Project Title: Vending Machine (Mealy)

Semester Project: Digital Logic Design

Course: BEE-13CD

Teacher: Sir Arshad Nazir

Submitted by:

Name	Reg.No
Aazmir Ahmed Bhatti	366399
Abdur Rahim Muhammad Ghani	369247
Waleed Amir	365843

Dedication

I would like dedicate this project to my close friends and family. They inspired me to keep moving on this journey to learn no matter how many sacrifices you made on the way. Also, this is dedicated to my Lecturer Sir.Arshad Nazir who taught me that learning is the process whereby knowledge is created through the transformation of experience.

Acknowledgements

I wish to register my profound gratitude to Almighty Allah for the guidance and grace throughout my life. I would like to extend special regards to my amazing parents who are the source of any success in my life. May Allah continue showering them with blessings, Ameen.

I am also grateful to all of my friends in section BEE-13D for making my life at university educative and worthwhile.

In addition, my special gratitude goes to my digital logic design professer at national university of science and technology, Sir.Arshad Nazir for his immense contributions. Likewise, I also appreciate all my amazing lecturers in the department for their seasoned lectures and guidance. May the Almighty bless them all.

Abstract

The vending machine is an automated machine that dispenses various products such as snacks, Beverages etc to customers when money is inserted. The Vending Machine are way more accessible and practical compared to the typical purchasing methods. There has been growing demand of vending machine in various countries including Pakistan. There are 2 different types of state machines, Moore and Mealy. Our project focuses on Mealy machine which shows different outputs on each transition between states. In mealy machine, the outputs are a function of the present state and the current inputs. The aim of this project is to design a vending machine that can dispense four different products with different prices with a few additional features such as displaying the change received. The machine accepts coins of denominations 10Rs, 20Rs and 50Rs. The modelling of this Vending machine will help in reducing the required hardware and build a more efficient & cost friendly product.

Keywords – Vending machine, Mealy, modelling, state machines.

List of Figures:

Table of Contents

Contents

Chapter 1: Introduction

1.1 Overview of Project

A state diagram is constructed for the proposed machine which can vend four products that is a burger, juice, chocolate and a cupcake. Four select (select1, select2, select3, select4) inputs are taken for selection of products. Select1 is used for the selection of burger. Similarly select2, select3, select4 are used for cupcake, juice and chocolate respectively. Two bits are used to represent the binary codes that represent each item. A 2 to 4 decoder is used to convert the binary input into separate selection inputs for each item.

Rs_10, Rs_20, Rs_50, coins are used as inputs. For the inputs, two bits are used to represent each coin inputs and a 2 to 4 decoder is used to convert the binary input into selection inputs for each coin entered which changes the state of the machine.Product and change are the outputs.The change is displayed through a seven bit display and calculated through a binary subtractor. |The binary subtractor is also used as a magnitude comparator. If the result of the subtraction is negative(carry out is 1) that means that the price of the item is greater than the money inputted so the transaction is unsuccessful. If the money entered is more than the price of the item(carry out is 0) then the transaction is successful, the change is shown and the item is dispensed. .The products with their prices are shown by table 1. Since the machine is asynchronous in nature, no clock inputs are used. The proposed vending machine is designed using FSM modelling.

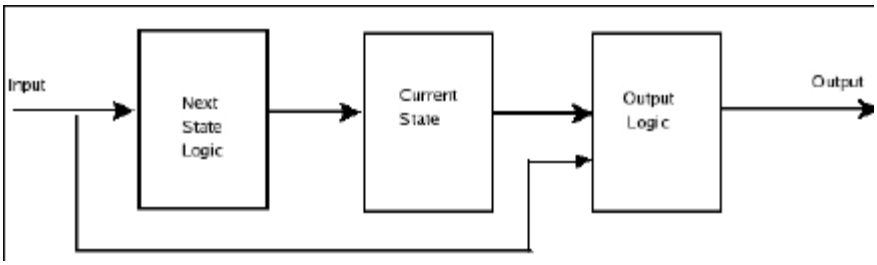


Figure 1: Mealy machine block diagram

Binary Code	Products	Price
00	Burger	30/-
01	Cupcake	65/-
10	Juice	100/-
11	Chocolate	150/-

