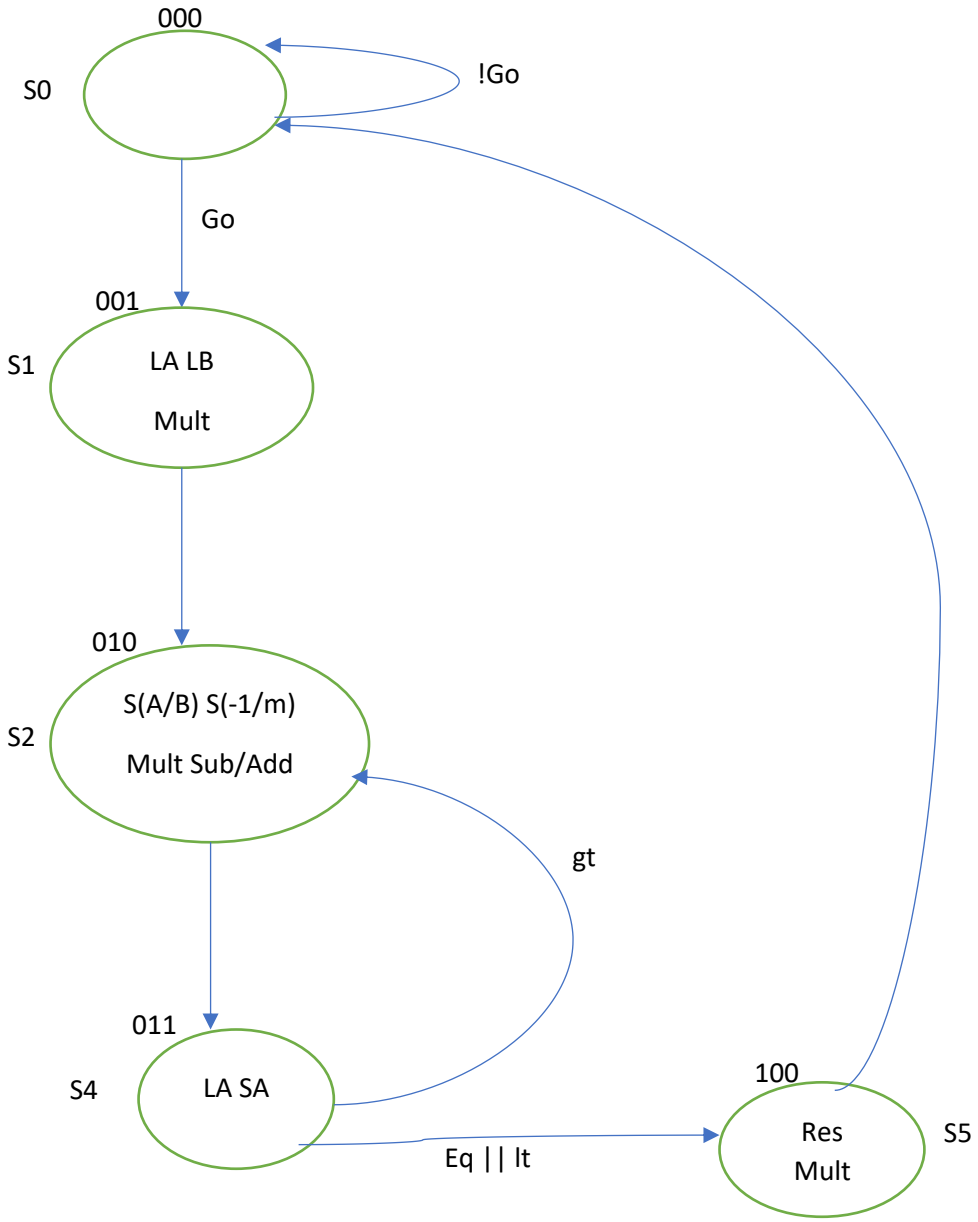
Then I use demultiplexer to choose addition or subtraction.Then I put a register to keep mult and result.



