Kyle Powers
Assignment 4
Section 107
4/4/11

Introduction

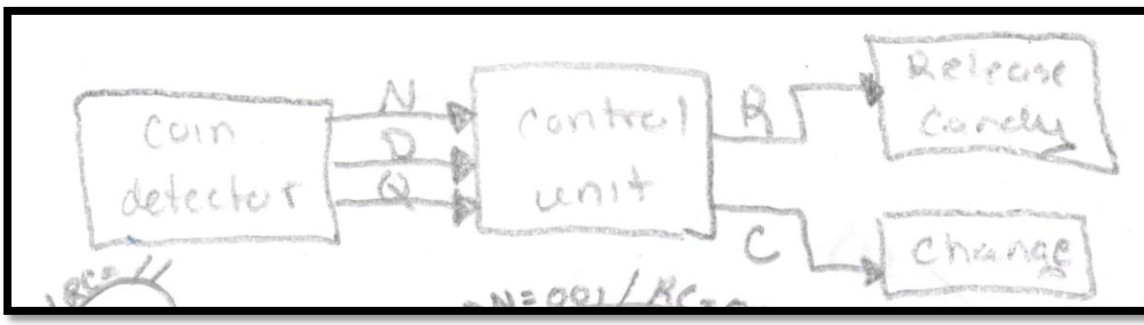
The purpose of the laboratory assignment 4 was to design a simple controller. A written description of the problem was given. From there, interfaces and coding schemes were defined. Then the FSM, encoders, and decoders to process the inputs and produce the output were implemented.

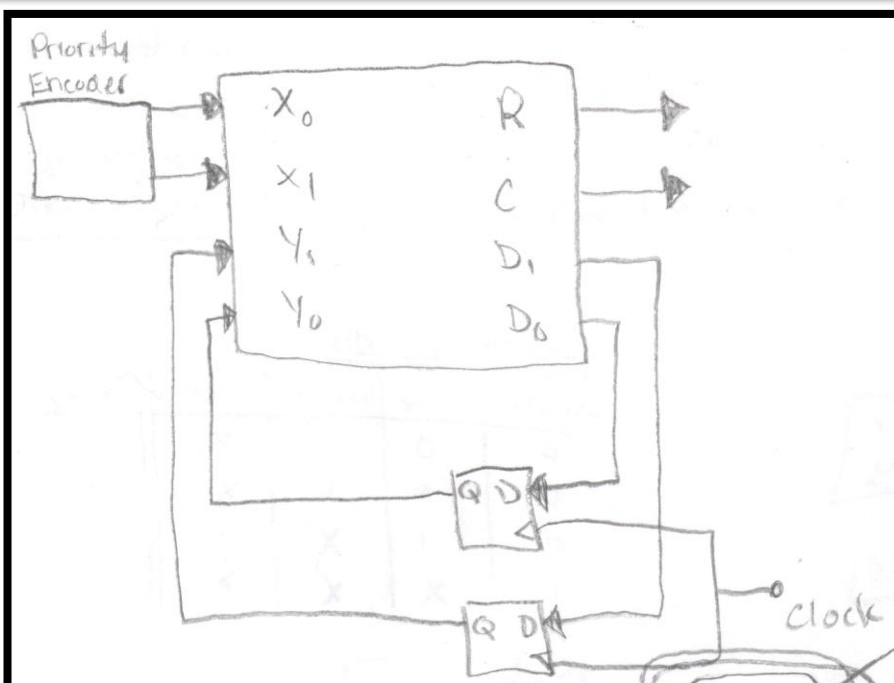
Problem Statement

The problem in laboratory assignment 4 was to design a gumball machine controller using D Flip-Flops or T Flip-Flops. The gumball machine would accept nickels, dimes, and quarters (one at a time). A single gumball would cost $0.20. Lastly, the machine could also make change.