Table 1: Products with their prices and corresponding binary codes

Binary Code	Coin
00	0/-
01	10/-
10	20/-
11	50/-

Table 2: Coin inputs with their corresponding inputs

1.2 Block Diagram

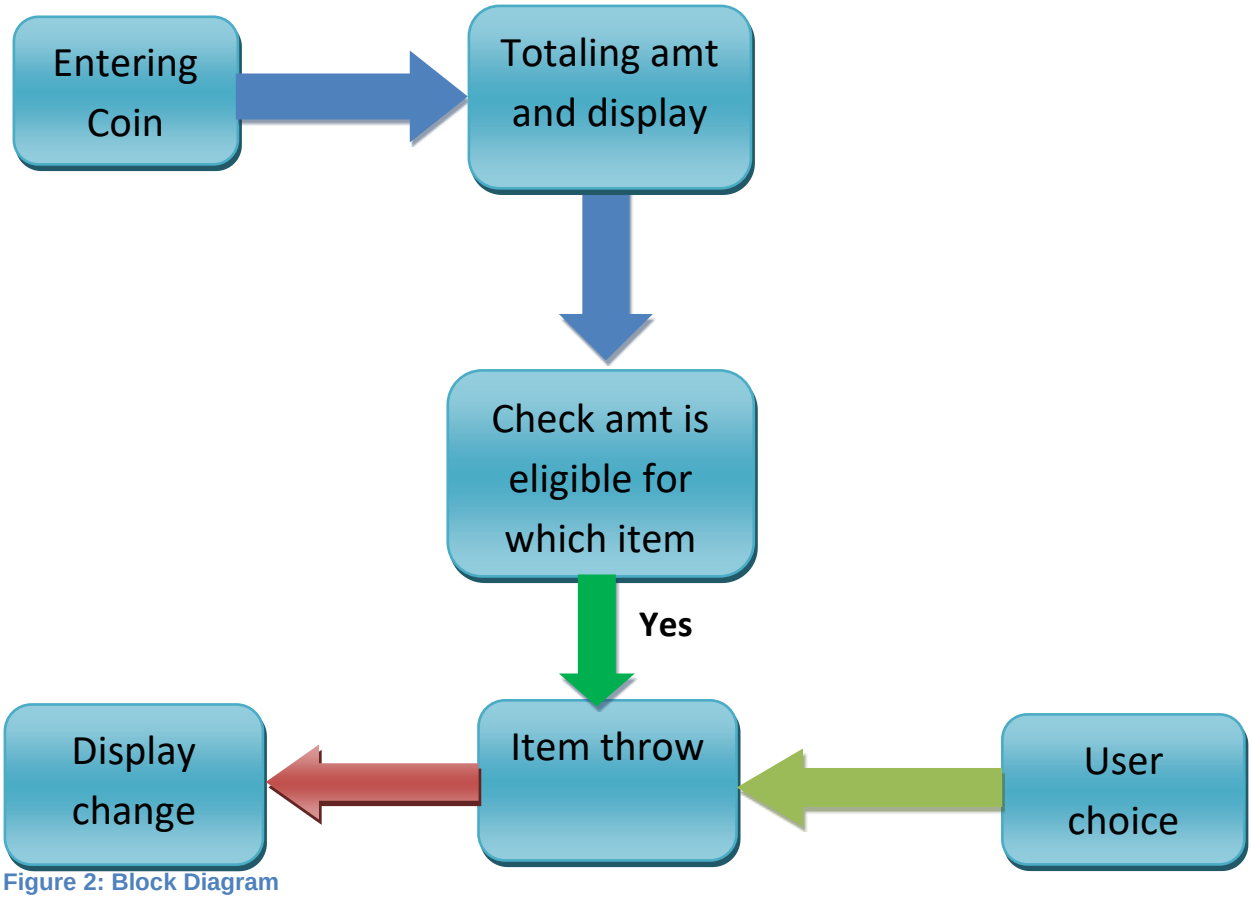


Figure 2: Block Diagram

1.2 Clear Work Division

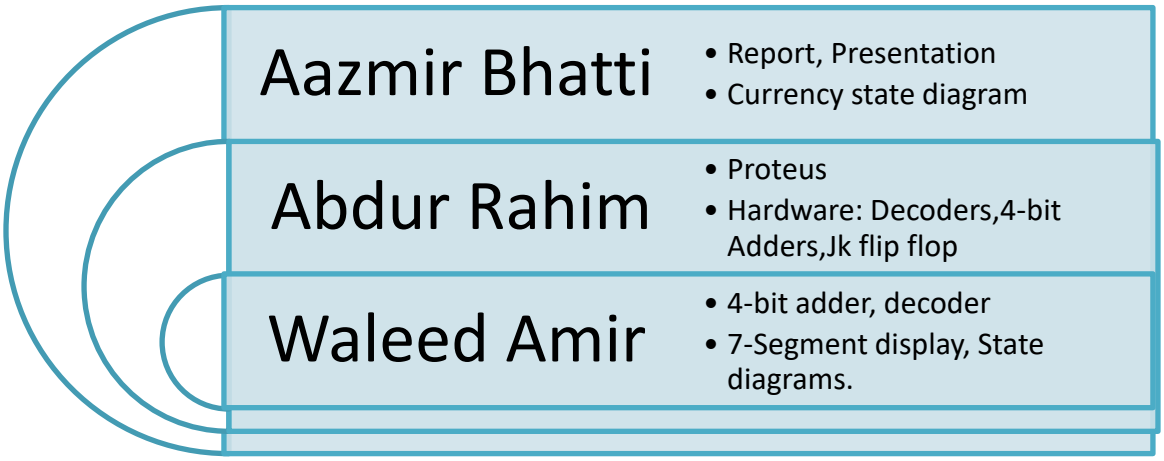


Figure 3: Work Division

Chapter 2: Design

2.1 Problem Statement

The vending machines today are controlled by a simple control system that only allows for basic functionality. We would like to improve the user experience and increase the efficiency of our vending machine by implementing a Mealy machine that can model the complex behavior of the vending machines and respond intelligently to user inputs. Our project will be able to dispense products from mulitple price ranges and also be able display change to user.

Our goal is to create a Mealy machine that can accurately model the behavior of our vending machines and improve the user experience. We will accomplish this by designing and implementing the finite state Mealy machine, testing and debugging it, and integrating it into our vending machine.

2.2 State Table

Present State (ABCD)	Input(Coins)	Next state (A*B*C*D*)	output
0 0 0 0	0 0	0 0 0 0	
0 0 0 0	0 1	0 0 0 1	
0 0 0 0	1 0	0 0 1 0	
0 0 0 0	1 1	0 1 0 1	
0 0 0 1	0 0	0 0 0 1	
0 0 0 1	0 1	0 0 1 0	
0 0 0 1	1 0	0 0 1 1	
0 0 0 1	1 1	0 1 1 0	
0 0 1 0	0 0	0 0 1 0	
0 0 1 0	0 1	0 0 1 1	
0 0 1 0	1 0	0 1 0 0	
0 0 1 0	1 1	0 1 1 1	
0 0 1 1	0 0	0 0 1 1	
0 0 1 1	0 1	0 1 0 0	
0 0 1 1	1 0	0 1 0 1	
0 0 1 1	1 1	1 0 0 0	
0 1 0 0	0 0	0 1 0 0	
0 1 0 0	0 1	0 1 0 1	
0 1 0 0	1 0	0 1 1 0	
0 1 0 0	1 1	1 0 0 1	
0 1 0 1	0 0	0 1 0 1	
0 1 0 1	0 1	0 1 1 0	
0 1 0 1	1 0	0 1 1 1	
0 1 0 1	1 1	1 0 1 0	
0 1 1 0	0 0	0 1 1 0	
0 1 1 0	0 1	0 1 1 1	
0 1 1 0	1 0	1 0 0 0	
0 1 1 0	1 1	1 0 1 1	
0 1 1 1	0 0	0 1 1 1	
0 1 1 1	0 1	1 0 0 0	
0 1 1 1	1 0	1 0 0 1	
0 1 1 1	1 1	1 1 0 0	
1 0 0 0	0 0	1 0 0 0	
1 0 0 0	0 1	1 0 0 1	
1 0 0 0	1 0	1 0 1 0	
1 0 0 0	1 1	1 1 0 1	
1 0 0 1	0 0	1 0 0 1	
1 0 0 1	0 1	1 0 1 0	
1 0 0 1	1 0	1 0 1 1	
1 0 0 1	1 1	1 1 1 0	
1 0 1 0	0 0	1 0 1 0	
1 0 1 0	0 1	1 0 1 1	
1 0 1 0	1 0	1 1 0 0	

1 0 1 0	1 1	1 1 1 1	
1 0 1 1	0 0	1 0 1 1	
1 0 1 1	0 1	1 1 0 0	
1 0 1 1	1 0	1 1 0 1	
1 0 1 1	1 1	0 0 0 0	1
1 1 0 0	0 0	1 1 0 0	
1 1 0 0	0 1	1 1 0 1	
1 1 0 0	1 0	1 1 1 0	
1 1 0 0	1 1	0 0 0 0	1
1 1 0 1	0 0	1 1 0 1	
1 1 0 1	0 1	1 1 1 0	
1 1 0 1	1 0	1 1 1 1	
1 1 0 1	1 1	0 0 0 0	1
1 1 1 0	0 0	1 1 1 0	
1 1 1 0	0 1	1 1 1 1	
1 1 1 0	1 0	0 0 0 0	1
1 1 1 0	1 1	0 0 0 0	1
1 1 1 1	0 0	1 1 1 1	
1 1 1 1	0 1	0 0 0 0	1
1 1 1 1	1 0	0 0 0 0	1
1 1 1 1	1 1	0 0 0 0	1

