

# Lab 6 Finite State Machine.

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Part 1:

1. The Reset is an asynchronous reset.

The Reset is active high.

The Reset should be set to 0 when we are trying to simulate.

	$F[2:0]$	w	$F[2:0]$	z
A	000	0	A 0 0 0	0
A	000	1	B 0 0 1	0
B	001	0	A 0 0 0	0
B	001	1	C 0 1 0	0
C	010	0	E 1 0 0	0
C	010	1	D 0 1 1	0
D	011	0	E 1 0 0	0
D	011	1	F 1 0 1	0
E	100	0	A 0 0 0	0
E	100	1	G 1 1 0	0
F	101	0	E 1 0 0	1
F	101	1	F 1 0 1	1
G	110	0	A 0 0 0	1
G	110	1	C 0 1 0	1

K-Maps for  $F(t \geq 0)$ .

(1) K-Map for  $F_2$

		$\bar{F}_0 \cdot \bar{W}$	$\bar{F}_0 \cdot W$	$F_0 \cdot \bar{W}$	$F_0 \cdot W$
		0 0	0 1	1 1	1 0
		$\bar{F}_2 \cdot \bar{F}_1$	$F_2 \cdot F_1$	$\bar{F}_2 \cdot F_1$	$F_2 \cdot \bar{F}_1$
0 0	$\bar{F}_2 \cdot \bar{F}_1$	0	0	0	0
0 1	$\bar{F}_2 \cdot F_1$	1	0	1	1
1 1	$F_2 \cdot F_1$	0	0	X	X
1 0	$F_2 \cdot \bar{F}_1$	0	1	1	1

Equation:  $F_2 = F_2 F_0 + F_1 F_0 + \bar{F}_2 F_1 \bar{W} + F_2 \bar{F}_1 W$

(2) K-map for  $F_1$

		$\bar{F}_0 \cdot \bar{W}$	$\bar{F}_0 \cdot W$	$F_0 \cdot \bar{W}$	$F_0 \cdot W$
		0 0	0 1	1 1	1 0
		$\bar{F}_2 \cdot \bar{F}_1$	$F_2 \cdot F_1$	$\bar{F}_2 \cdot F_1$	$F_2 \cdot \bar{F}_1$
0 0	$\bar{F}_2 \cdot \bar{F}_1$	0	0	1	0
0 1	$\bar{F}_2 \cdot F_1$	0	1	0	0
1 1	$F_2 \cdot F_1$	0	1	X	X
1 0	$F_2 \cdot \bar{F}_1$	0	1	0	0

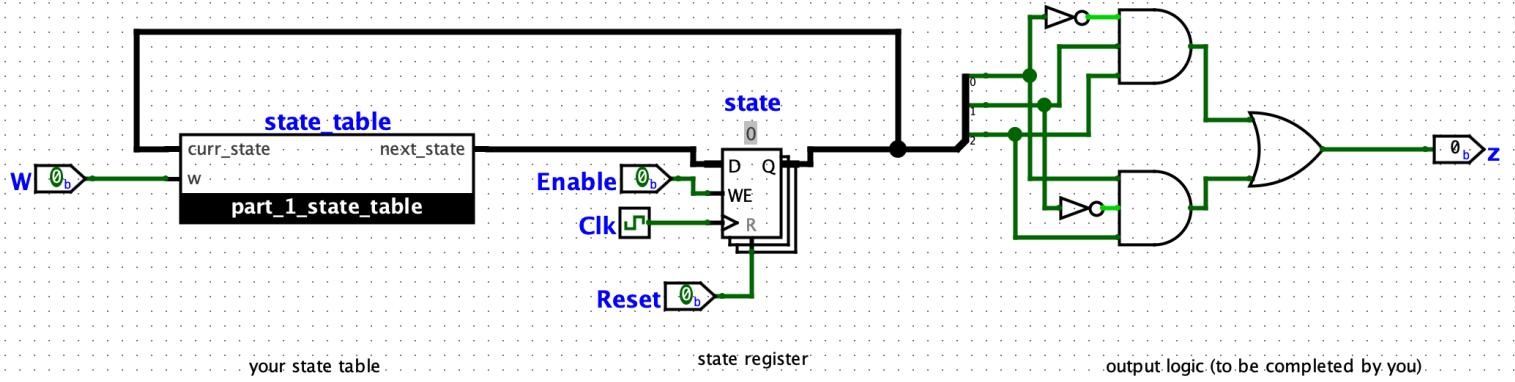
Equation:  $F_1 = F_1 \bar{F}_0 W + F_2 \bar{F}_0 W + \bar{F}_2 \bar{F}_1 F_0 W$