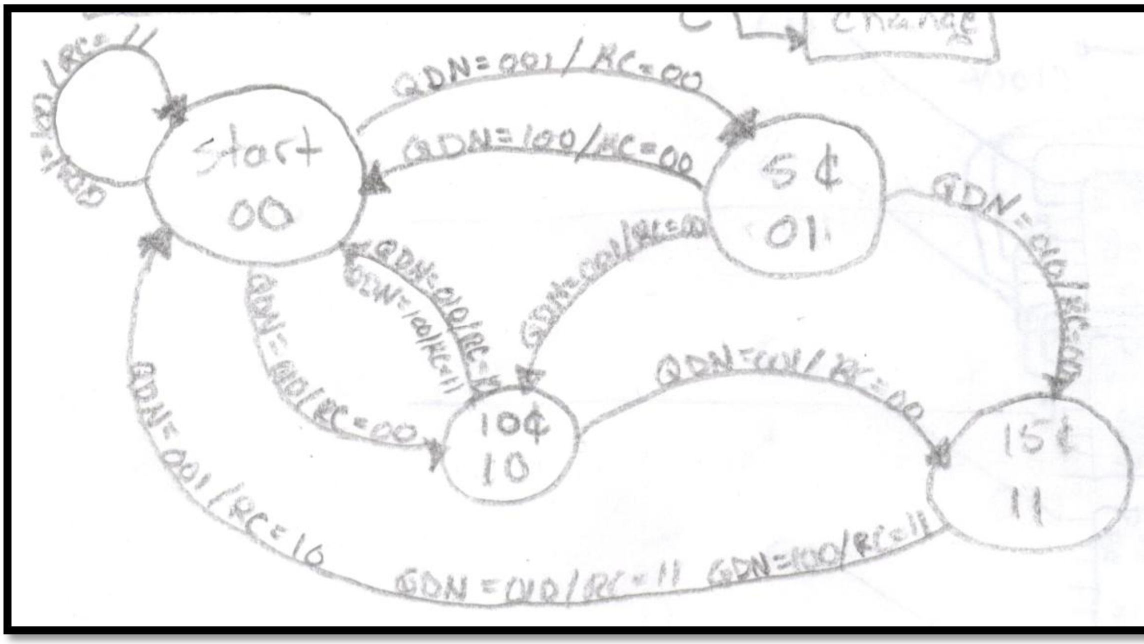
Solution

The first step in tackling this laboratory assignment was define the interface between the controller and the rest of the candy machine, similar to what was done in the class example from March 21st. The following picture from the pre-laboratory assignment shows this:

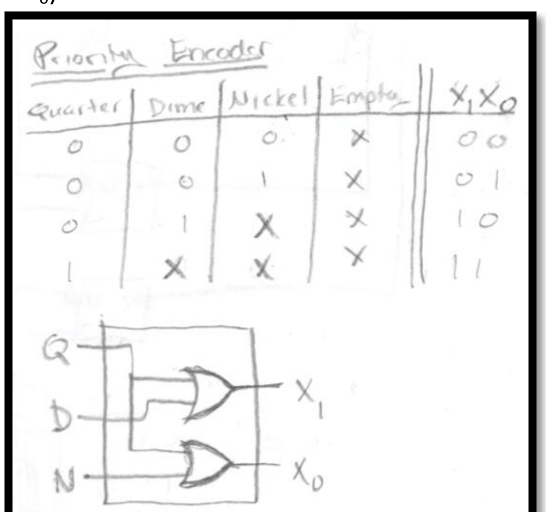




The next step involved drawing a state diagram:



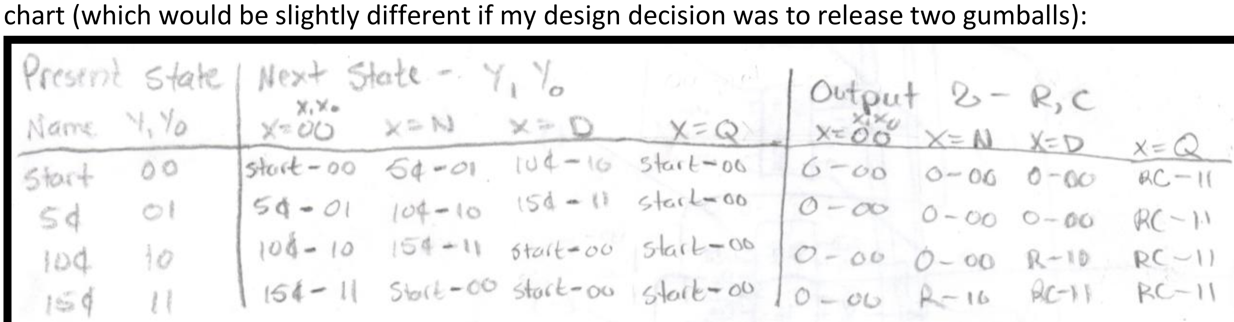
After that, a priority encoder was designed to turn three inputs (quarter, dime, nickel) into two inputs (which were then called x_1 and x_0):



