COMPUTER SYSTEMS AND NETWORKS

Assignment 1 – Semester 1, 2016 Due Week 11

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Contents

Objective

Part A's objective

The first objective, **Part A**, is to create a key and lock circuit using only the three basic logic gates (AND, OR, NOT) with a maximum of 2 inputs. Where the user has input a key value (K1, K2 and K3) and lock value (L1, L2 and L3) and the circuit decodes the K1, K2, K3 and L1, L2, L3 values using a decoder as well as other permitted logic gates to determine if the key matches the lock. The output will be a single LED labelled **OPEN** which is lit if the key matches the lock, and it doesn't light up if the key and lock are different. In this report, the circuit is required to implement a simple key and lock mechanism. The key will be an octal digit (3 input bits, values 0 to 7). The lock will also be octal digit (3 inputs, values 0 to 7). The key will fit the lock if its octal digits matches the octal digit of the lock.

Example 1: Key is 2 and Lock is 7. The numbers don't match because the key doesn't match the lock.

Example 2: Key is 5 and Lock is 5. The numbers match, the key unlocks the lock.

The tables below represent the key and the lock represented by three inputs (3-bits) and shows the assignment of bits to each key value:

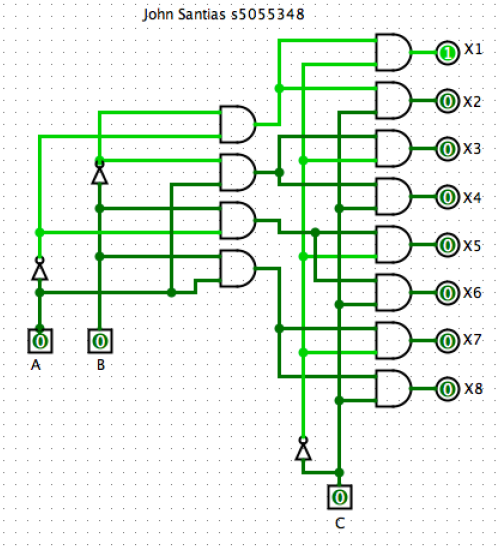
Key value	K1	K2	K3	L1	L2	L3
1	0	0	0	0	0	0
2	0	0	1	0	0	1
3	0	1	0	0	1	0
4	0	1	1	0	1	1
5	1	0	0	1	0	0
6	1	0	1	1	0	1
7	1	1	0	1	1	0
8	1	1	1	1	1	1

Part B's objective

The second objective, **Part B**, is to create a counting and locking mechanism. Where when the lock allows a certain number of incorrect attempts. The number of times an invalid key can be input ranges from 0 to 7 and should be set via combination of three separate inputs: X1, X2 and X3. When the 3 inputs are combined into a single 3-bit input. With an ***n*** value of 0 you can make 0 incorrect key attempts. Only three gates can be used (AND, OR, NOT). Using the same circuit as Part A, add the circuit to count how many incorrect attempts have been made. The circuit should count the incorrect key attempts. Also reset when correctly unlocked. Combine part B circuit with the part A. The circuit will have a single LED output labelled OPEN. If, and only if, the key and lock match then the OPEN LED will be set to 1. If the key and lock value don't match the OPEN LED will be 0. If n incorrect unlocking attempts are made, the OPEN LED will remain at 0 and can't be set to 1.

Part A

The 3 to 8 decoder



A decoder is the form of a multiple-input, that converts codes from inputs into outputs. Like an input for example, 'n' will output '2n', binary-code decimal decoder. There are many more types of decoders, all of them are electronic circuits converting each combination of data inputs into a combination of outputs. The kind of decoder used for combining together a key and lock circuit is a 3 to 8 decoder. An 8 data output is needed as there are 8 keys and 8 locks which will be used to try and unlock the lock. Two of these decoders will be used later to combine our final key and lock system. One decoder representing the key and the other decoder representing the lock.

When both the key and the lock have the same outputs, the lock will unlock.

E.g. Key 1 and Lock 1 both have outputs, it will unlock the lock.