(3) K-map for  $F_0$

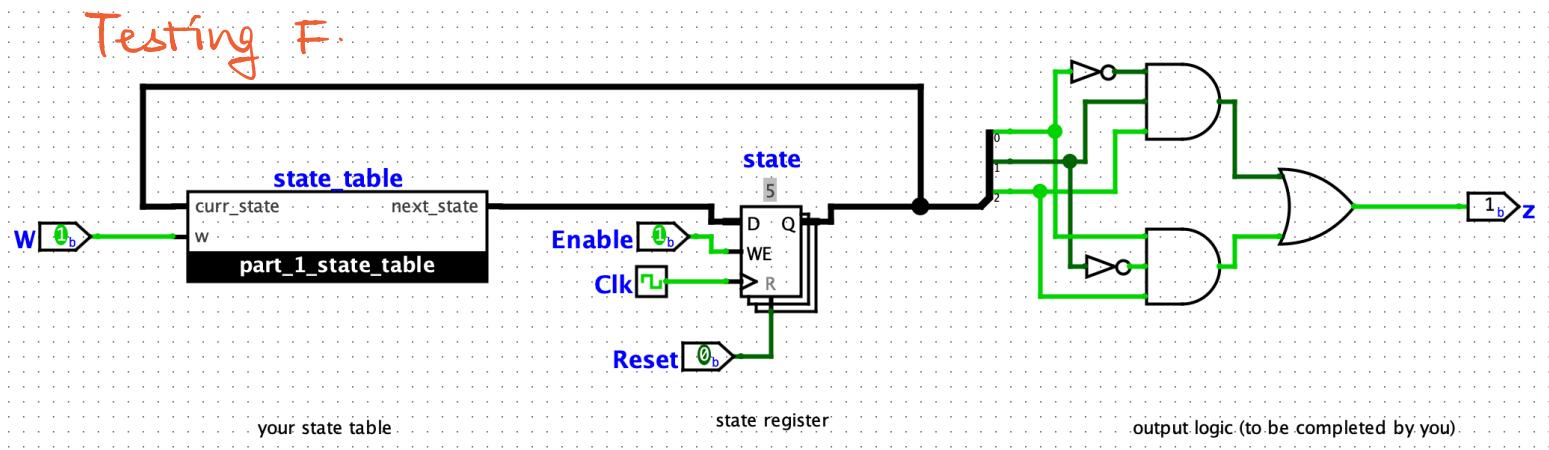
		$\bar{F}_0 \cdot \bar{W}$	$\bar{F}_0 \cdot W$	$F_0 \cdot \bar{W}$	$F_0 \cdot W$
		0 0	0 1	1 1	1 0
		$\bar{F}_2 \cdot \bar{F}_1$	$F_2 \cdot F_1$	$\bar{F}_2 \cdot F_1$	$F_2 \cdot \bar{F}_1$
0 0	$\bar{F}_2 \cdot \bar{F}_1$	0	1	0	0
0 1	$\bar{F}_2 \cdot F_1$	0	1	1	0
1 1	$F_2 \cdot F_1$	0	0	X	X
1 0	$F_2 \cdot \bar{F}_1$	0	0	1	0

