EECS 281, March 24, 2015

HW Hint: Output 1 = 31

Example: Design a finite state machine for a keypad lock of an office door.

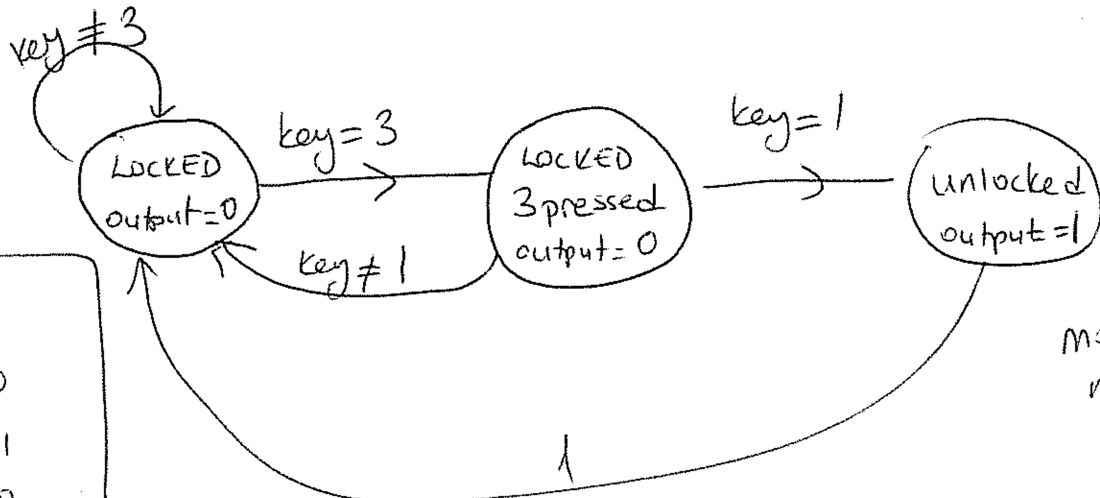
The door unlocks if the input is:

31

First : 3 pressed
Then : 1 pressed
} ⟹ Door unlocks.

The output is Unlock.

Once the door unlocks, it locks back again.



Moore machine.

key pad:
0 : 00
1 : 01
2 : 10
3 : 11

input key

current state	00	01	10	11
LOCKED	LOCKED	LOCKED	LOCKED	LOCKED 3 PRESSED
LOCKED 3 PRESSED	LOCKED	UNLOCKED	LOCKED	LOCKED
UNLOCKED	LOCKED	LOCKED	LOCKED	LOCKED

State Name	Assignment Simplest Q1–Q3	Decomposed Q1–Q3	One-Hot Q1–Q5	Almost One-Hot Q1–Q4
INIT	000	000	00001	0000
A0	001	100	00010	0001
A1	010	101	00100	0010
OK0	011	110	01000	0100
OK1	100	111	10000	1000

Table 7-6

Possible state assignments for the state machine in Table 7-5.

state assignments:

Assign binary combination to each named state.

Total number of states in a machine with $\underline{n}$ flip-flops is $\underline{2^n}$

in our example we have 3 states

$\log_2 3 \approx 2$ flip-flops

$\Rightarrow 2^2 = 4$ states

need 3 states

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1 state unused.

Simplest state assignment: use first 3 binary integers in binary counting order.

Simplest assignment does not always lead to the simplest excitation equations, output equations and resulting logic circuit.

Practical guidelines for reasonable state assignments:

- Choose initial coded state which machine can easily be forced at reset (0...0 , 1...1)

- minimize number of state variables that change on each transition.

- Take into account symmetries. If one state means almost the same thing as another ⇒ similar assignments differing only one bit.

- If there unused states ⇒ don't limit choice to first s n-bit integers.

- Use more than minimum # of state variables

(example): 3 states ⇒ use binary counting order for state assignments:

LOCKED = 00 LOCKED/3 = 01

UNLOCKED = 10

current state Q_1Q_0	Input (A_1A_0) 00	01	10	11	output
00	00	00	00	01	0
01	00	10	00	00	0
10	00	00	00	00	1
	Q_1^* Q_0^*				
unused state: 11 (minimal risk)	00	00	00	00	0
unused state: 11 (minimal cost)	XX	XX	XX	XX	0

unused states:

1) Minimal risk: for any input condition the unused state goes to initial/idle/safe state.

2) Minimal cost: assume no entry to the unused states ⇒ mark them as don't cares.

Form k-maps to find the transition eqn.