Datapath



New Finite State Machine after datapath



State Table

PS P2 P1 P0	Inputs Lt gt eq go	NS N2 N1 N0
0 0 0	- - - 0	0 0 0
0 0 0	- - - 1	0 0 1
0 0 1	- - - -	0 1 0
0 1 0	- - - -	0 1 1
0 1 1	0 1 0 -	0 1 0
0 1 1	1 0 0 -	1 0 0
0 1 1	0 0 1 -	1 0 0
1 0 0	- - - -	0 0 0

N2 = P2’P1’P0 Lt + P2’P1P0eq

N1 = P2’P1’P0 + P2’P1P0’ + P2’P1P0gt

N0 = P2’P1’P0’go + P2’P1P0’

When I simplify these equations

N2 = P2’P1P0(Lt+eq)

N1 = P2’(P1’P0+P1P0’) + P2’P1P0gt

N1 = P2’(P1 XOR P0)+P2’P1P0gt

N0 = P2’P0’(P1’go+P1)

State	P2	P1	P0		LA	LB	Mult	S(A/B)	S(-1/M)	Sub/add	SA	Res
S0	0	0	0		0	0	0	0	0	0	0	0
S1	0	0	1		1	1	1	0	0	0	0	0
S2	0	1	0		0	0	1	1	1	1	0	0
S3	0	1	1		1	0	0	0	0	0	1	0
S4	1	0	0		0	0	1	0	0	0	0	1

