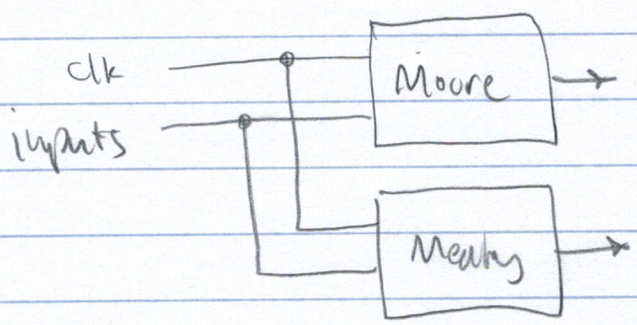
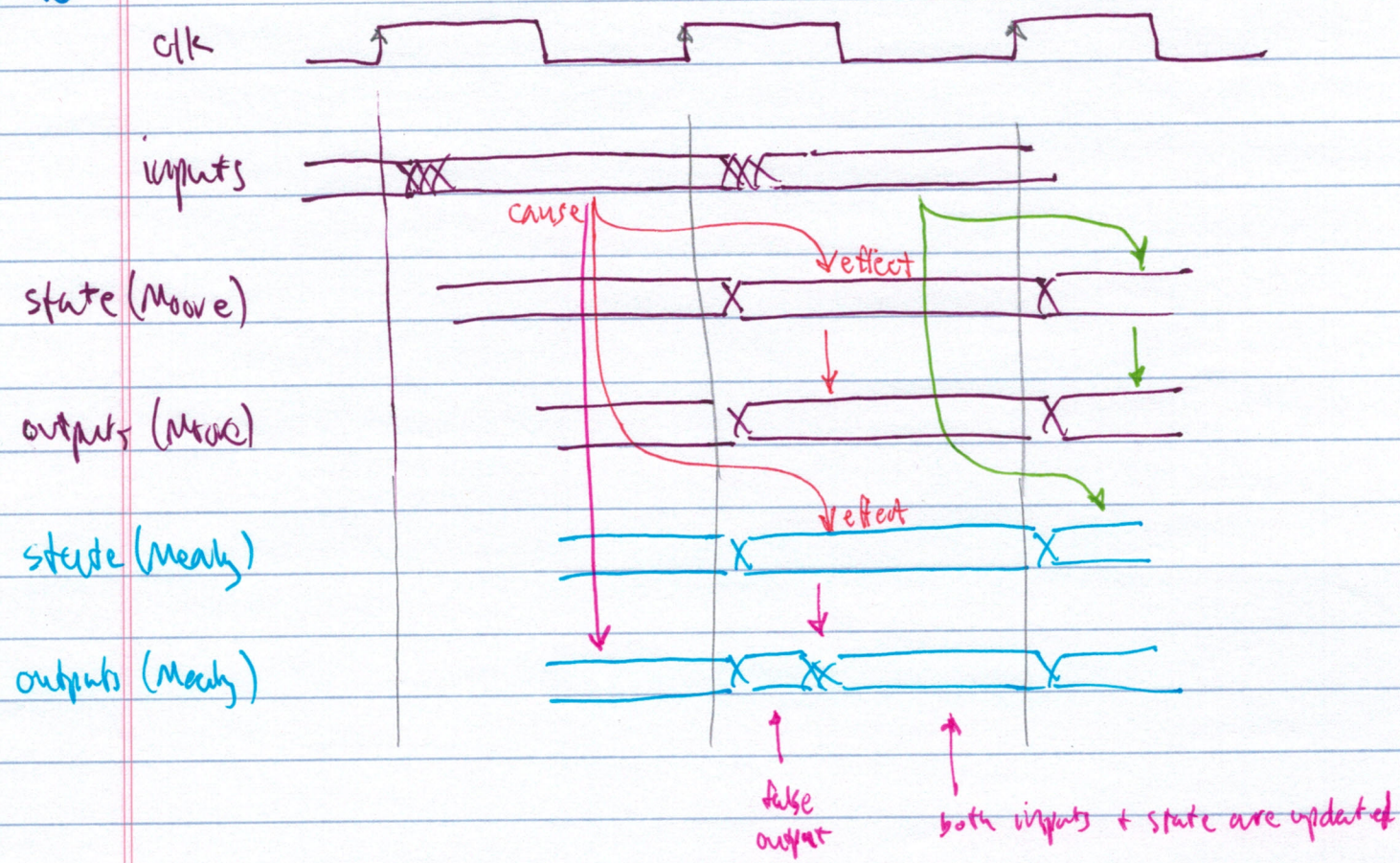