Priority Encoder

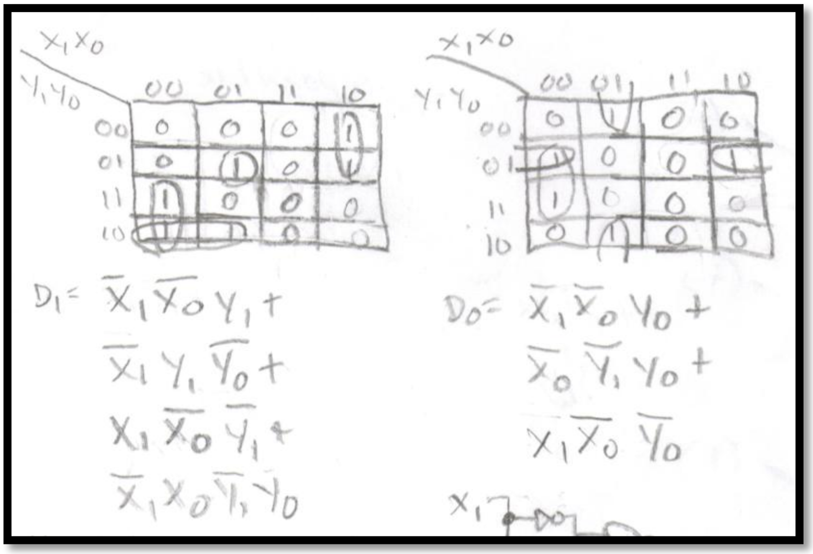
Quarter	Dime	Nickel	Empty	X_1X_0
0	0	0	X	00
0	0	1	X	01
0	1	X	X	10
1	X	X	X	11

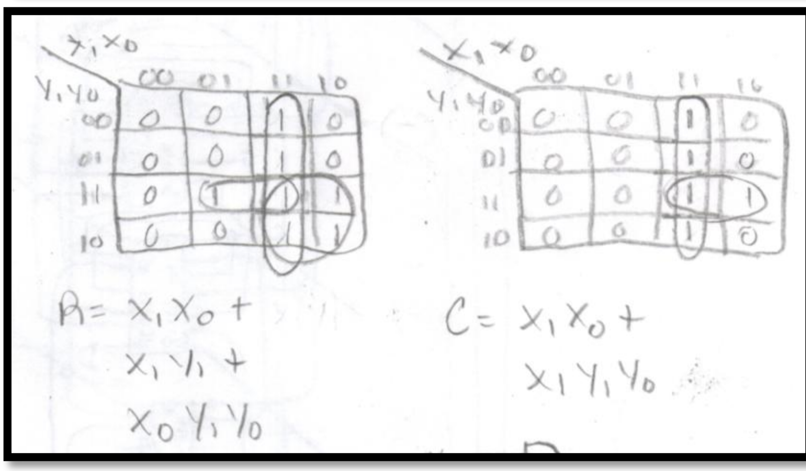
It was decided that my machine would simply give change instead of two gumballs if a user was to deposit $0.40. With this in mind, the next step in solving this laboratory assignment was to make a state chart (which would be slightly different if my design decision was to release two gumballs):