Equation:  $F_0 = \bar{F}_2 \bar{F}_0 W + \bar{F}_2 F_1 W + F_2 F_0 W$

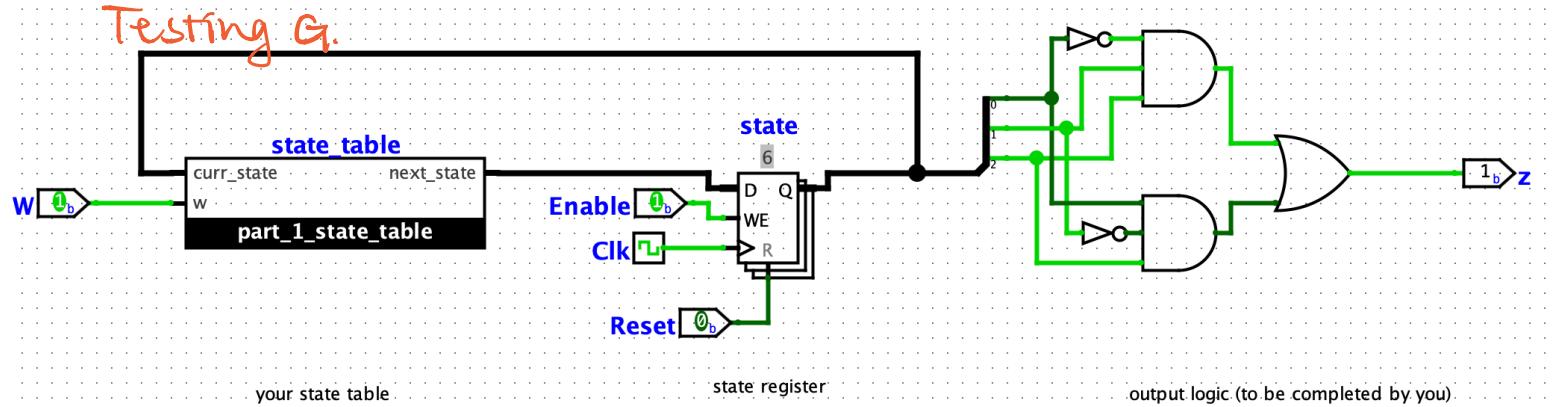
4.



5.

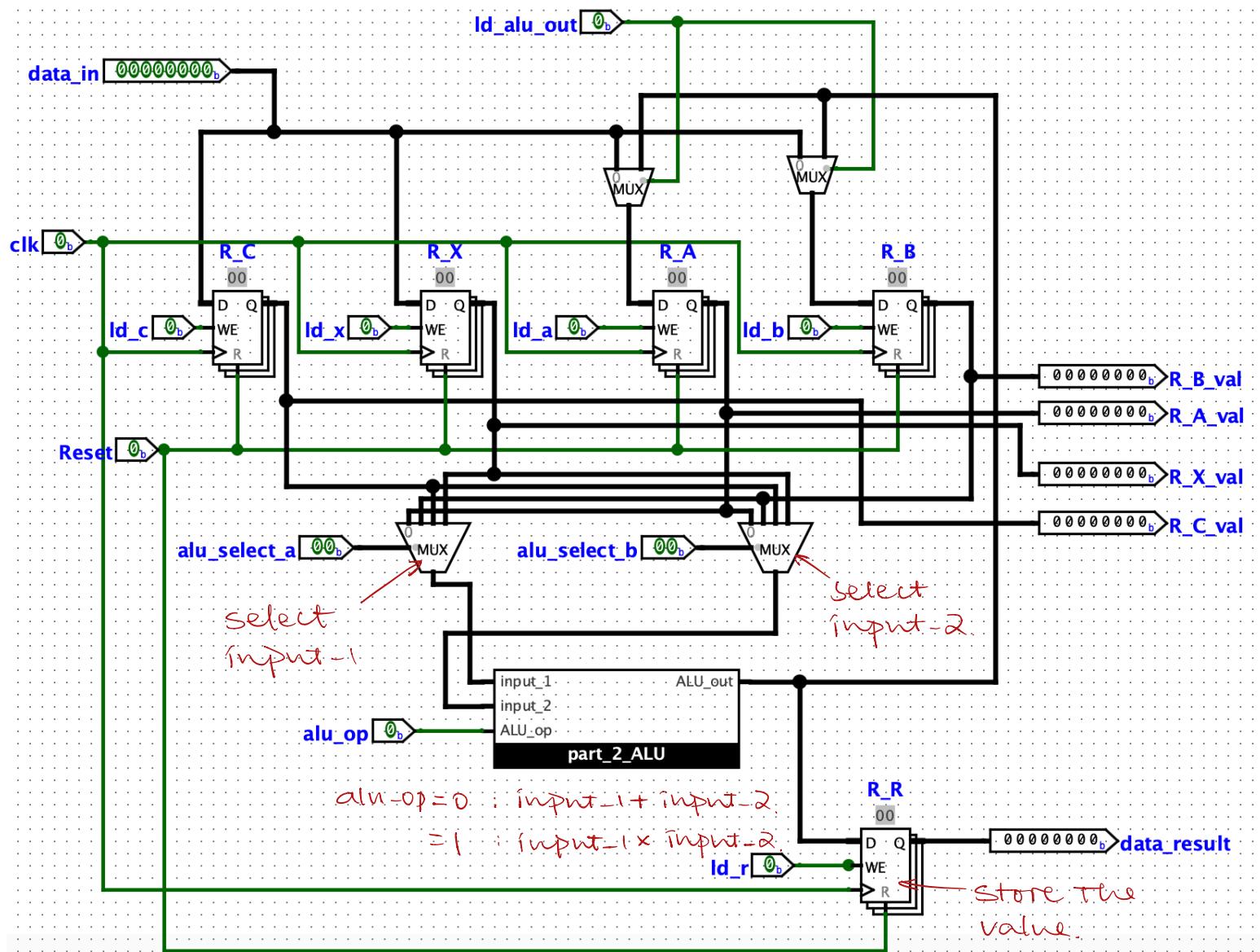


Testing G.