LA=S1+S3

LB=S1

Mult=S1+S2+S4

S(A/B)=S2

S(-1/M)=S2

Sub/add=S2

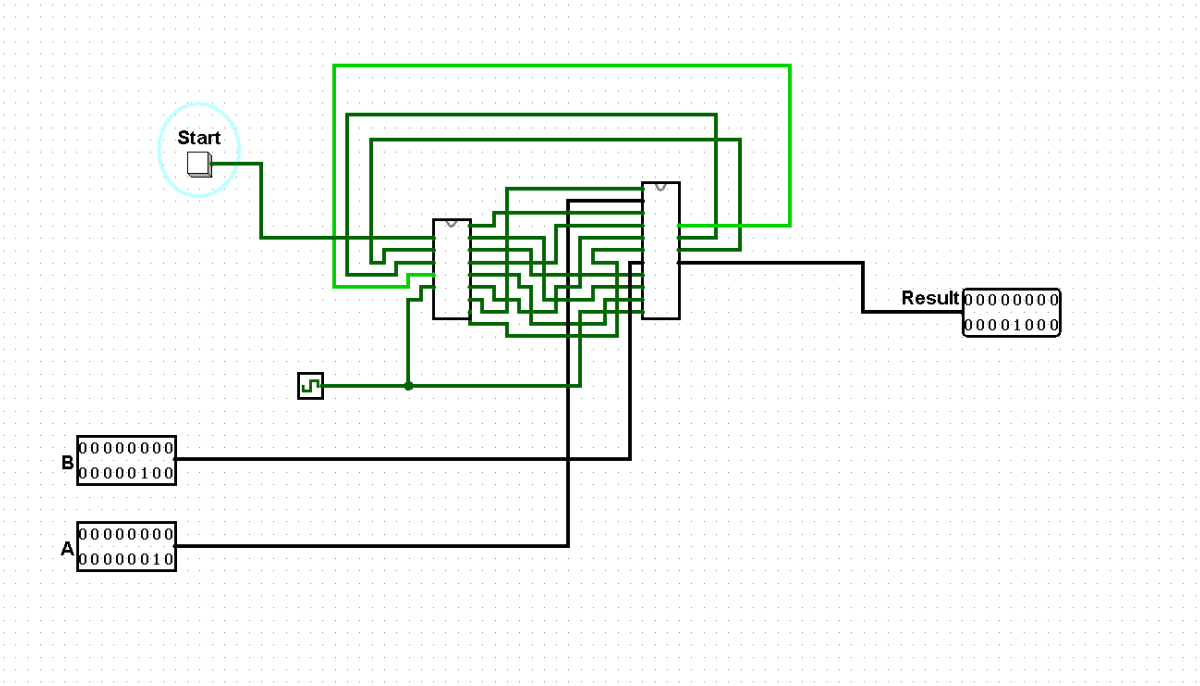
SA=S3

Res=S4

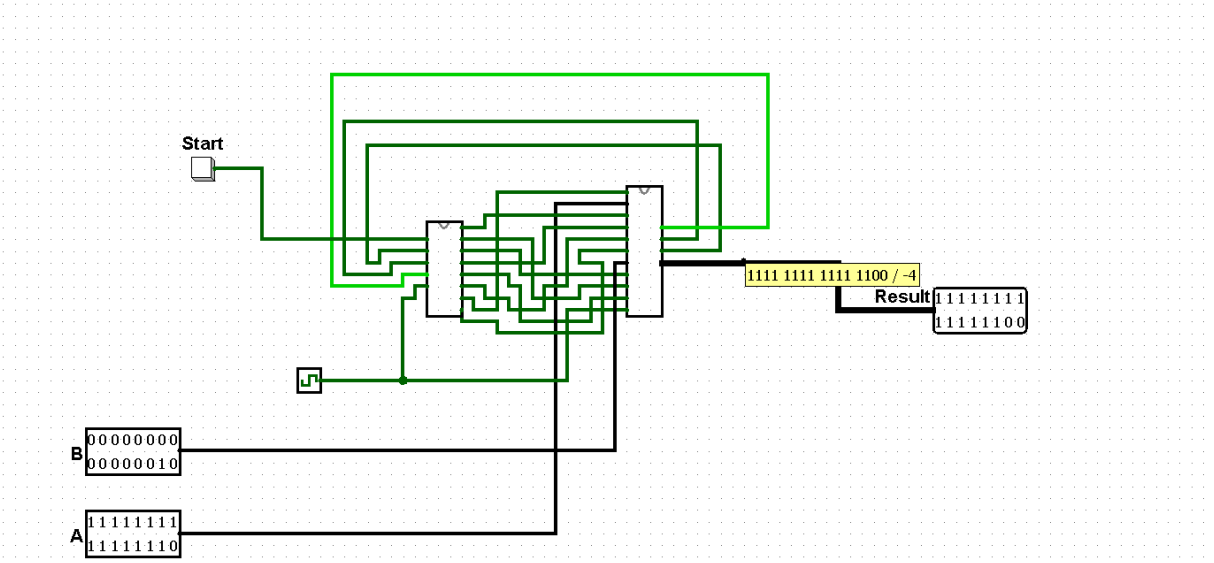
Then I designed Control unit in logisim and made the connection between control unit and datapath.

Results=

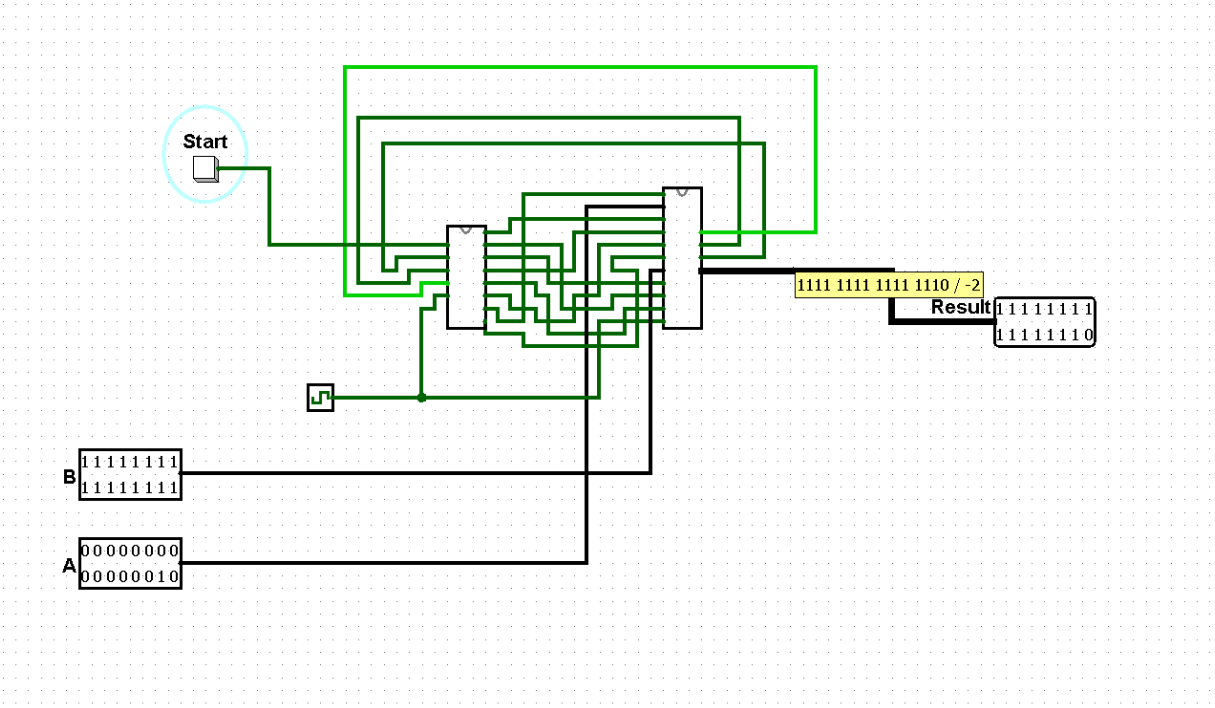
When a and b positive numbers for example b=4(0100) and a=2 (010) then result is 8(1000)