EEEC 18

Nov. 18



Design Process

1) Figure out necessary states

2) Moore or Mealy

3) Draw State Graph

- states

- transitions

4) Add outputs

5) Number of FFs

a) normal counting order

b) random

c) try to minimize logic

d) One-hot

- One FF for each state

$N \text{ states} \rightarrow N \text{ FFs}$

$N = 16$

min: 4

one hot: 16

- One FF high, $N-1$ FFs low

- can be very fast

e) Gray code

Ex:

000
001
011
111

low power (?)

$$\text{Minimum \# of FFs: } \lceil \log_2(\# \text{ of states}) \rceil$$

6) Output logic

7) Assign States

< see a-e above >

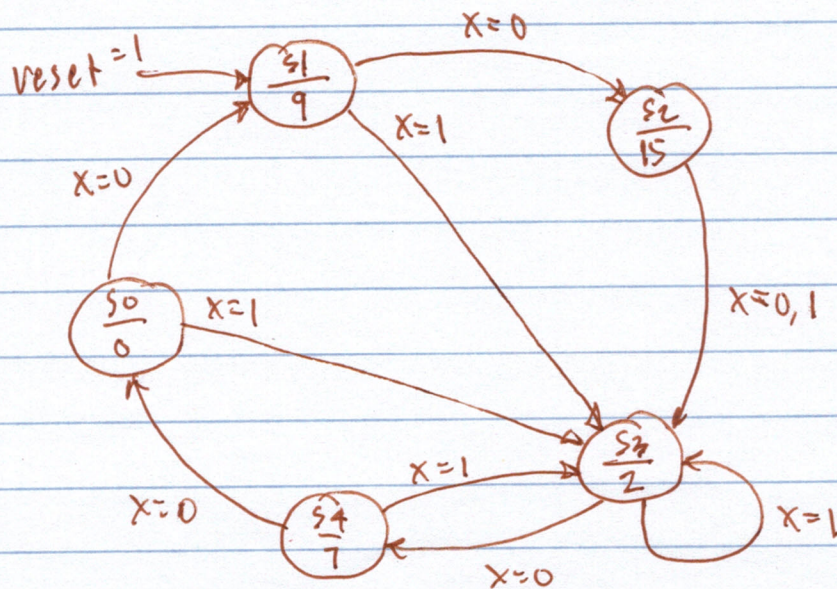
8) State Table

9) N.S. logic equations

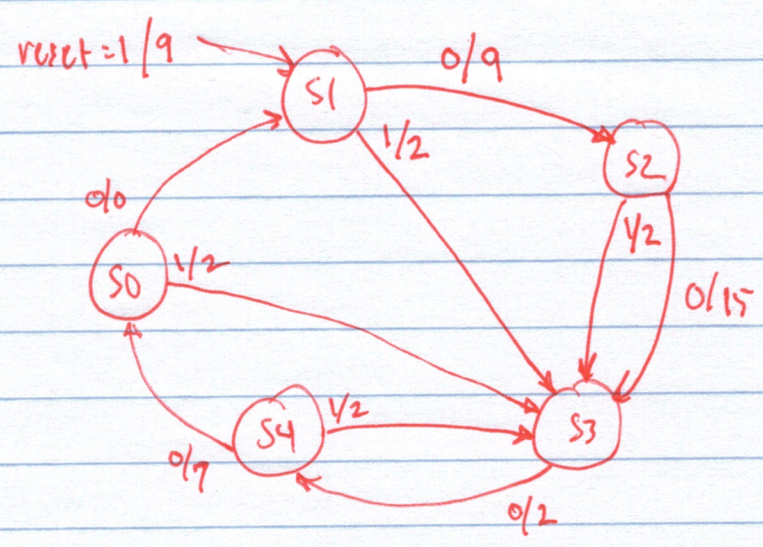
10) output logic equations

Ex: Count 0, 9, 15, 2, 7, <repeat>, when ^{input} $x=0$
 if $x=1$, output 2 next, start counting when $x=0$ again
 when reset = 1, goto 9

Moore State Graph