## Part 2.

1.



2. Create a state table for  $Cx^2 + Bx + A$ .

$F[3:0]$

State

$F[3:0]$

next\_state. signal-high.

A

0000

0001

ld-a.

B

0001

0011

ld-b

C

0011

0100

ld-c.

X

0100

0101

ld-x.

Bx

0101

0110

alu-op, alu-select-a=01

alu-select-b=11, ld\_alu\_out.

ld-b.

Bx+A

0110

1000

alu-select-a=00,

alu-select-b=01, ld\_alu\_out

ld-b.

x<sup>2</sup>

1000

1001

alu-op, alu-select-a=11,

alu-select-b=11, ld\_alu\_out

ld-a.

Cx<sup>2</sup>

1001

1010

alu-op, alu-select-a=10,

alu-select-b=00, ld\_alu\_out

ld-a.

Cx<sup>2</sup>+bx+A

1010

0000

alu-select-a=00,

alu-select-b=01, ld-r.

K-map for  $F_3$ :

	$\begin{smallmatrix} 0 & 0 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 & 1 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 1 \\ F_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 0 \\ F_1 & \bar{F}_0 \end{smallmatrix}$
00 $\bar{F}_3 \bar{F}_2$	0	0	0	x
01 $\bar{F}_3 F_2$	0	0	x	1
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	1	1	x	0

$$\text{Expression: } F_3 = F_3 \bar{F}_1 + F_2 F_1.$$

K-map for  $F_2$ :

	$\begin{smallmatrix} 0 & 0 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 & 1 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 1 \\ F_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 0 \\ F_1 & \bar{F}_0 \end{smallmatrix}$
00 $\bar{F}_3 \bar{F}_2$	0	0	1	x
01 $\bar{F}_3 F_2$	1	1	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	0	0	x	0

$$\text{Expression: } F_2 = F_1 F_0 + F_2 \bar{F}_1$$

K-map for  $F_1$ :