Figure 1: State Table for the Design

2.3 State Diagram of Currency

10RS currency:

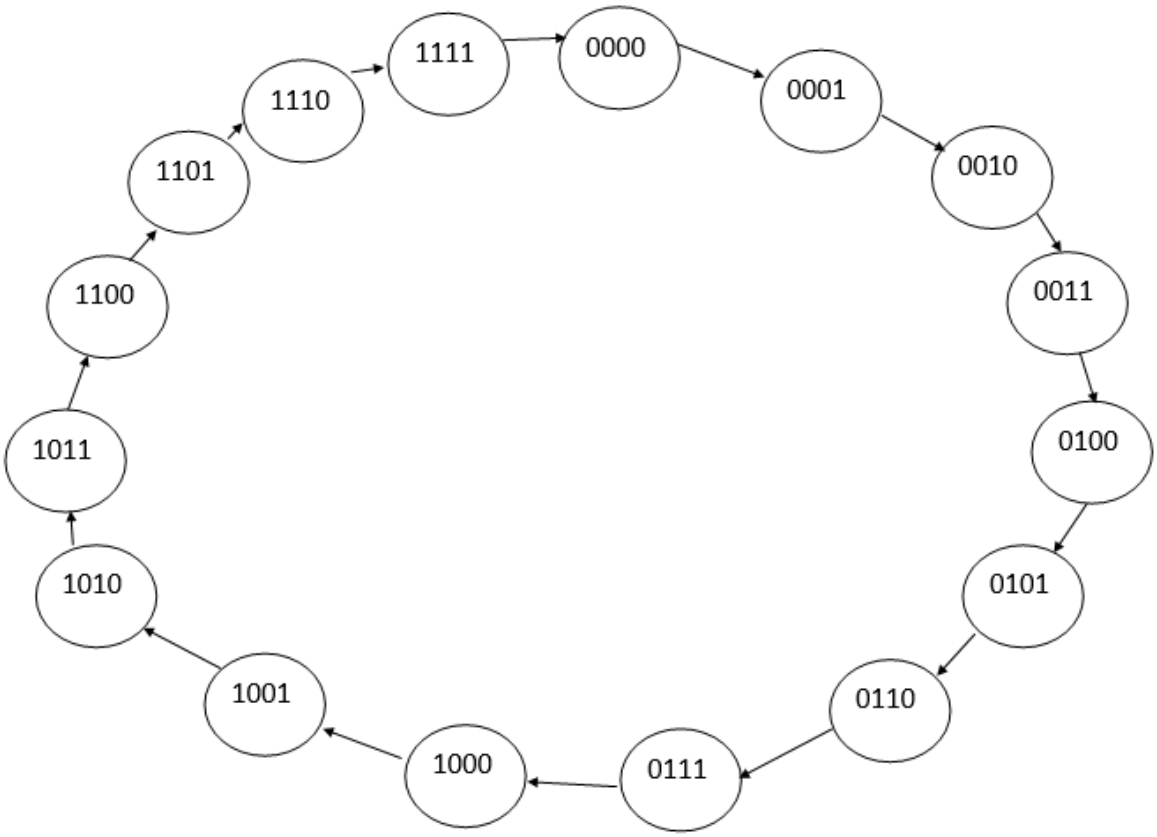


Figure 4: 10Rs cuurency

20RS currency:

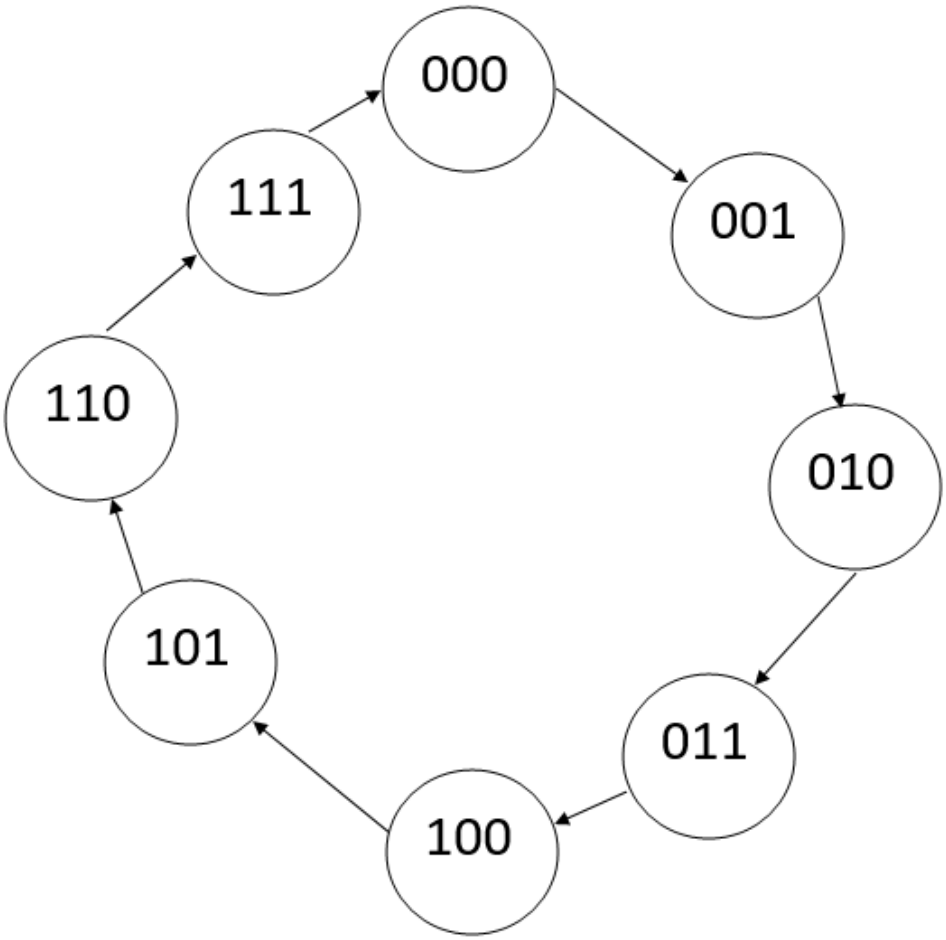


Figure 5: 20Rs cuurency

50RS currency:

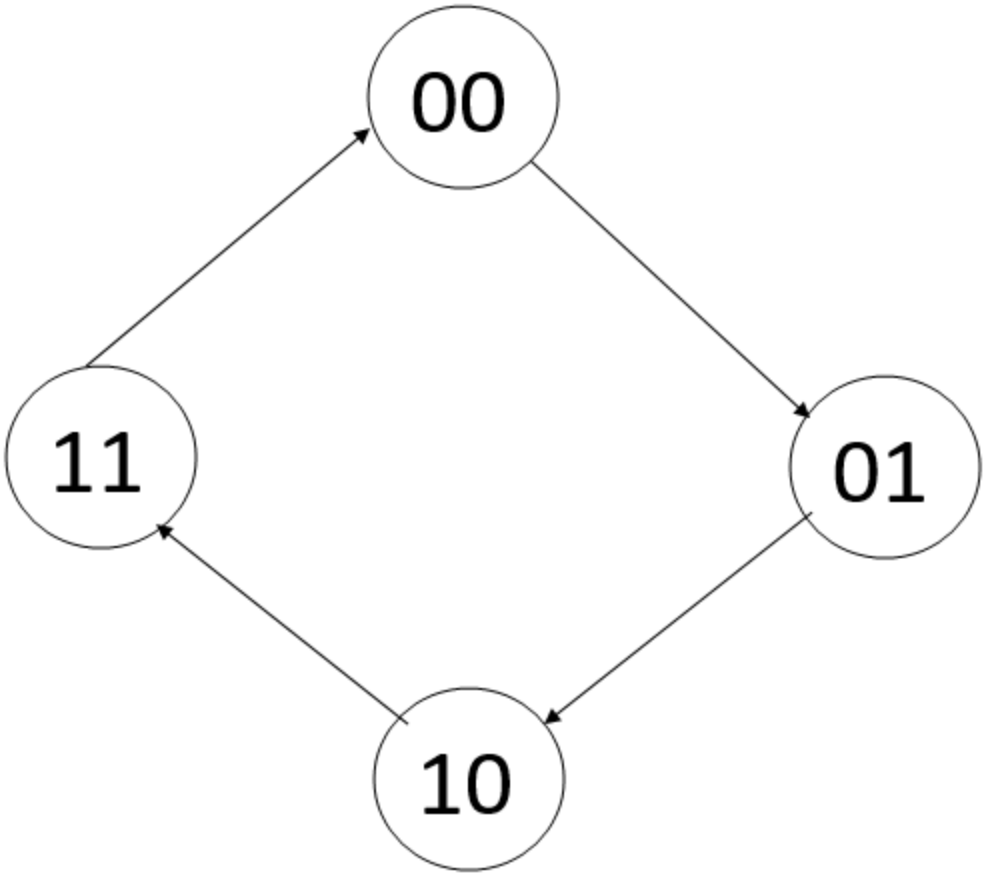


Figure 6: 50Rs cuurency

2.4 Simplification of Functions / K-Maps & Equations

Give the K-maps in a standard table format. Again, do not copy-paste it. Use consistent font. Edit equations using a standard format.

- Simplification of A:

(32,33,34,35,36,37,38,39)	$A\overline{B}\overline{C}$
(32,33,34,35,40,41,42,43)	$A\overline{B}\overline{D}$
(32,33,36,37,40,41,44,45)	$A\overline{B}\overline{E}$
(32,33,36,37,48,49,52,53)	$A\overline{C}\overline{E}$
(32,33,40,41,48,49,56,57)	$A\overline{D}\overline{E}$
(32,34,36,38,40,42,44,46)	$A\overline{B}\overline{F}$
(32,34,36,38,48,50,52,54)	$A\overline{C}\overline{F}$
(32,36,40,44,48,52,56,60)	$A\overline{E}\overline{F}$
(19,23,27,31)	$\overline{A}BEF$
(26,27,30,31)	$\overline{A}BCE$
(15,31)	$\overline{A}CDEF$

$$y = AB'C' + AB'D' - AB'E' - AC'E' - AD'E' + AB'F' - AC'F' - AE'F' - A'BEF - A'BCE + A'CDEF$$

- Simplification of B:

(16,17,20,21,48,49,52,53)	$B.\overline{C}.\overline{E}$
(16,17,24,25,48,49,56,57)	$B.\overline{D}.\overline{E}$
(16,18,20,22,48,50,52,54)	$B.\overline{C}.\overline{F}$
(16,20,24,28,48,52,56,60)	$B.\overline{E}.\overline{F}$
(3,7,35,39)	$\overline{B}.\overline{C}.E.F$
(3,11,35,43)	$\overline{B}.\overline{D}.E.F$
(10,14,42,46)	$\overline{B}.C.E.\overline{F}$
(13,45)	$\overline{B}.C.D.\overline{E}.F$
(31)	$\overline{A}.B.C.D.E.F$

$$y = BC'E' + BD'E' + BC'F' + BE'F' + B'C'EF + B'D'EF - B'CEF' - B'CDE'F - A'BCDEF$$

- Simplification of C:

(2,6,18,22,34,38,50,54)	$\overline{C}.E.\overline{F}$
(5,7,21,23)	$\overline{A}.\overline{C}.D.F$
(5,7,37,39)	$\overline{B}.\overline{C}.D.F$
(5,21,37,53)	$\overline{C}.D.\overline{E}.F$
(8,9,40,41)	$\overline{B}.C.\overline{D}.\overline{E}$
(9,11,25,27)	$\overline{A}.C.\overline{D}.F$
(9,11,41,43)	$\overline{B}.C.\overline{D}.F$
(12,28,44,60)	$C.D.\overline{E}.\overline{F}$
(40,41,56,57)	$A.C.\overline{D}.\overline{E}$