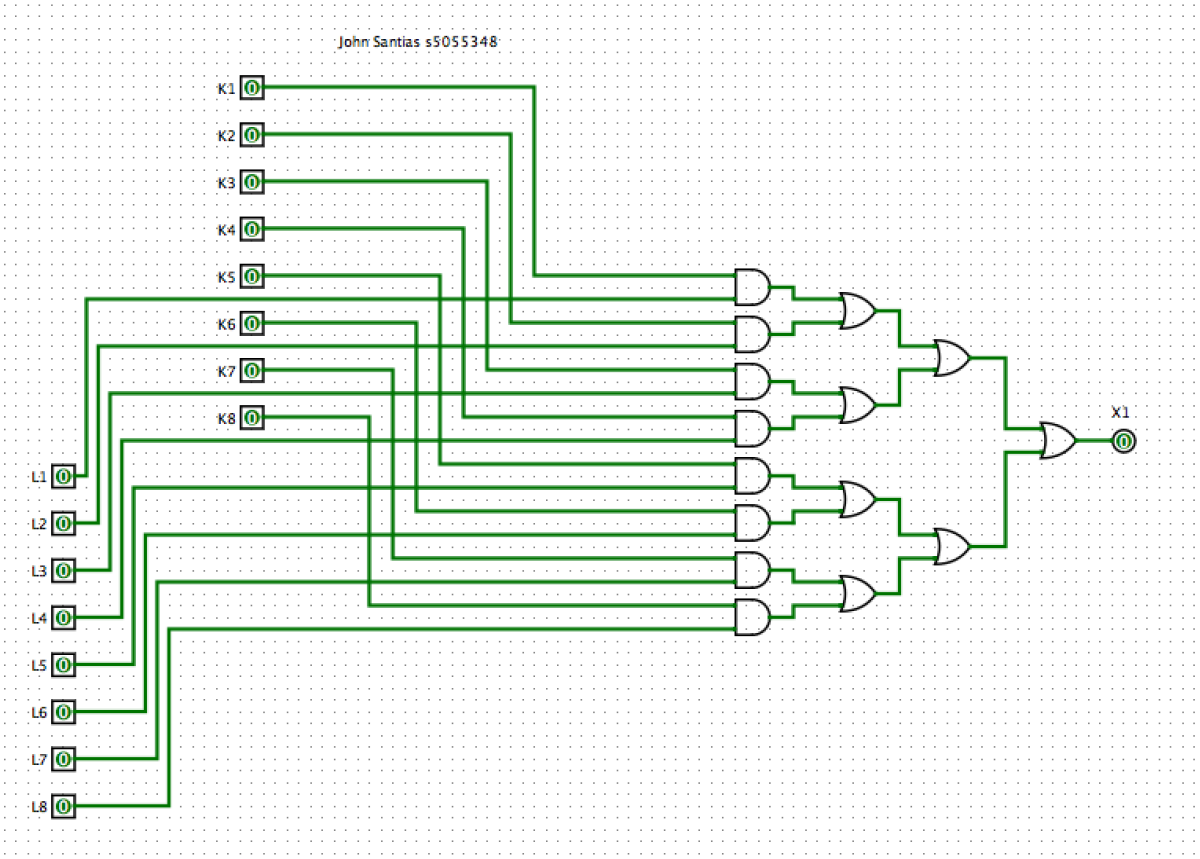
In the 3 to 8 decoder, this uses every AND gate and will only send an output when there are two input value. This 3-bit input will activate one of the 8 decoded outputs. The NOT gate blocks it's input value from giving an output. However, does give an output when there is no input. X1 has an output because the NOT gates not having an input gave an output leading to X1.

Truth table:

A	B	C	X1	X2	X3	X4	X5	X6	X7	X8
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

A, B and C is represented as inputs K1, K2 and K3 or L1, L2 and L3. Outputs X1-X8 can represent outputs L1-L8 or K1-K8.

Comparator



As the 3 to 8 decoders have 8 decoded outputs. The outputs of the decoder will connect to the comparator. This comparator will have one output which will later represent the final circuit that the lock has been unlocked.