Q1* :

$Q_1Q_0 \backslash A_1A_0$	00	01	11	10
00				
01		1		
11	X	X	X	X
10				

unused

for minimal cost

For minimal risk:

$$Q1^* = Q1'\, Q0\, A1'\, A0$$

For minimal cost:

$$Q1^* = A1'\, A0\, Q0$$

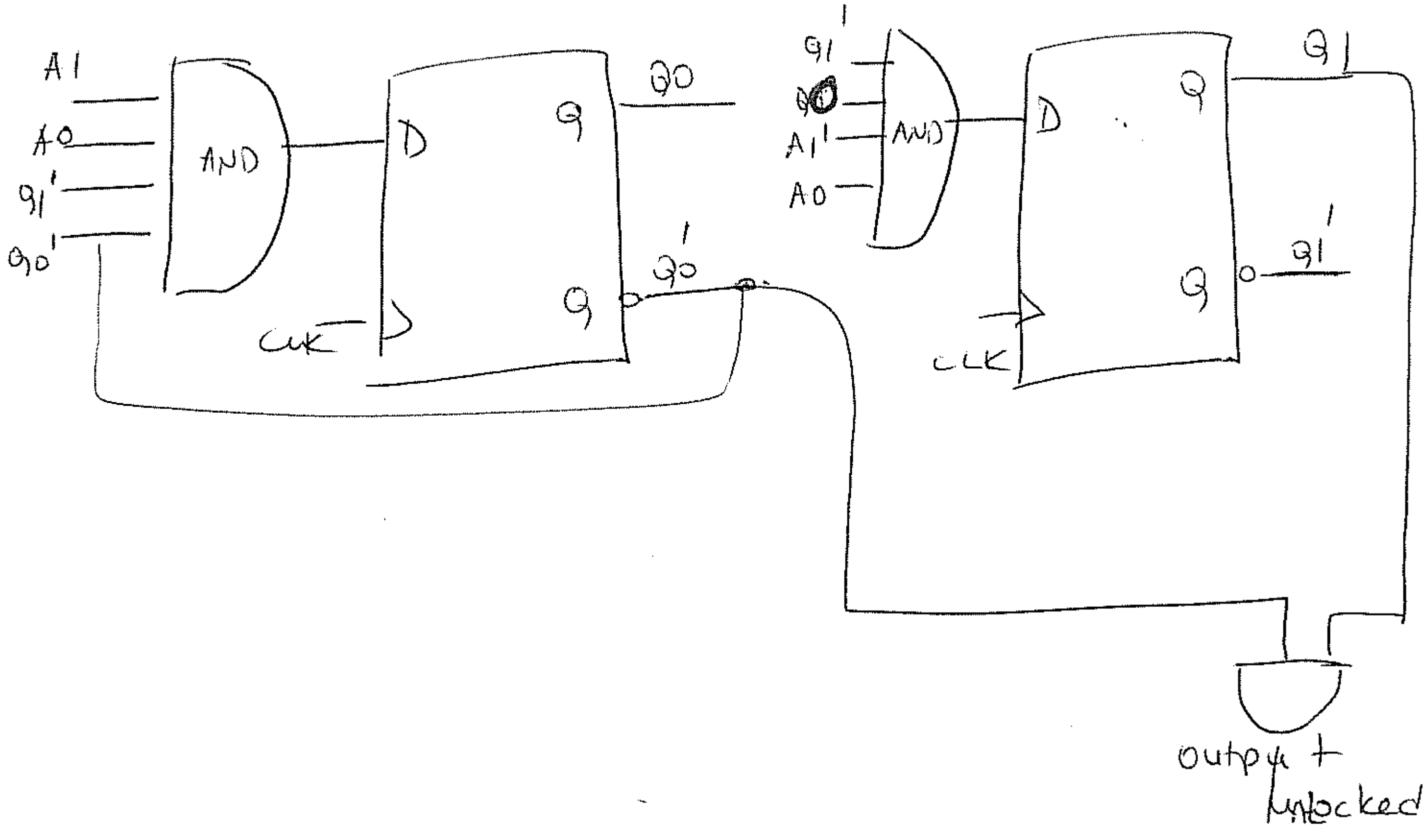
$$Q0^* = Q1'\, Q0'\, A1\, A0$$

transition equations

Excitation eqns:

$D1 = Q1^*$, $D0 = Q0^*$

Output eqn: $UNLOCKED = Q1 \cdot Q0'$


A1
A0
q1'
q0'
AND
D
Q
Q0
Q
Q0'
CLK
q1'
Q0
A1'
A0
AND
D
Q
Q1
Q
Q1'
CLK
output
unlocked