Mealy State Graph

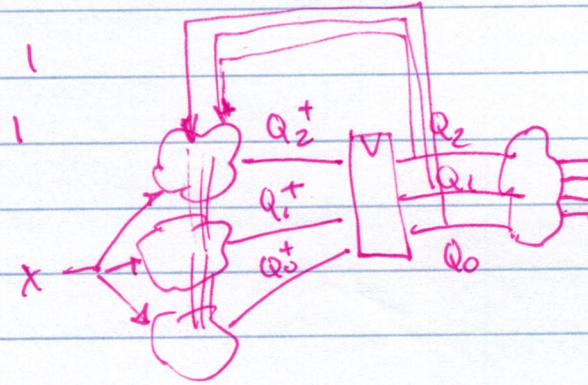
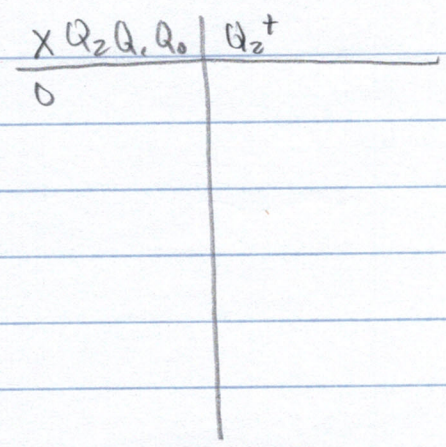


P.S.	N.S.		Output Moore	output Mealy	
	x=0	x=1		x=0	x=1
000	S_1	S_3	0	0	2
001	S_2	S_3	9	9	2
010	S_3	S_3	15	15	2
011	S_4	S_3	2	2	2
100	S_0	S_3	7	7	2

Same for Moore + Mealy

Moore

N.S.	P.S.			N.S.	
	Q ₂	Q ₁	Q ₀	X=0	X=1
				Q ₂ ⁺ Q ₁ ⁺ Q ₀ ⁺	Q ₂ ⁺ Q ₁ ⁺ Q ₀ ⁺
S ₀	0	0	0	0 0 1	0 1 1
S ₁	0	0	1	0 1 0	0 1 1
S ₂	0	1	0	0 1 1	0 1 1
S ₃	0	1	1	1 0 0	0 1 1
S ₄	1	0	0	0 0 0	0 1 1



N.S. Logic

X Q ₂	Q ₁ Q ₀			
	00	01	11	10
00	0	0	1	0
01	0	X	X	X
11	0	X	X	X
10	0	0	0	0

$$Q_2^+ = \bar{X} \cdot Q_1 + Q_0$$

$$Q_1^+ = X + \bar{Q}_1 \cdot Q_0 + Q_1 \cdot \bar{Q}_0$$

$$Q_0^+ = X + \bar{Q}_2 \cdot \bar{Q}_0$$

Output Logic

P.S.			out ₃	out ₂	out ₁	out ₀
Q ₂	Q ₁	Q ₀				
0	0	0	0	0	0	0
0	0	1	1	0	0	1
0	1	0	1	1	1	1
0	1	1	0	0	1	0
1	0	0	0	1	1	1
1	0	1	X	X	X	X
1	1	0	X	X	X	X
1	1	1	X	X	X	X