Since the whole key and lock circuit will need two 3 to 8 decoders, one representing keys and the other locks. One from the 8 outputs of the lock and key decoder will serve as an input to the 8 decoders in this comparator. When both the key and lock are the same values, the input will go through an AND gate and later going to the output which is represented by X1.

For example, K1 and L1 are the inputs, which both lead to the same AND gate. The AND gate gets two active inputs which is needed to give an output going towards the OR gates which need at least one input for an output. So K1 and L1 are the same and it will give an output to X1. The truth table below shows only 2 inputs. As there are 16 inputs in this comparator, only 2 inputs can be used. At least one from lock and one from key.

Truth table:

	K1	K2	K3	K4	K5	K6	K7	K8	L1	L2	L3	L4	L5	L6	L7	L8	X1
1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1
11	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
12	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
13	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
14	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
15	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
17	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
18	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
19	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1
20	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
21	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
22	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0

23	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
24	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
25	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
26	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
27	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
28	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1
29	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
30	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
31	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
32	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
33	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
34	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
35	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
36	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
37	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1
38	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
39	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
40	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
41	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
42	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
43	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
44	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
45	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
46	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1

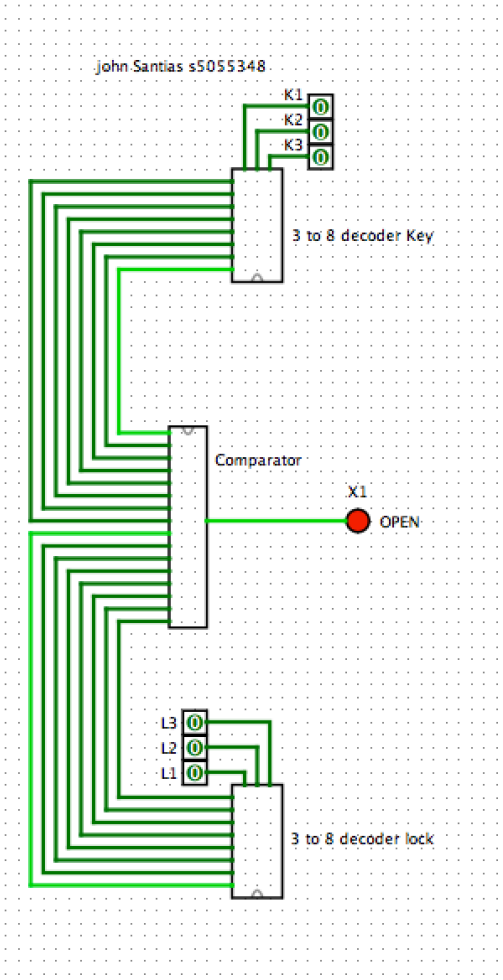
47	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
48	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
49	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
50	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
51	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
52	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
53	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
54	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
55	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
56	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
59	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
60	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
61	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
62	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
63	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
64	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
65	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
66	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
67	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
68	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
69	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
70	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0

71	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
74	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1
75	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
76	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
77	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
78	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
79	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
80	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
81	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
82	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
83	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1
84	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
85	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
86	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
87	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
88	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
89	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
90	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
91	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
92	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1
93	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
94	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0

95	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
96	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
97	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
98	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
99	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
100	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
101	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1
102	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
103	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
104	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
105	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
106	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
107	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
108	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
109	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
110	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1
111	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
112	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
113	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
114	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
115	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
116	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
117	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
118	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

119	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
120	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
121	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
122	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
123	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
124	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
125	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
126	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
127	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
128	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

The key to lock circuit



The final complete key to lock circuit is combining the two 3 to 8 decoders (key decoder and lock) and the comparator. The key, 3 to 8 decoder, is represented at the top. The 8 outputs of that decoder connects to the comparator (Each input to comparator representing K1 to K8). Same goes for the 3 to 8 decoder lock. As it is all connected, there are 6 inputs. 3 going into the lock decoder and 3 for key decoder.