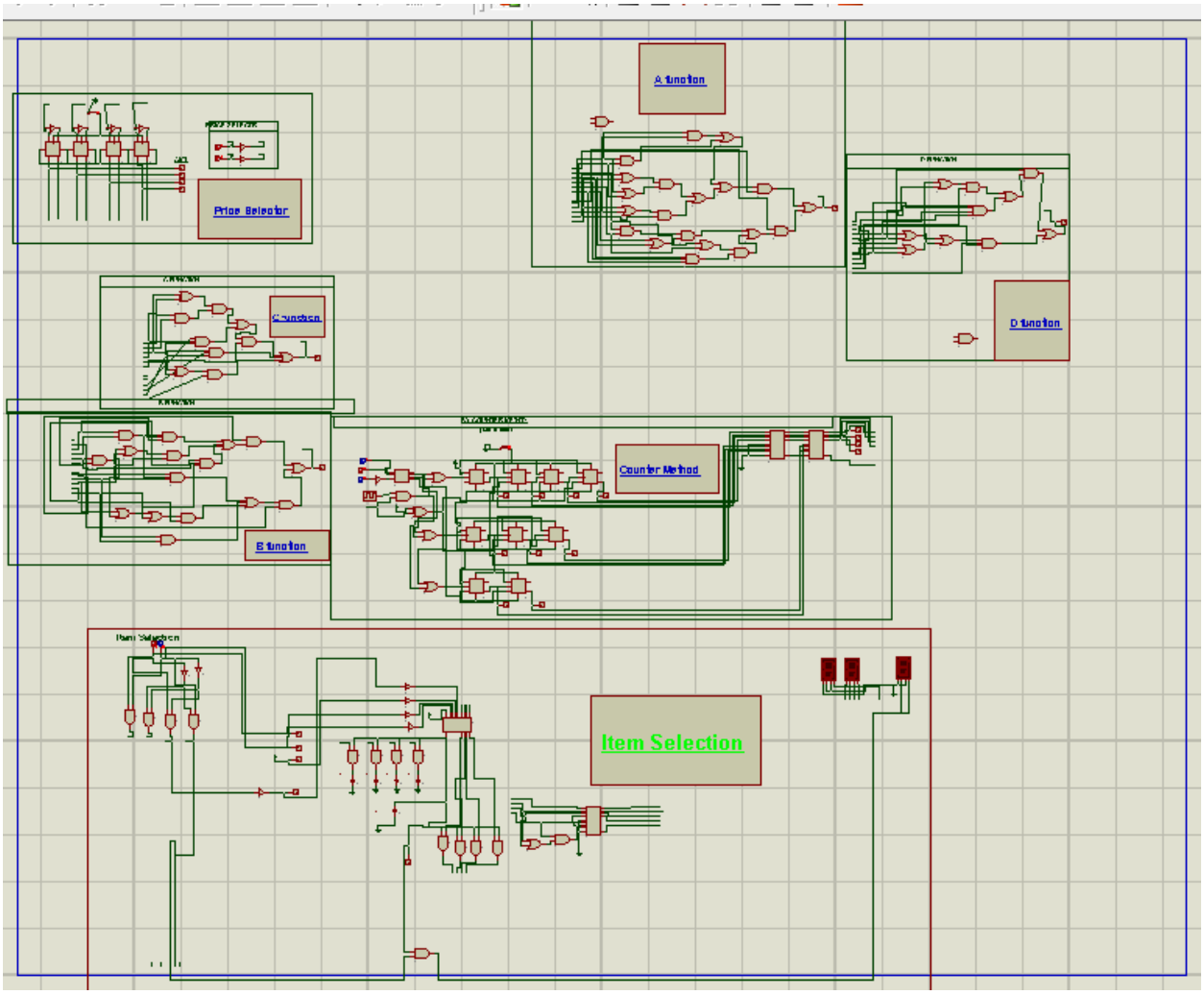
$$y = C'EF' + A'C'DF - B'C'DF - C'DE'F + B'CD'E' - A'CD'F + B'CD'F + CDE'F' - ACD'E'$$

- Simplification of D:

(1,3,9,11,17,19,25,27)	$\overline{A}.\overline{D}.F$
(1,3,9,11,33,35,41,43)	$\overline{B}.\overline{D}.F$
(1,9,17,25,33,41,49,57)	$\overline{D}.\overline{E}.F$
(4,6,12,14,20,22,28,30)	$\overline{A}.D.\overline{F}$
(4,6,12,14,36,38,44,46)	$\overline{B}.D.\overline{F}$
(4,6,20,22,36,38,52,54)	$\overline{C}.D.\overline{F}$
(4,12,20,28,36,44,52,60)	$D.\overline{E}.\overline{F}$

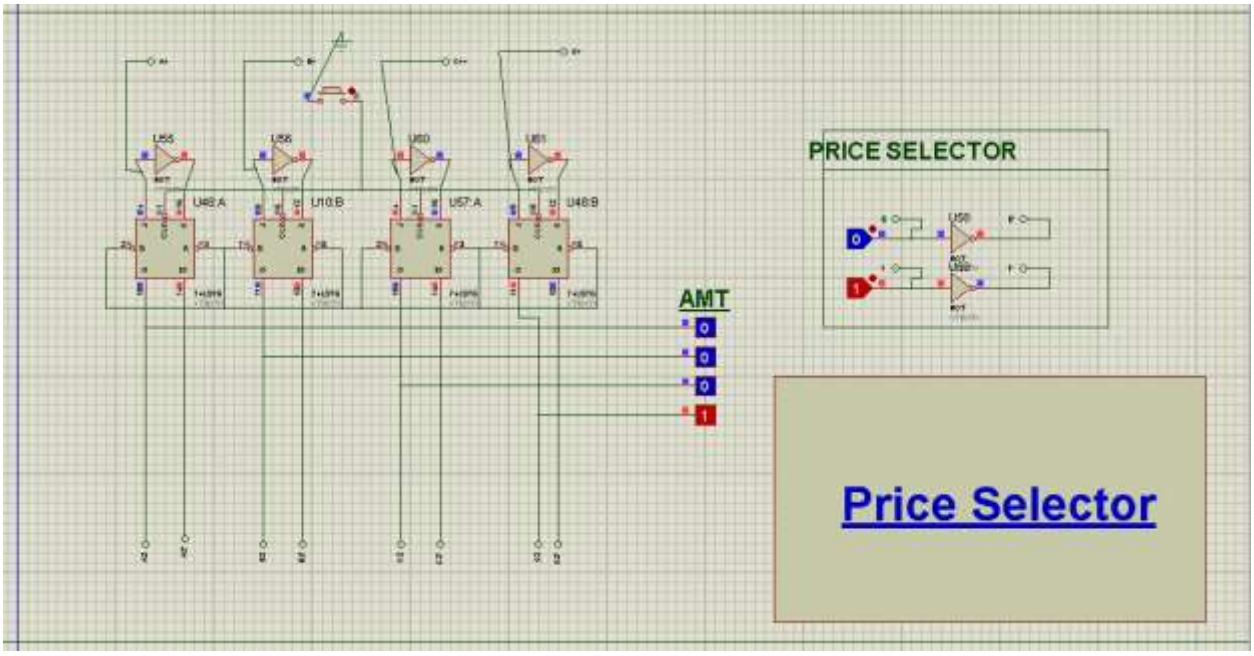
$$y = A'D'F + B'D'F + D'E'F + A'DF' + B'DF' + C'DF' - DE'F'$$