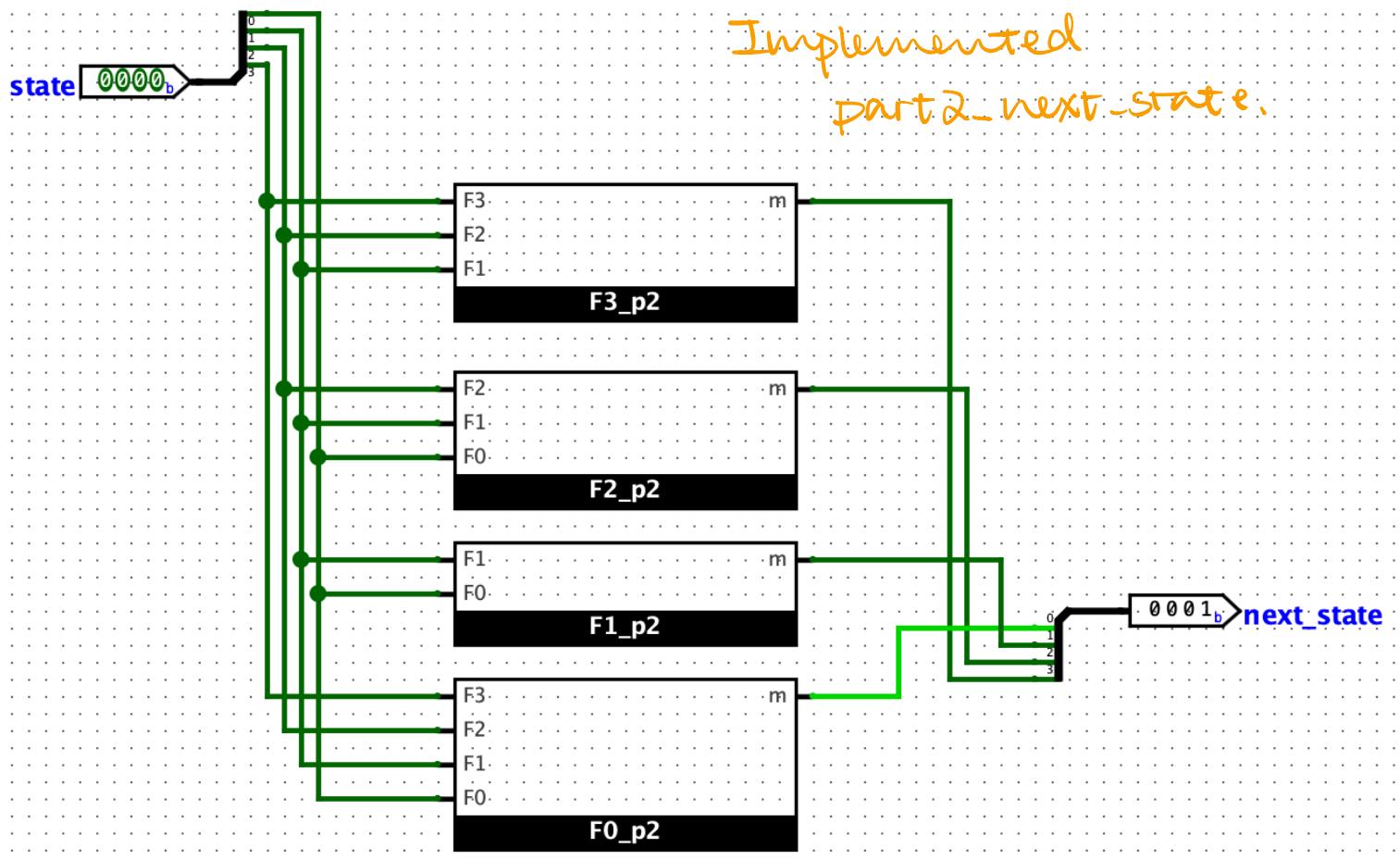
	$\begin{smallmatrix} 0 & 0 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 & 1 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 1 \\ F_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 0 \\ F_1 & \bar{F}_0 \end{smallmatrix}$
00 $\bar{F}_3 \bar{F}_2$	0	1	0	x
01 $\bar{F}_3 F_2$	0	1	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	0	1	x	0

$$\text{Expression: } F_1 = \bar{F}_1 F_0.$$

K-map for  $F_0$ :

	$\begin{smallmatrix} 0 & 0 \\ \bar{F}_1 & \bar{F}_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 & 1 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 1 \\ F_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 0 \\ F_1 & \bar{F}_0 \end{smallmatrix}$	
00	$\bar{F}_3 \bar{F}_2$	1	1	0	x
01	$\bar{F}_3 F_2$	1	0	x	0
11	$F_3 F_2$	x	x	x	x
10	$F_3 \bar{F}_2$	1	0	x	0

$$\text{Expression : } F_0 = \bar{F}_1 \bar{F}_0 + \bar{F}_3 \bar{F}_2 \bar{F}_1$$



K-map for Id-a:

	$\begin{smallmatrix} 0 & 0 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 & 1 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 1 \\ F_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 0 \\ F_1 & \bar{F}_0 \end{smallmatrix}$
00 $\bar{F}_3 \bar{F}_2$	1	0	0	x
01 $\bar{F}_3 F_2$	0	0	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	1	1	x	0

$$\text{Expression: } \text{Id-}a = F_3 \bar{F}_1 + \bar{F}_2 \bar{F}_1 F_0$$

K-map for Id-b:

	$\begin{smallmatrix} 0 & 0 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 & 1 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 1 \\ F_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 0 \\ F_1 & \bar{F}_0 \end{smallmatrix}$
00 $\bar{F}_3 \bar{F}_2$	0	1	0	x
01 $\bar{F}_3 F_2$	0	1	x	1
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	0	0	x	0

$$\text{Expression: } \text{Id-}b = F_2 F_1 + \bar{F}_3 \bar{F}_1 F_0$$

K-map for Id-c:

	$\begin{smallmatrix} 0 & 0 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 & 1 \\ \bar{F}_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 1 \\ F_1 & F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 & 0 \\ F_1 & \bar{F}_0 \end{smallmatrix}$
00 $\bar{F}_3 \bar{F}_2$	0	0	1	x
01 $\bar{F}_3 F_2$	0	0	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	0	0	x	0

$$\text{Expression: } \text{Id-}c = F_1 F_0$$

K-map for  $1d\_x$ :