For example, When the X8 from the key and lock decoders active, it will connect to the inputs of the comparator as K8 and L8 which outputs and inputs to the LED which unlocks the lock (X1 OPEN).

Truth table:

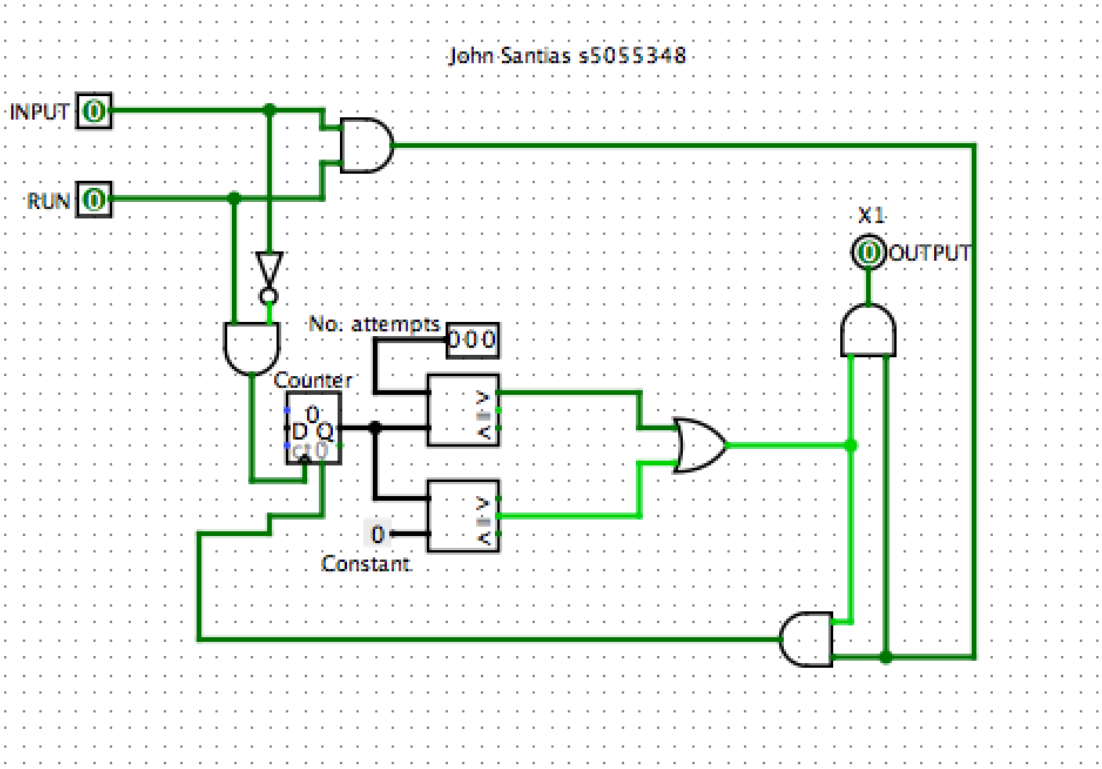
	K1	K2	K3	L1	L2	L3	X1
1	0	0	0	0	0	0	0
2	0	0	0	0	0	1	0
3	0	0	0	0	1	0	0
4	0	0	0	0	1	1	0
5	0	0	0	1	0	0	0
6	0	0	0	1	0	1	0
7	0	0	0	1	1	0	0
8	0	0	0	1	1	1	0
9	0	0	1	0	0	0	0
10	0	0	1	0	0	1	0
11	0	0	1	0	1	0	0
12	0	0	1	0	1	1	0
13	0	0	1	1	0	0	0
14	0	0	1	1	0	1	0
15	0	0	1	1	1	0	0
16	0	0	1	1	1	1	0
17	0	1	0	0	0	0	0
18	0	1	0	0	0	1	0
19	0	1	0	0	1	0	0
20	0	1	0	0	1	1	0
21	0	1	0	1	0	0	0
22	0	1	0	1	0	1	0