2.5 Complete Logic Diagram

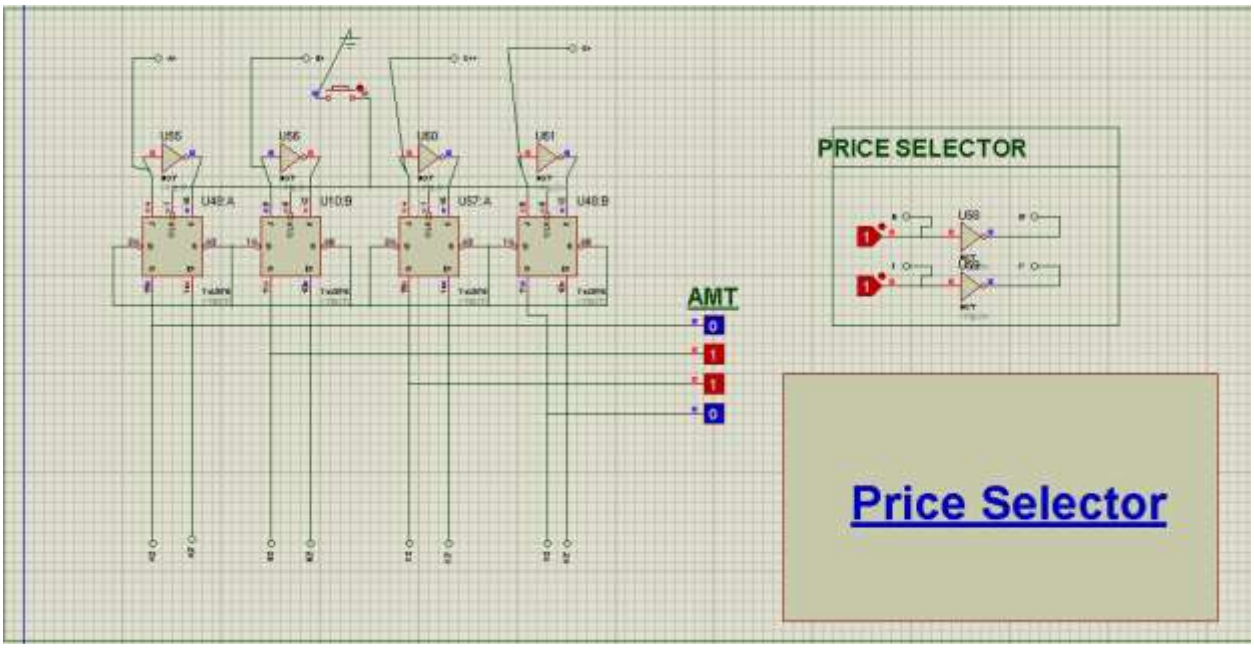


2.6 Simulation If Required

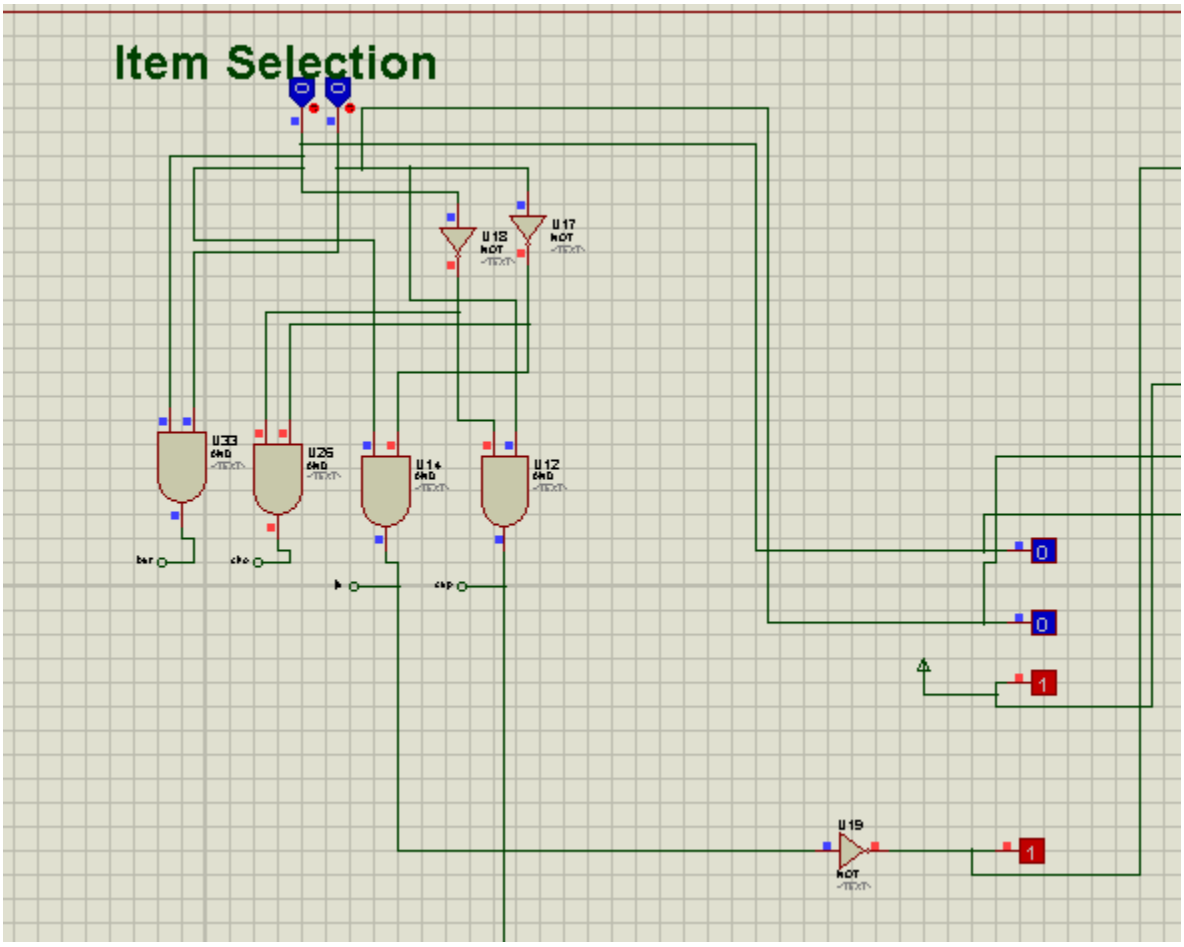
- **10Rs(01) entered button is clicked output 0001 =10Rs.**



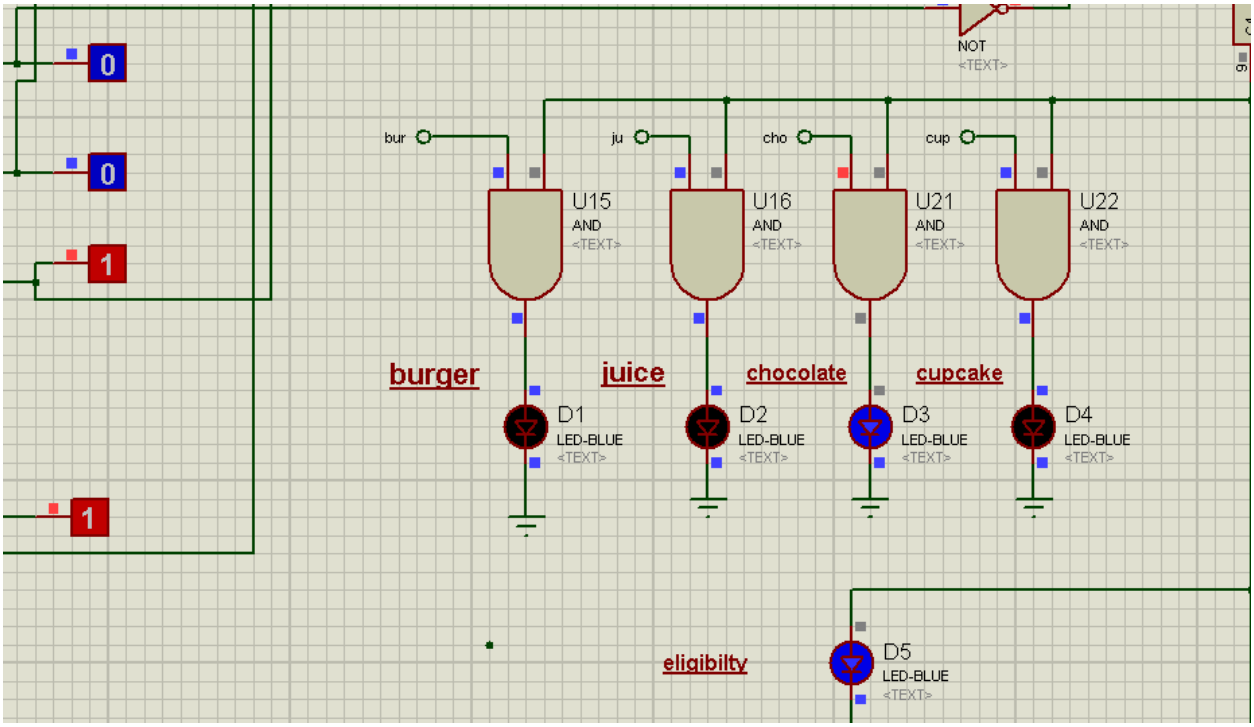
- **50Rs(1 1) entered button is cliked total is added with previous which is 60Rs = 0 1 1 0.**



