Combination Lock Project DLD

Keeyan Haghshenas
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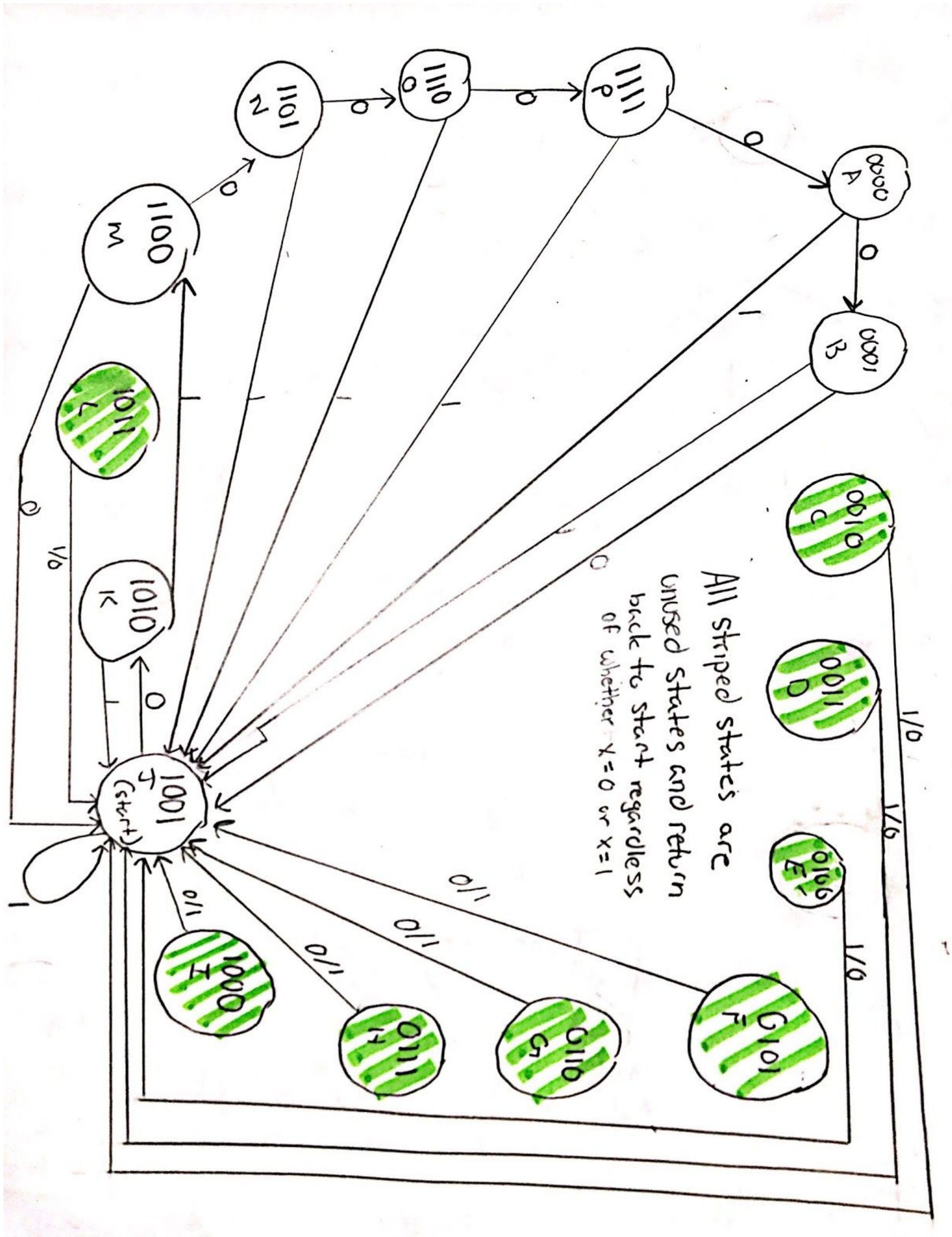
RUID: 171000841
RUID in binary: 1 0000 0100 1111 0000 0010 1001

Part 2: State Diagram: with all 16 states including start state, the 8 states that you are using and the 8 unused states.