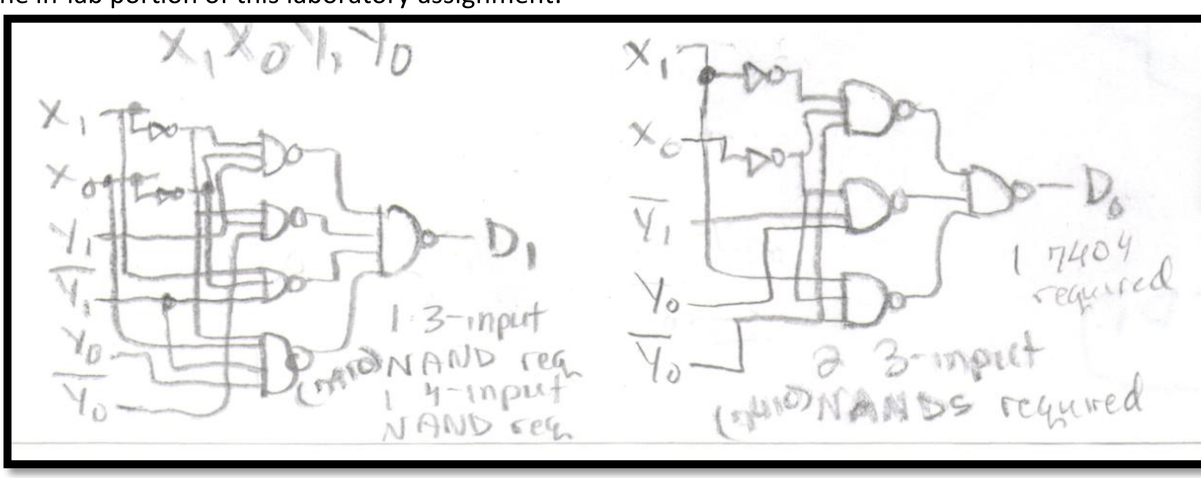
Present State		Next State - Y_1Y_0				Output Z - R,C			
Name	Y_1Y_0	X_1X_0 X=00	X=N	X=D	X=Q	X_1X_0 X=00	X=N	X=D	X=Q
Start	00	Start-00	5¢-01	10¢-10	Start-00	0-00	0-00	0-00	RC-11
5¢	01	5¢-01	10¢-10	15¢-11	Start-00	0-00	0-00	0-00	RC-11
10¢	10	10¢-10	15¢-11	Start-00	Start-00	0-00	0-00	R-10	RC-11
15¢	11	15¢-11	Start-00	Start-00	Start-00	0-00	R-10	RC-11	RC-11

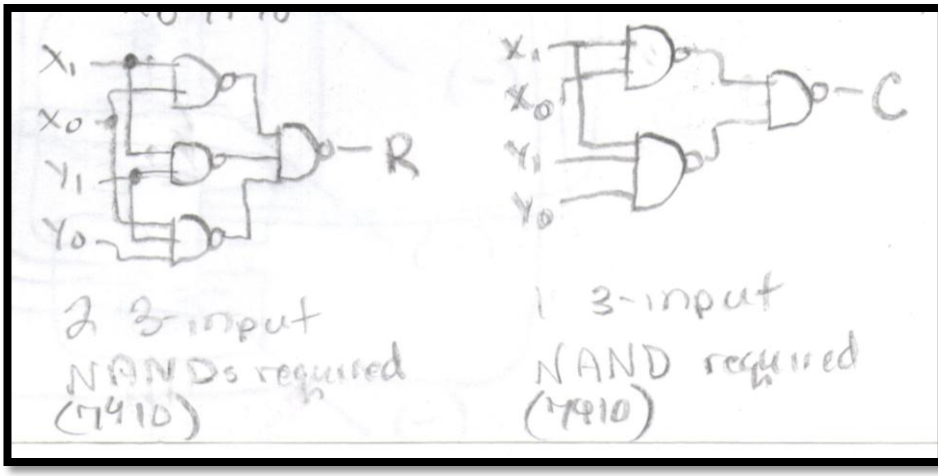
After the state chart, Karnaugh maps were used to determine D_1, D_0, R (Release gumball), and C (Give change):