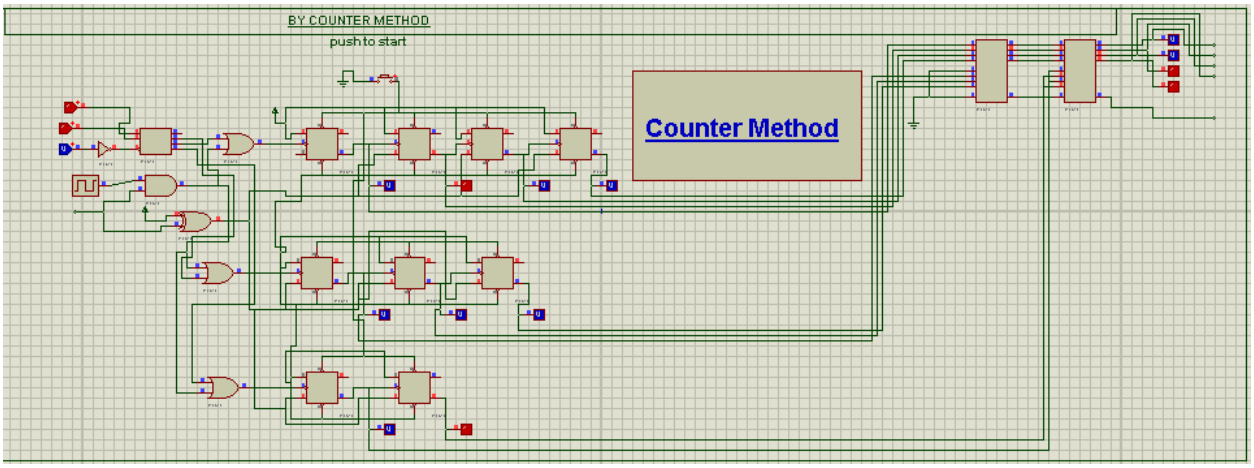
- **30 Rs(0 0) item selected :**



- **Chocolate led is on as the amount is accepted and the led for eligibility turns on :**