Part 3 - State transition Table - showing the 8 states you are using and X=0,X=1

- All USED states are marked in GREEN
- All UNUSED states are marked in RED

Current State (* denotes unused state)		Next State	
		X=0	X=1
A	0000	0001	1001
B	0001	1001	1001
C	0010	1001	1001
D	0011	1001	1001
E	0100	1001	1001
F	0101	1001	1001
G	0110	1001	1001
H	0111	1001	1001
I	1000	1001	1001
J (Start)	1001	1010	1001
K	1010	1001	1100
L	1011	1001	1001
M	1100	1101	1001
N	1101	1110	1001
O	1110	1111	1001
P	1111	0000	1001

Part 4: Excitation Table for JK FF

States		Inputs	
Q	Q_{next}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Part 5: State Transition Table for JK FF

State Transition Table for JK inputs (X=0)

States				Inputs			
State letter	Q	Next State letter	Q_{next}	X=0			
	$q_3\, q_2\, q_1\, q_0$		$q^*_3\, q^*_2\, q^*_1\, q^*_0$	$J_3\, K_3$	$J_2\, K_2$	$J_1\, K_1$	$J_0\, K_0$
J	1 0 0 1	K	1 0 1 0	X 0	0 X	1 X	X 1
K	1 0 1 0	J	1 0 0 1	X 0	0 X	X 1	1 X
M	1 1 0 0	N	1 1 0 1	X 0	X 0	0 X	1 X
N	1 1 0 1	O	1 1 1 0	X 0	X 0	1 X	X 1
O	1 1 1 0	P	1 1 1 1	X 0	X 0	X 0	1 X
P	1 1 1 1	A	0 0 0 0	X 1	X 1	X 1	X 1
A	0 0 0 0	B	0 0 0 1	0 X	0 X	0 X	1 X
B	0 0 0 1	J	1 0 0 1	1 X	0 X	0 X	X 0

State Transition table for Unused States JK (X=0)

Unused States				Inputs			
State letter	Q	Next State letter	Q_{next}	X=0			
	$q_3\, q_2\, q_1\, q_0$		$q^*_3\, q^*_2\, q^*_1\, q^*_0$	$J_3\, K_3$	$J_2\, K_2$	$J_1\, K_1$	$J_0\, K_0$
L	1 0 1 1	J	1 0 0 1	X 0	0 X	X 1	X 0
C	0 0 1 0	J	1 0 0 1	1 X	0 X	X 1	1 X
D	0 0 1 1	J	1 0 0 1	1 X	0 X	X 1	X 0
E	0 1 0 0	J	1 0 0 1	1 X	X 1	0 X	1 X
F	0 1 0 1	J	1 0 0 1	1 X	X 1	0 X	X 0
G	0 1 1 0	J	1 0 0 1	1 X	X 1	X 1	1 X

H	0 1 1 1	J	1 0 0 1	1 X	X 1	X 1	X 0
I	1 0 0 0	J	1 0 0 1	X 0	0 X	0 X	1 X

Part 6 - State Transition Table for JK inputs (X=1)

State Transition Table for JK inputs (X=1)

States				Inputs			
State letter	Q	Next State letter	Q_{next}	X=1			
	$q_3\, q_2\, q_1\, q_0$		$q^*_3\, q^*_2\, q^*_1\, q^*_0$	$J_3\, K_3$	$J_2\, K_2$	$J_1\, K_1$	$J_0\, K_0$
J	1 0 0 1	J	1 0 0 1	X 0	0 X	0 X	X 0
K	1 0 1 0	M	1 1 0 0	X 0	1 X	X 1	0 X
M	1 1 0 0	J	1 0 0 1	X 0	X 1	0 X	1 X
N	1 1 0 1	J	1 0 0 1	X 0	X 1	0 X	X 0
O	1 1 1 0	J	1 0 0 1	X 0	X 1	X 1	1 X
P	1 1 1 1	J	1 0 0 1	X 0	X 1	X 1	X 0
A	0 0 0 0	J	1 0 0 1	1 X	0 X	0 X	1 X
B	0 0 0 1	J	1 0 0 1	1 X	0 X	0 X	X 0

Unused States				Inputs			
State letter	Q	Next State letter	Q_{next}	X=1			
	$q_3\, q_2\, q_1\, q_0$		$q^*_3\, q^*_2\, q^*_1\, q^*_0$	$J_3\, K_3$	$J_2\, K_2$	$J_1\, K_1$	$J_0\, K_0$
L	1 0 1 1	J	1 0 0 1	X 0	0 X	X 1	X 0
C	0 0 1 0	J	1 0 0 1	1 X	0 X	X 1	1 X
D	0 0 1 1	J	1 0 0 1	1 X	0 X	X 1	X 0

E	0 1 0 0	J	1 0 0 1	1 X	X 1	0 X	1 X
F	0 1 0 1	J	1 0 0 1	1 X	X 1	0 X	X 0
G	0 1 1 0	J	1 0 0 1	1 X	X 1	X 1	1 X
H	0 1 1 1	J	1 0 0 1	1 X	X 1	X 1	X 0
I	1 0 0 0	J	1 0 0 1	X 0	0 X	0 X	1 X

Part 7 - State Transition table for R and G (X=0)