23	0	1	0	1	1	0	0
24	0	1	0	1	1	1	0
25	0	1	1	0	0	0	0
26	0	1	1	0	0	1	0
27	0	1	1	0	1	0	0
28	0	1	1	0	1	1	0
29	0	1	1	1	0	0	0
30	0	1	1	1	0	1	0
31	0	1	1	1	1	0	0
32	0	1	1	1	1	1	0
33	1	0	0	0	0	0	0
34	1	0	0	0	0	1	0
35	1	0	0	0	1	0	0
36	1	0	0	0	1	1	0
37	1	0	0	1	0	0	0
38	1	0	0	1	0	1	0
39	1	0	0	1	1	0	0
40	1	0	0	1	1	1	0
41	1	0	1	0	0	0	0
42	1	0	1	0	0	1	0
43	1	0	1	0	1	0	0
44	1	0	1	0	1	1	0
45	1	0	1	1	0	0	0
46	1	0	1	1	0	1	0

47	1	0	1	1	1	0	0
48	1	0	1	1	1	1	0
49	1	1	0	0	0	0	0
50	1	1	0	0	0	1	0
51	1	1	0	0	1	0	0
52	1	1	0	0	1	1	0
53	1	1	0	1	0	0	0
54	1	1	0	1	0	1	0
55	1	1	0	1	1	0	0
56	1	1	0	1	1	1	0
57	1	1	1	0	0	0	0
58	1	1	1	0	0	1	0
59	1	1	1	0	1	0	0
60	1	1	1	0	1	1	0
61	1	1	1	1	0	0	0
62	1	1	1	1	0	1	0
63	1	1	1	1	1	0	0
64	1	1	1	1	1	1	0

Part B

The counting and locking mechanism



The counting and locking mechanism consists of a counter, two comparators, a constant, and an input with a limited value. The two input, serve to give an output. However, a locking mechanism is needed to lock the circuit when the user has too many attempts. The aim of this circuit is to use the inputs to get an output within a limited amount of attempts. The counter counts the amount of tries the user has had. It counts up to 7 however does not lock the whole circuit afterwards. The output of the counter is then inputted into two comparators. One of the comparator will have another input. This input will come from an input which its data bits have been changed to 3. The 3-bit input can be also known as the number of attempts. This will help towards locking the circuit. From the comparator, it will output from the greater sign. So when the 3-bit input has been set to 3 attempts, and the counter counts to 3, the circuit will lock. The comparator won't give an output value as the number of attempts and counter doesn't have a greater number between the two (3 attempts and counter is 3 so it is equal not greater therefore not output).

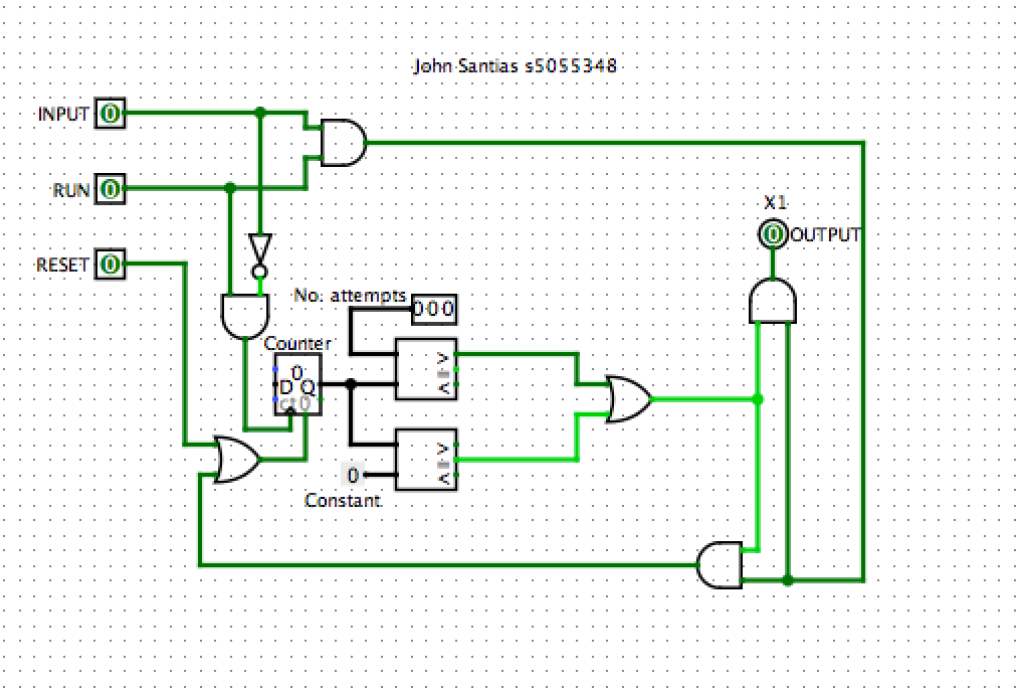
The other comparator will have an input from the constant, with a value of zero and the comparator output will be from the equals sign. So when the counter and constant are zero there will be an output value. If counter and constant don't have zeroes, then there won't be an output value (counter is 1 and constant is zero so no output because they're not equal. Counter 0 and constant zero is equal so there is an output) .