	$\begin{smallmatrix} 0 \\ \bar{0} \\ \bar{F}_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 1 \\ \bar{F}_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 \\ 1 \\ F_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 0 \\ F_1 \\ \bar{F}_0 \end{smallmatrix}$	
00	$\bar{F}_3 \bar{F}_2$	0	0	0	x
01	$\bar{F}_3 F_2$	1	0	x	0
11	$F_3 F_2$	x	x	x	x
10	$F_3 \bar{F}_2$	0	0	x	0

$$\text{Expression: } 1d\_x = F_2 \bar{F}_1 \bar{F}_0$$

K-map for aln-op:

	$\begin{smallmatrix} 0 \\ \bar{0} \\ \bar{F}_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 1 \\ \bar{F}_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 \\ 1 \\ F_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 0 \\ F_1 \\ \bar{F}_0 \end{smallmatrix}$	
00	$\bar{F}_3 \bar{F}_2$	0	0	0	x
01	$\bar{F}_3 F_2$	0	1	x	0
11	$F_3 F_2$	x	x	x	x
10	$F_3 \bar{F}_2$	1	1	x	0

$$\text{Expression: } \text{aln-op} = F_2 F_0 + F_3 \bar{F}_1$$

K-map for  $1d\_{\text{aln\_out}}$ :

	$\begin{smallmatrix} 0 \\ \bar{0} \\ \bar{F}_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 1 \\ \bar{F}_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 1 \\ 1 \\ F_1 \\ F_0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 0 \\ F_1 \\ \bar{F}_0 \end{smallmatrix}$	
00	$\bar{F}_3 \bar{F}_2$	0	0	0	x
01	$\bar{F}_3 F_2$	0	1	x	1
11	$F_3 F_2$	x	x	x	x
10	$F_3 \bar{F}_2$	1	1	x	0

$$\text{Expression: } 1d\_{\text{aln\_out}} = F_2 F_0 + F_2 \bar{F}_1 + F_3 \bar{F}_1$$

K-map for  $1d-r$

	$\begin{smallmatrix} 0 \\ 0 \end{smallmatrix}$ $\bar{F}_1 \bar{F}_0$	$\begin{smallmatrix} 0 \\ 1 \end{smallmatrix}$ $\bar{F}_1 F_0$	$\begin{smallmatrix} 1 \\ 1 \end{smallmatrix}$ $F_1 F_0$	$\begin{smallmatrix} 1 \\ 0 \end{smallmatrix}$ $F_1 \bar{F}_0$
00 $\bar{F}_3 \bar{F}_2$	0	0	0	x
01 $\bar{F}_3 F_2$	0	0	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	0	0	x	1

$$\text{Expression: } 1d-r = F_3 F_1.$$

K-map for alu-select-a- $F_1$ :

	$\begin{smallmatrix} 0 \\ 0 \end{smallmatrix}$ $\bar{F}_1 \bar{F}_0$	$\begin{smallmatrix} 0 \\ 1 \end{smallmatrix}$ $\bar{F}_1 F_0$	$\begin{smallmatrix} 1 \\ 1 \end{smallmatrix}$ $F_1 F_0$	$\begin{smallmatrix} 1 \\ 0 \end{smallmatrix}$ $F_1 \bar{F}_0$
00 $\bar{F}_3 \bar{F}_2$	0	0	0	x
01 $\bar{F}_3 F_2$	0	0	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	1	1	x	0

$$\text{Expression: } F_1 = F_3 \bar{F}_1.$$

K-map for alu-select-a- $F_0$ :

	$\begin{smallmatrix} 0 \\ 0 \end{smallmatrix}$ $\bar{F}_1 \bar{F}_0$	$\begin{smallmatrix} 0 \\ 1 \end{smallmatrix}$ $\bar{F}_1 F_0$	$\begin{smallmatrix} 1 \\ 1 \end{smallmatrix}$ $F_1 F_0$	$\begin{smallmatrix} 1 \\ 0 \end{smallmatrix}$ $F_1 \bar{F}_0$
00 $\bar{F}_3 \bar{F}_2$	0	0	0	x
01 $\bar{F}_3 F_2$	0	1	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	1	0	x	0

$$\text{Expression: } F_0 = F_2 F_0 + F_3 \bar{F}_1 \bar{F}_0$$

K-map for alu\_select\_b\_F<sub>0</sub>:

	00 $\bar{F}_1 \bar{F}_0$	01 $\bar{F}_1 F_0$	11 $F_1 \bar{F}_0$	10 $F_1 F_0$
00 $\bar{F}_3 \bar{F}_2$	0	0	0	x
01 $\bar{F}_3 F_2$	0	1	x	1
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	1	0	x	1.