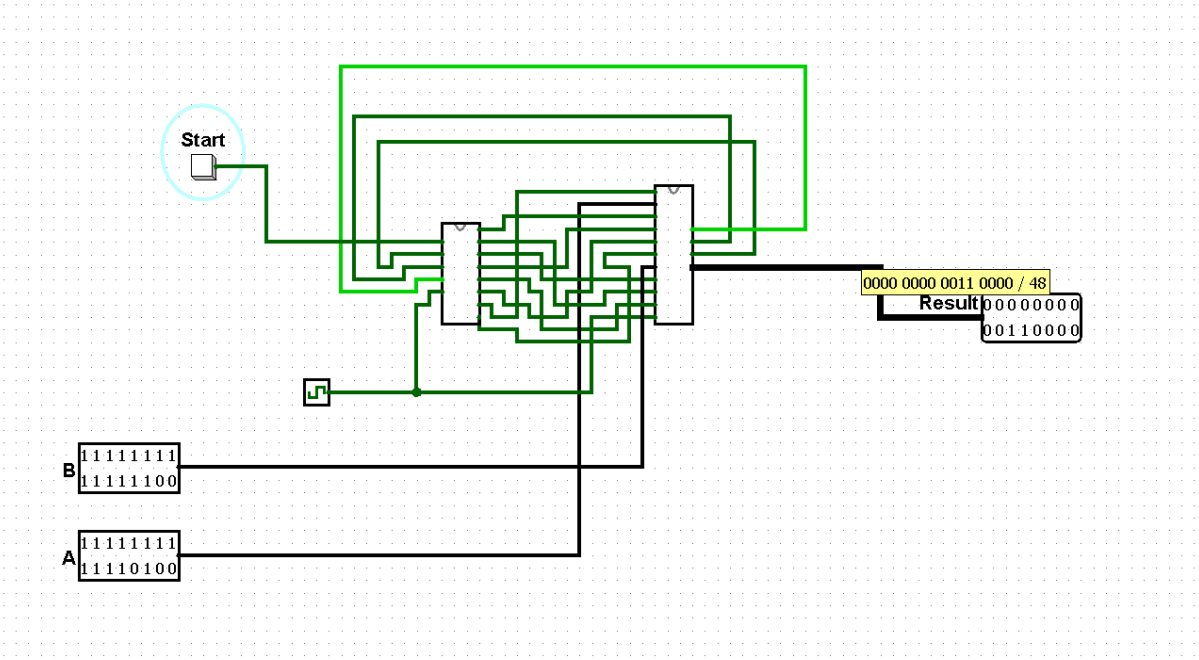
When a is negative and b is positive ,b=2 and a=-2 then result is - -4



When a is positive and b is negative b=-1 and a=2 then result is -2



When a and b are both negative , b= -4 and a = -12 then result is 48



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