Coming from the outputs of the comparator, they become inputs into the OR gate which needs at least one or both input values to give an output value which then leads to the AND gate and the output (X1). The two inputs, input and run, also run towards the AND gate leading to the counter. When both inputs are on, the counter doesn't count the amount of attempts because of the NOT gate blocking the input. The circuit resets when correctly have an output.

Truth table:

INPUT	RUN	OUTPUT
0	0	0
1	0	0
0	1	0
1	1	1

Adding the reset button

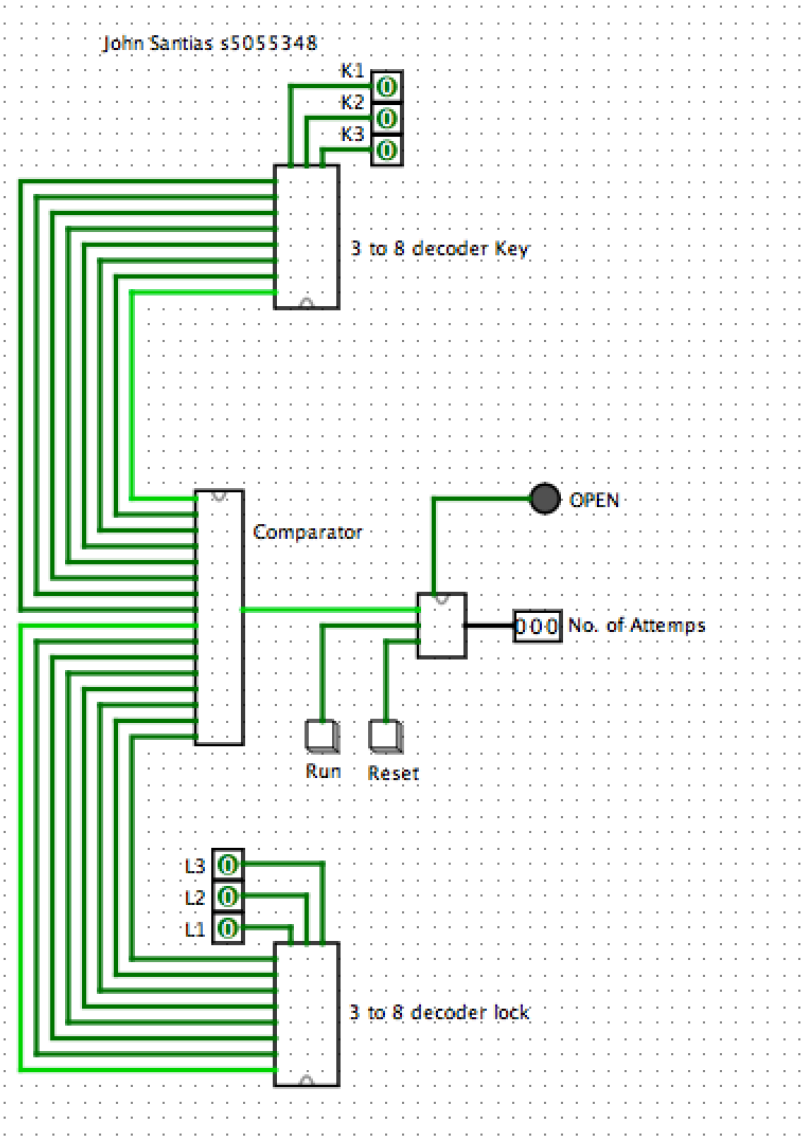


With the addition of the reset input, it is connected to the OR gate leading to the counter as an input to the "0" (bottom of the Counter). So when the input is active the counter will reset to zero. The reset input cannot just be connected to the output from the AND gate going into the counter. It is an error as you cannot just join two values, so an OR gate was added before the counter.

Truth table:

Input	Run	Reset	Output
0	0	0	0
0	0	1	0
0	1	0	0
1	0	0	0
0	1	1	0
1	1	0	1
1	1	1	1

Combining Parts A and B



Connecting the locking mechanism to the key to lock circuit is a bonus to locking the whole circuit when the user has too many attempts. The little box to the right of the comparator serves to be the locking mechanism. It has 3 inputs, the input, run and reset. So when the lock and