Expression:  $F_0 = \bar{F}_1 \bar{F}_0 + F_2 F_0 + F_3 \bar{F}_0$

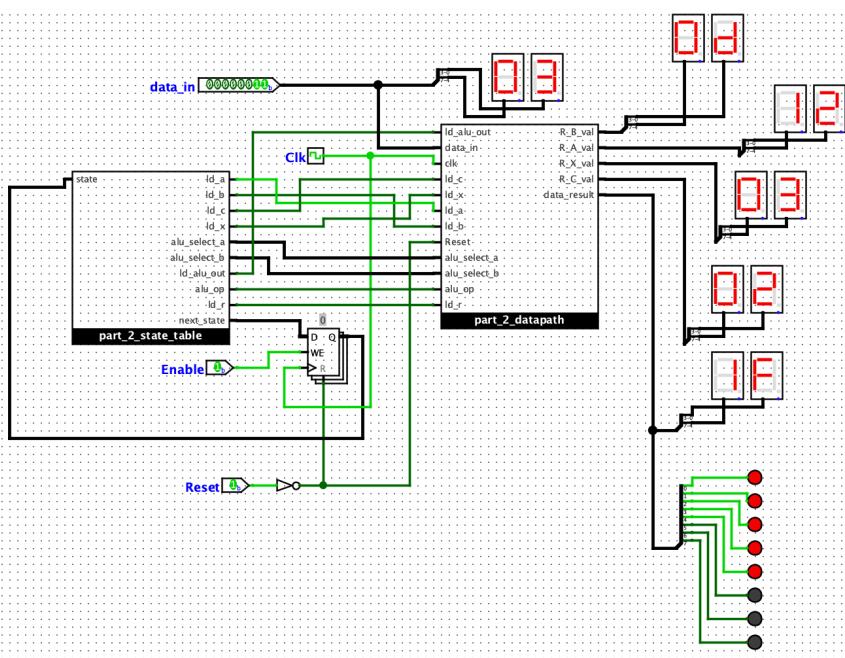
K-map for alu\_select\_b\_F<sub>1</sub>:

	00 $\bar{F}_1 \bar{F}_0$	01 $\bar{F}_1 F_0$	11 $F_1 \bar{F}_0$	10 $F_1 F_0$
00 $\bar{F}_3 \bar{F}_2$	0	0	0	x
01 $\bar{F}_3 F_2$	0	1	x	0
11 $F_3 F_2$	x	x	x	x
10 $F_3 \bar{F}_2$	1	0	x	0.