X=0					
States				Outputs (Z)	
State letter	Q	Next State Letter	Q_{next}	Red	Green
J	1 0 0 1	K	1 0 1 0	0	0
K	1 0 1 0	J	1 0 0 1	1	0
M	1 1 0 0	N	1 1 0 1	0	0
N	1 1 0 1	O	1 1 1 0	0	0
O	1 1 1 0	P	1 1 1 1	0	0
P	1 1 1 1	A	0 0 0 0	0	0
A	0 0 0 0	B	0 0 0 1	0	0
B	0 0 0 1	J	1 0 0 1	0	0

Unused State Transition table for R and G (X=0)

X=0					
Unused States				Outputs (Z)	
State letter	Q	NSL	Q_{next}	Red	Green
L	1 0 1 1	J	1 0 0 1	1	0
C	0 0 1 0	J	1 0 0 1	1	0
D	0 0 1 1	J	1 0 0 1	1	0

E	0 1 0 0	J	1 0 0 1	1	0
F	0 1 0 1	J	1 0 0 1	1	0
G	0 1 1 0	J	1 0 0 1	1	0
H	0 1 1 1	J	1 0 0 1	1	0
I	1 0 0 0	J	1 0 0 1	1	0

Part 8 - State Transition table for R and G (X=1)

X=1					
States				Outputs (Z)	
State Letter	Q	NSL	Q_{next}	Red	Green
J	1 0 0 1	J	1 0 0 1	1	0
K	1 0 1 0	M	1 1 0 0	0	0
M	1 1 0 0	J	1 0 0 1	1	0
N	1 1 0 1	J	1 0 0 1	1	0
O	1 1 1 0	J	1 0 0 1	1	0
P	1 1 1 1	J	1 0 0 1	1	0
A	0 0 0 0	J	1 0 0 1	1	0
B	0 0 0 1	J	1 0 0 1	0	1

Unused State Transition Table R and G (X=1)

X=1					
Unused States				Outputs (Z)	
State Letter	Q	NSL	Q_{next}	Red	Green
L	1 0 1 1	J	1 0 0 1	1	0
C	0 0 1 0	J	1 0 0 1	1	0
D	0 0 1 1	J	1 0 0 1	1	0

E	0 1 0 0	J	1 0 0 1	1	0
F	0 1 0 1	J	1 0 0 1	1	0
G	0 1 1 0	J	1 0 0 1	1	0
H	0 1 1 1	J	1 0 0 1	1	0
I	1 0 0 0	J	1 0 0 1	1	0

Part 9: R and G Outputs Kmaps

R (x=0)		q3,q2				
	q1,q0		00	01	11	10
		00	0	1	0	1
		01	0	1	0	0
		11	1	1	0	1
		10	1	1	0	1

R (x=1)		q3,q2				
	q1,q0		00	01	11	10
		00	1	1	1	1
		01	0	1	1	1
		11	1	1	1	1
		10	1	1	1	0

G (x=0)		q3,q2				
	q1,q0		00	01	11	10
		00	0	0	0	0
		01	0	0	0	0
		11	0	0	0	0
		10	0	0	0	0

G (x=1)		q3,q2				
	q1,q0		00	01	11	10
		00	0	0	0	0
		01	1	0	0	0
		11	0	0	0	0
		10	0	0	0	0

Part 10: Sixteen 4 Variable K maps:

J3 (x=0)	q3,q2				
q1,q0		00	01	11	10
	00	0	1	X	X
	01	1	1	X	X
	11	1	1	X	X
	10	1	1	X	X

J3(x=1)	q3,q2				
q1,q0		00	01	11	10
	00	1	1	X	X
	01	1	1	X	X
	11	1	1	X	X
	10	1	1	X	X

K3 (x=0)	q3,q2				
q1,q0		00	01	11	10
	00	X	X	0	0
	01	X	X	0	0
	11	X	X	1	0
	10	X	X	0	0

K3 (x=1)	q3,q2				
q1,q0		00	01	11	10
	00	X	X	0	0
	01	X	X	0	0
	11	X	X	0	0
	10	X	X	0	0

J2 (x=0)	q3,q2				
q1,q0		00	01	11	10
	00	0	X	X	0
	01	0	X	X	0
	11	0	X	X	0
	10	0	X	X	0

J2(x=1)	q3,q2				
q1,q0		00	01	11	10
	00	0	X	X	0
	01	0	X	X	0
	11	0	X	X	0
	10	0	X	X	1

K2 (x=0)	q3,q2				
q1,q0		00	01	11	10
	00	X	1	0	X
	01	X	1	0	X
	11	X	1	1	X
	10	X	1	0	X

K2 (x=1)	q3,q2				
q1,q0		00	01	11	10
	00	X	1	1	X
	01	X	1	1	X
	11	X	1	1	X
	10	X	1	1	X