key value are the same, it will give an output value from the comparator and with the locking mechanism, the number of attempts can be set and the run button will send an output which will unlock the lock when pushed. The reset button resets the whole circuit.

Truth table:

	K1	K2	K3	L1	L2	L3	X1
1	0	0	0	0	0	0	0
2	0	0	0	0	0	1	0
3	0	0	0	0	1	0	0
4	0	0	0	0	1	1	0
5	0	0	0	1	0	0	0
6	0	0	0	1	0	1	0
7	0	0	0	1	1	0	0
8	0	0	0	1	1	1	0
9	0	0	1	0	0	0	0
10	0	0	1	0	0	1	0
11	0	0	1	0	1	0	0
12	0	0	1	0	1	1	0
13	0	0	1	1	0	0	0
14	0	0	1	1	0	1	0
15	0	0	1	1	1	0	0
16	0	0	1	1	1	1	0
17	0	1	0	0	0	0	0
18	0	1	0	0	0	1	0
19	0	1	0	0	1	0	0
20	0	1	0	0	1	1	0
21	0	1	0	1	0	0	0
22	0	1	0	1	0	1	0

23	0	1	0	1	1	0	0
24	0	1	0	1	1	1	0
25	0	1	1	0	0	0	0
26	0	1	1	0	0	1	0
27	0	1	1	0	1	0	0
28	0	1	1	0	1	1	0
29	0	1	1	1	0	0	0
30	0	1	1	1	0	1	0
31	0	1	1	1	1	0	0
32	0	1	1	1	1	1	0
33	1	0	0	0	0	0	0
34	1	0	0	0	0	1	0
35	1	0	0	0	1	0	0
36	1	0	0	0	1	1	0
37	1	0	0	1	0	0	0
38	1	0	0	1	0	1	0
39	1	0	0	1	1	0	0
40	1	0	0	1	1	1	0
41	1	0	1	0	0	0	0
42	1	0	1	0	0	1	0
43	1	0	1	0	1	0	0
44	1	0	1	0	1	1	0
45	1	0	1	1	0	0	0
46	1	0	1	1	0	1	0

47	1	0	1	1	1	0	0
48	1	0	1	1	1	1	0
49	1	1	0	0	0	0	0
50	1	1	0	0	0	1	0
51	1	1	0	0	1	0	0
52	1	1	0	0	1	1	0
53	1	1	0	1	0	0	0
54	1	1	0	1	0	1	0
55	1	1	0	1	1	0	0
56	1	1	0	1	1	1	0
57	1	1	1	0	0	0	0
58	1	1	1	0	0	1	0
59	1	1	1	0	1	0	0
60	1	1	1	0	1	1	0
61	1	1	1	1	0	0	0
62	1	1	1	1	0	1	0
63	1	1	1	1	1	0	0
64	1	1	1	1	1	1	0