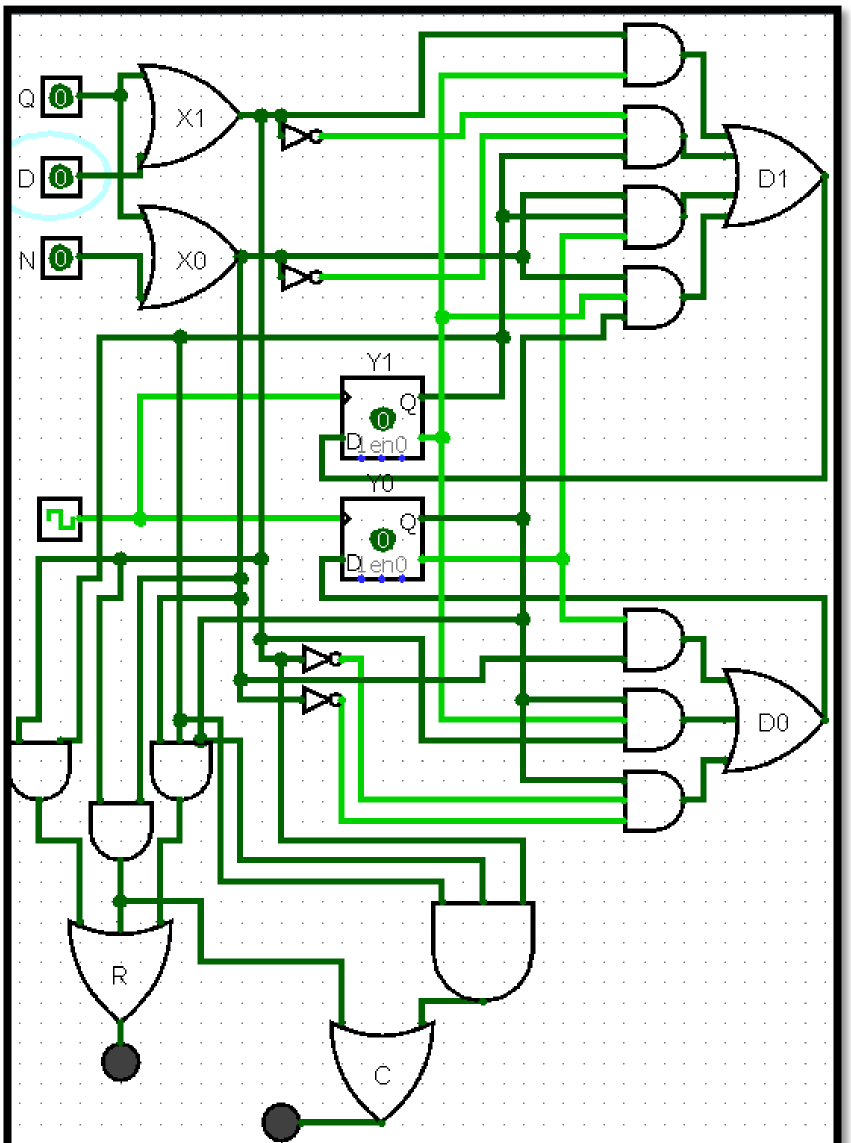


After realizing the functions for D_1, D_0, R, and C, circuit diagrams were created, to help preserve time in the in-lab portion of this laboratory assignment:

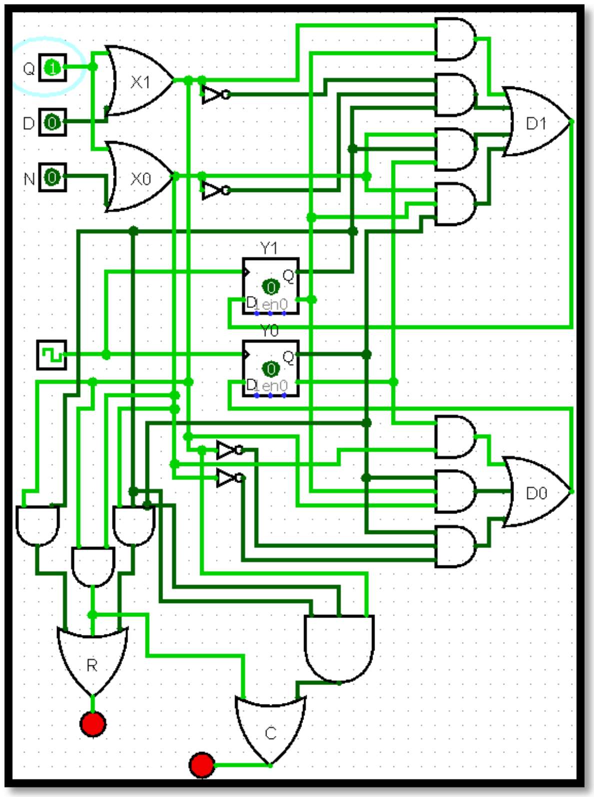




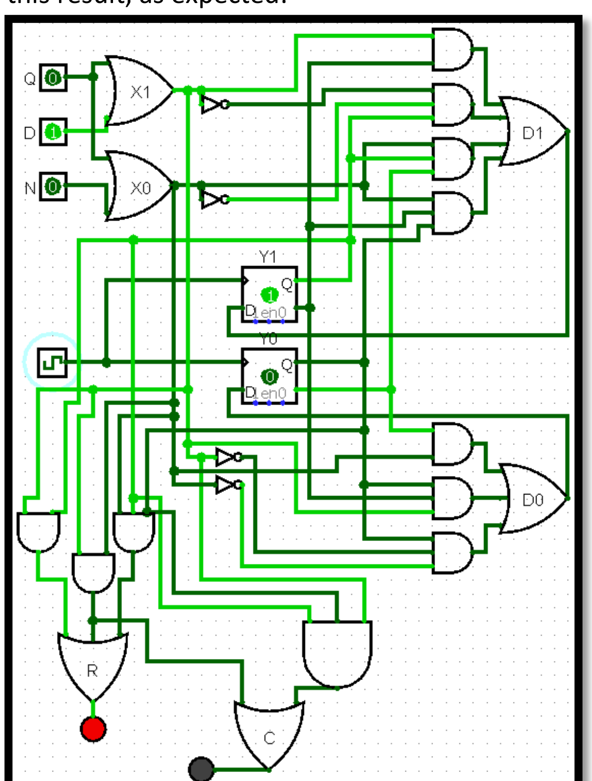
Once everything was determined, the gumball machine was then created in Logisim for testing.



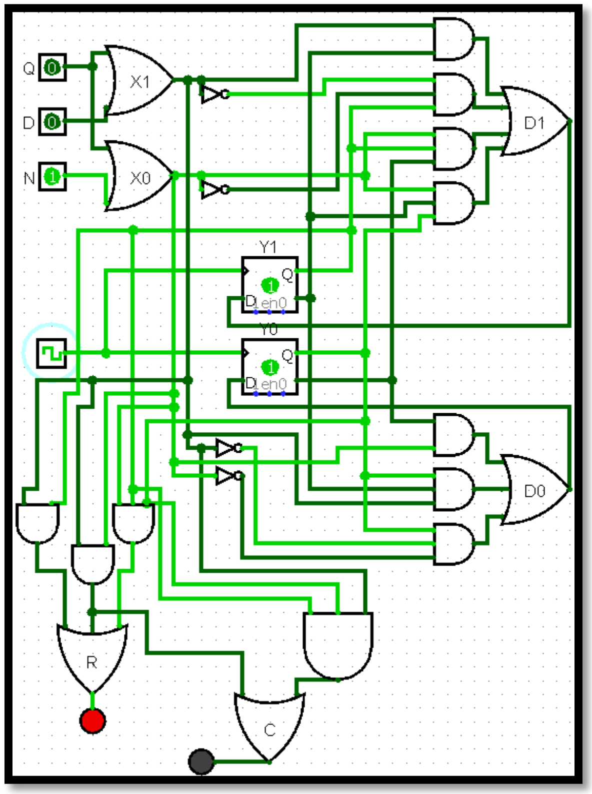
Turning on Q (a.k.a. inserting a quarter) produces this result, as expected:



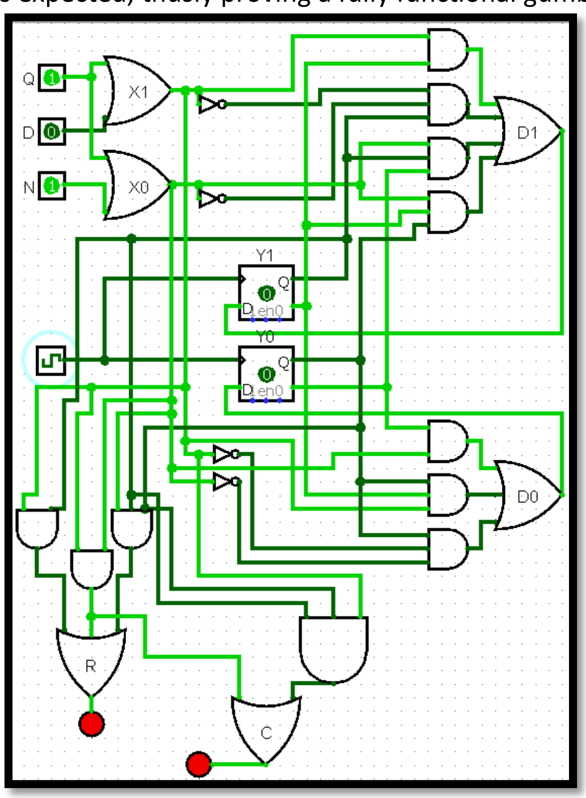
Turning on D (a.k.a. inserting a dime) and going through a clock cycle once (which resembles a second dime being inserted) yields this result, as expected:



Turning on N (a.k.a. inserting a dime) and going through 3 additional clock cycles (which resembles inserting 3 more nickels) yields this result, as expected:

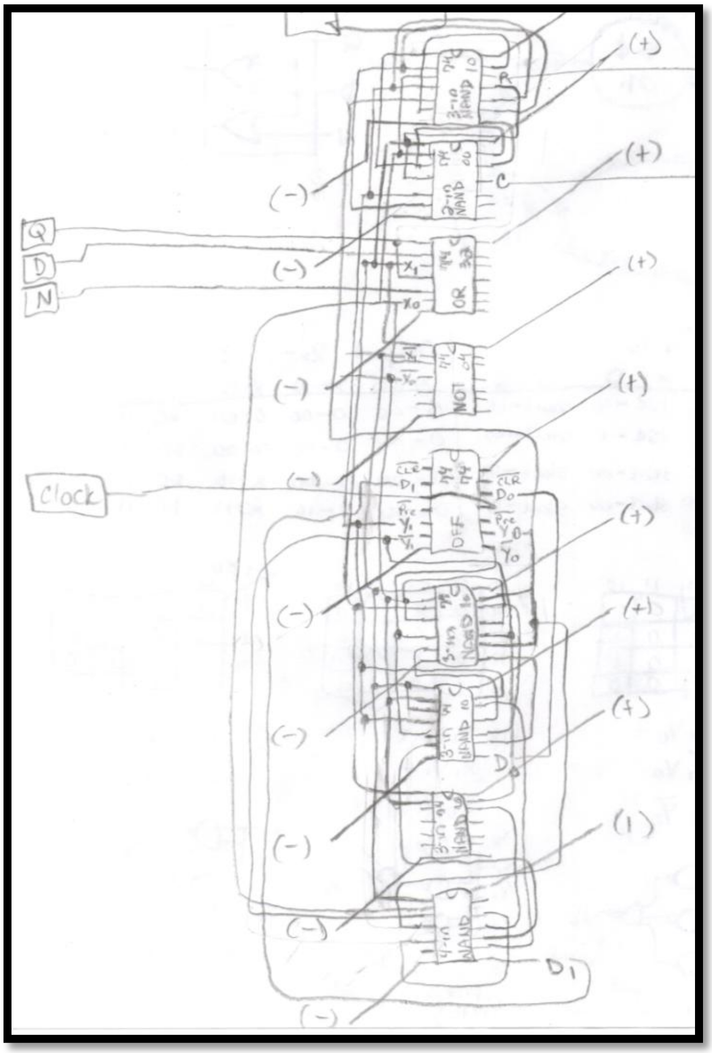


Other combinations work as expected, thusly proving a fully functional gumball machine.



Problems Encountered

The main problem encountered was how complicating the wiring became. The circuit diagram was so wire intensive, that the wires became in short supply. Most students simply stopped working when they ran out of wires, as there was nothing else they could do. In an attempt to alleviate the design process prior to lab, a realistic design was created as follows (which further exemplifies the complexity of this lab):



Conclusion

In the end, the gumball machine was proven effective. While the laboratory assignment took the entire time – due to the complications of wiring –, the use of Logisim to test the circuit diagram prior to lab proved to be an effective pre-laboratory decision. Laboratory assignment 4 ultimately enhanced my understanding of finite state machines, encoders, and decoders.

On my honor as a student of the University of Virginia, I have neither given nor received aid on this assignment.

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