J1 (x=0)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	0	0	0	0
	01	0	0	1	1
	11	X	X	X	X
	10	X	X	X	X

J1(x=1)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	0	0	0	0
	01	0	0	0	0
	11	X	X	X	X
	10	X	X	X	X

K1 (x=0)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	X	X	X	X
	01	X	X	X	X
	11	1	1	1	1
	10	1	1	0	1

K1 (x=1)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	X	X	X	X
	01	X	X	X	X
	11	1	1	1	1
	10	1	1	1	1

J0 (x=0)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	1	1	1	1
	01	X	X	X	X
	11	X	X	X	X
	10	1	1	1	1

J0 (x=1)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	1	1	1	1
	01	X	X	X	X
	11	X	X	X	X
	10	1	1	1	0

K0 (x=0)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	X	X	X	X
	01	0	0	1	1
	11	0	0	1	0
	10	X	1	X	X

K0 (x=1)	q3,q2 →	00	01	11	10
q1,q0 ↓					
	00	X	X	X	X
	01	0	0	0	0
	11	0	0	0	0
	10	X	X	X	X

Part 11: Reduced Equations

$J_3 = q_0+q_1+q_2+X$

$J_2= Xq_3q_1q_0'$

$J_1=X'q_3q_0$

$J_0=X'+q_3'+q_1'+q_2$

$K_3=q_3'$

$K_2=X+q_1q_0+q_3'$

$K_1=q_3'+q_2'+q_0+X$

$K_0=X'q_3q_1'+X'q_3q_2$

Part 12 - Page discussion

The task presented by this project was to design a combinational lock that will adhere to a set of limitations put forth by my RUID. The limitations include that the start state for the lock must be the last digit of my RUID number and then the proceeding transitions to unlock the lock must adhere to my RUID as well. To be able to do this, I first converted my RUID into binary, then separated the resulting bits into groups of four for ease later in the project. After converting, I considered and attempted to make the state table first, prior to the state diagram, thinking it would speed up the process, although I eventually realized that it was much easier to make the state diagram first for the visual aid. After converting to binary the first group of four bits that were present was, State J (1001) this state was declared my start state because of the directions given. Then to progress through the machine the X values needed for transition, are defined as the next 8 bits after my start state, going from b_4 to b_{12} the X values are 0100 0000. To progress through the machine, every time the input X is equal to a zero the state moves to the very next state, however when X=1, you would not proceed to the next state but the state after, skipping one state and moving to the next. For my RUID number, I started at state J (1001) and then went to K, then proceed to M, N, O, P, A, B, and then back to J again, adhering to my X values. The state machine was also designed to include what would happen if the wrong input was read, the result is to go back to the start state, you can see examples of this in the State Diagram and Truth tables. In order to fully understand what is happening the state diagram was made, when I was making the diagram the 8 used states and 8 unused states became apparent to me, and really aided in my conceptual understand to what was going on. I hand drew the diagram and scanned a picture of it to make an image I could put into a document. Using the state machine diagram, I then made the state table, carefully showing the transition of states according to the input and if the wrong input was read it would send the machine back to the start state for every state including the unused states (which always go back to the start no matter their input) for both X=0 and X=1. I then wrote the excitation table for a JK flip flop, and combined this information with the information on the state table to find all the input state transitions of the JK Flip flop. I did this by comparing the initial state to the next state bit by bit, and using that transition to find the JK Flip Flop equivalent in the excitation table. I did this for both the used and unused states because I felt it would help me later in the project when I was constructing the K maps. I then made the state transition table for the red and green LEDs. Separating the used and unused states, I constructed a transition table that would adhere to the limitation set forth by the project, which were to illuminate the red LEDs everytime and an incorrect bit was red (when the machine was sent back to the start) and illuminate the green LED when all the correct input bits were read and the lock was unlocked. Using the convention that when an incorrect bit was the red the illumination of the red LED was represented by a one, and when the lock was unlocked the illumination of the green LED was represented by a 1 as well. Due to the separation of unused and used states, it is clear that G will never equal 1 in the unused state chart. Then using all this information, I constructed kmaps for the R, G and all JK input bits and using 5 variable kmap minimization techniques I was able to formulate the equations for the JK input bits. A lot of this project was created in google drive, using docs for the write up and sheets for the kmaps. I also found it easier to draw out the state machine diagram by hand in order to further my understanding of the what was actually going on. There is not much to improve on in the project considering it both fun and challenging; however the only things that I think could use improvement is the amount of background information given about state machines, and the lack of different examples given. To fully understand what was happening was difficult in the start and I think having an example would have really helped in the concreting the conceptual part of this project.