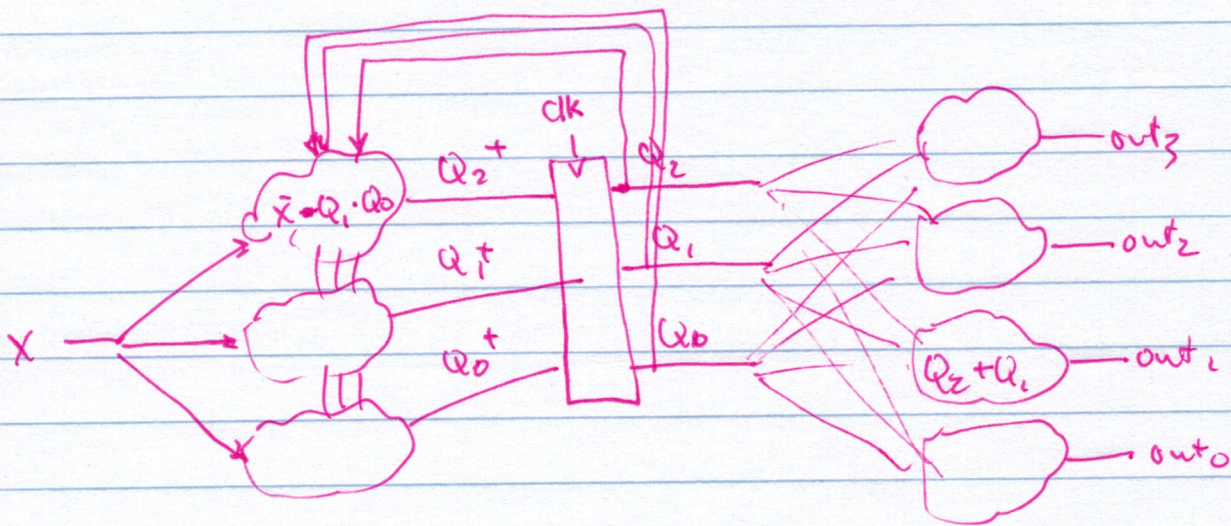
Q ₂	Q ₁ Q ₀			
	00	01	11	10
0	0	1	0	1
1	0	X	X	X

$$\text{out}_3 = \bar{Q}_1 \cdot Q_0 + Q_1 \cdot \bar{Q}_0$$

$$\text{out}_2 = Q_2 + Q_1 \bar{Q}_0$$

$$\text{out}_1 = Q_2 + Q_1$$

$$\text{out}_0 = Q_2 + \bar{Q}_1 \cdot Q_0 + Q_1 \bar{Q}_0$$



Option: 4-bits of state to skip output logic
 - 4 N.S. logic designs
 + 0 output logic

Multiplying out part

Office
Hour

X	Q ₂	Q ₁	Q ₀	out ₃	out ₂	out ₁	out ₀
0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	1
0	0	1	0	1	1	1	1
0	0	1	1	0	0	1	0
0	1	0	0	0	1	1	1
0	1	0	1	X	X	X	X
0	1	1	0	X	X	X	X
0	1	1	1	X	X	X	X
1	0	0	0	0	0	1	0
1	0	0	1	0	0	1	0
1				0	0	1	0
1				0	0	1	0
1				0	0	1	0
1				X	X	X	X
1				X	X	X	X
1				X	X	X	X

X Q ₂	Q ₁ Q ₀			
	00	01	11	10
00	0	1	0	1
01	0	X	X	X
11	0	X	X	X
10	0	0	0	0

out₃

X	Q ₂	Q ₁	Q ₀	Q ₂ ⁺
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	X
0	1	1	0	X
0	1	1	1	X
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	X
1	1	1	0	X
1	1	1	1	X

} state = 5, 6, 7

Mexaly output logic