Expression:  $F_1 = F_2 F_0 + F_3 \bar{F}_1 \bar{F}_0$

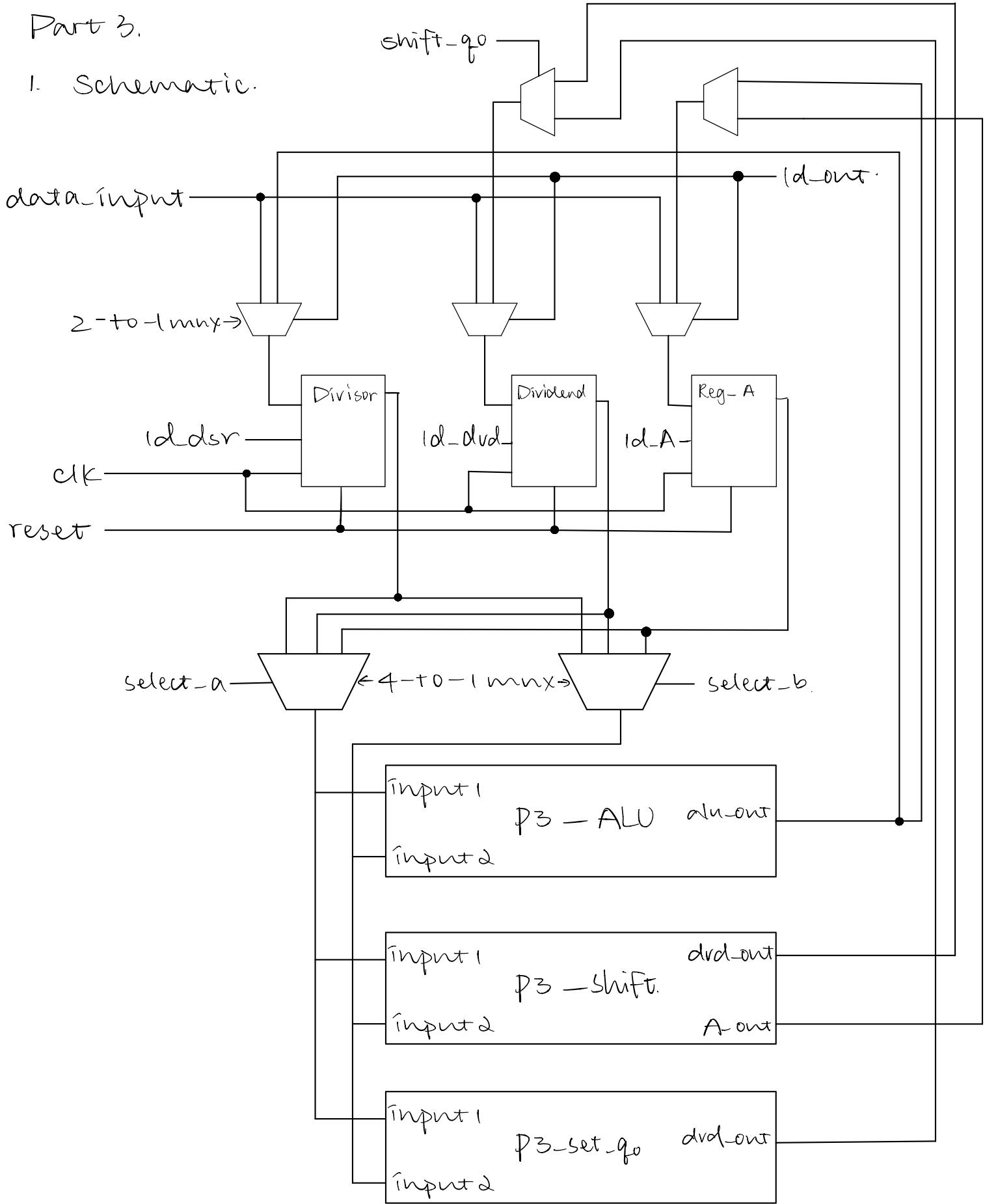
My Test: A=1. B=4. C=2. x=3.

$$Cx^2 + Bx + A = 2(3)^2 + 4(3) + 1 = 18 + 12 + 1 = 31.$$



### Part 3.

#### 1. Schematic.



## 2. State Diagram

Represents.	State.	Next_State.	signal_high.
Divisor	00000	00001	ld_dsr. ✓
Dividend.	00001	00010	ld_dvd. ✓
Shift	00010	00011	select_a=01 select_b=10 ld_A. ld_dvd. ld_out.
			<u>aln-shift</u> ✓
Subtract	00011	00100	ld_out ld_A. select_a=00.
			<u>select_b=10</u>
Set q <sub>0</sub>	00100	00101	ld_dvd. ld_out shift_q <sub>0</sub> . select_a=01
			<u>select_b=10</u>
Add	00101	00110	ld_out, ld_A select_a=00, select_b=10, aln-select=1.

Shift	00110	00111	select_a=01 select_b=10 ld_A, ld_dvd. ld_out.
<hr/>			
Subtract	00111	01000	ld_out ld_A - select_a=00.
<hr/>			
Set q <sub>0</sub>	01000	01001	ld_dvd, ld_out shift_q <sub>0</sub> . select_a=01
<hr/>			
Add	01001	01010	ld_out, ld_A select_a=00, select_b=10, aln_select=1.

Shift

01010

01011

select\_a=01

select\_b=10

ld\_A, ld\_dvd.

ld\_out.

alu\_shift

Subtract

01011

01100

ld\_out

ld\_A -

select\_a=00.

select\_b=10

Set q<sub>0</sub>

01100

01101

ld\_dvd, ld\_out

shift\_q<sub>0</sub>.

select\_a=01

select\_b=10.

Add

01101

01110

ld\_out, ld\_A

select\_a=00,

select\_b=10,

alu\_select=1.

Shift	01110	01111	select_a=01 select_b=10 ld_A, ld_dvd. ld_out.
<u>alu_shift</u>			
Subtract	01111	10000	ld_out ld_A - select_a=00.
<u>select_b=10</u>			
Set q <sub>0</sub>	10000	10001	ld_dvd, ld_out shift_q <sub>0</sub> . select_a=01
<u>select_b=10</u>			
Add	10001	10010	ld_out, ld_A select_a=00, select_b=10,
<u>alu-select = 1</u>			
Set A	10010	00000	ld_A.