- **Alternate method using counters :**

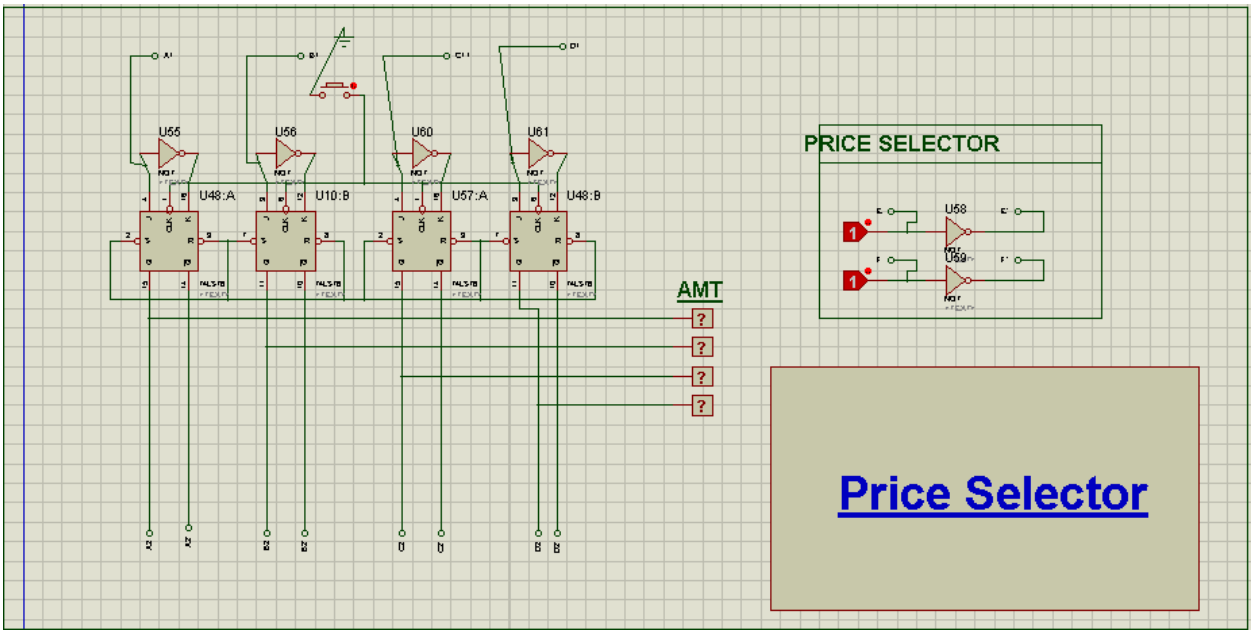


Chapter 3: Hardware Implementation

3.1 Detailed Schematic of Design and its Description

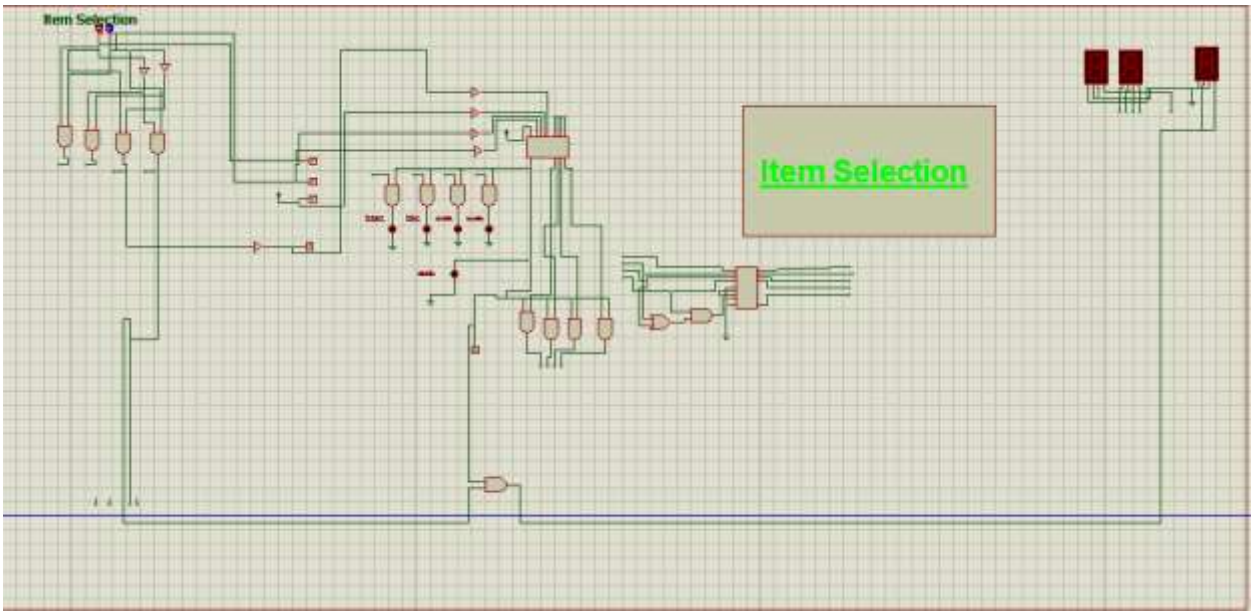
- **Price Selector :**

-Price of any input is chosen from here from a range of 0 to 150Rs.



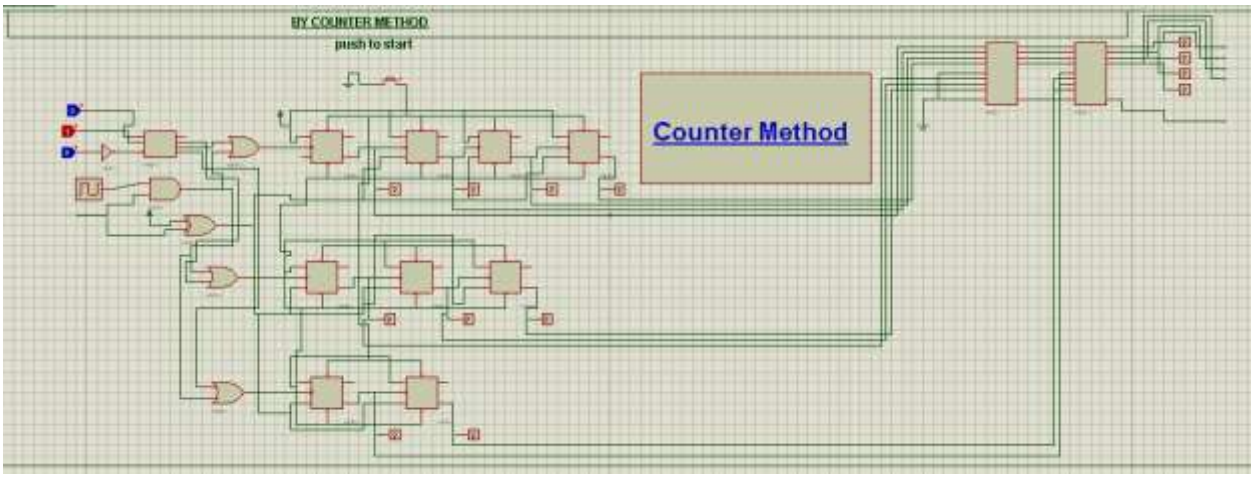
- **Item Selection :**

-Item is selected from here 4 types cupcake, chocolate,burger and juice. If the amount entered previously was enough to purchase product the led blinks indicating the eligibility if it can be purchaced..



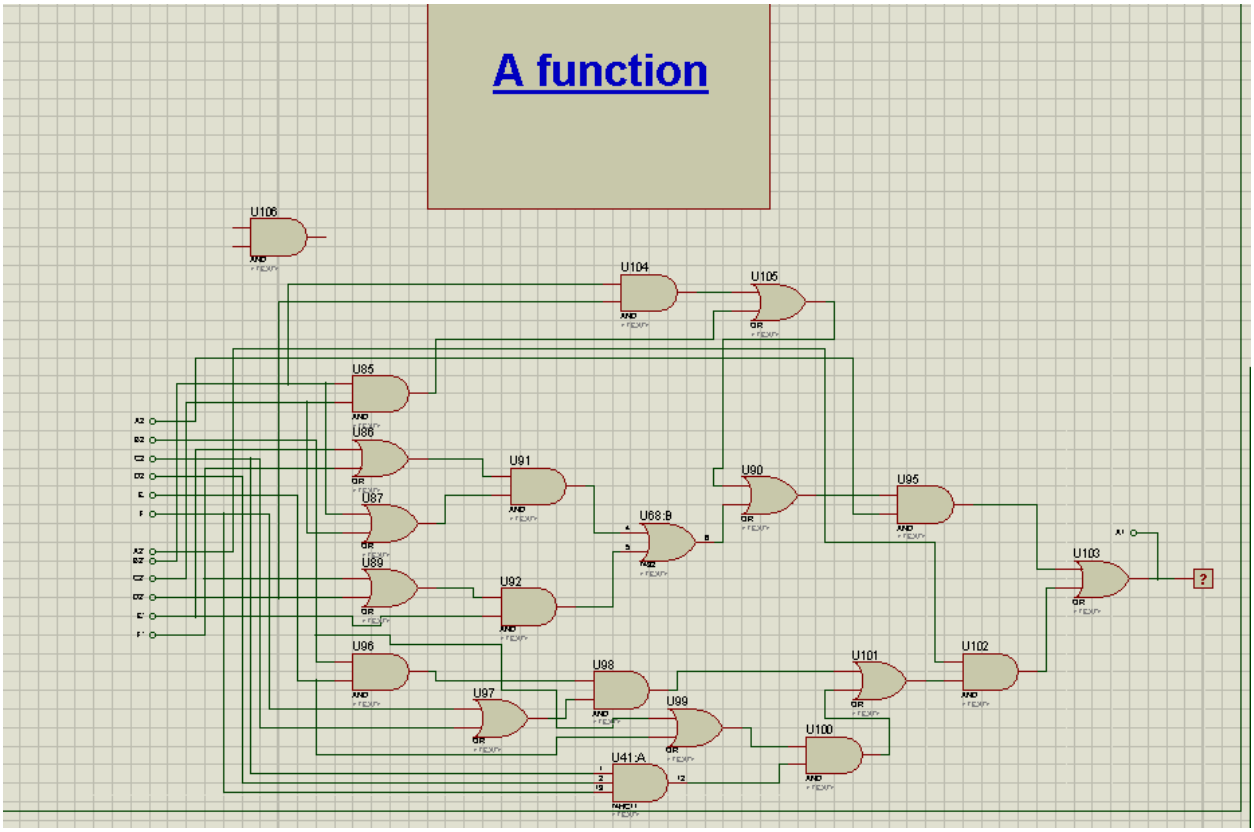
- **Counter Method :**

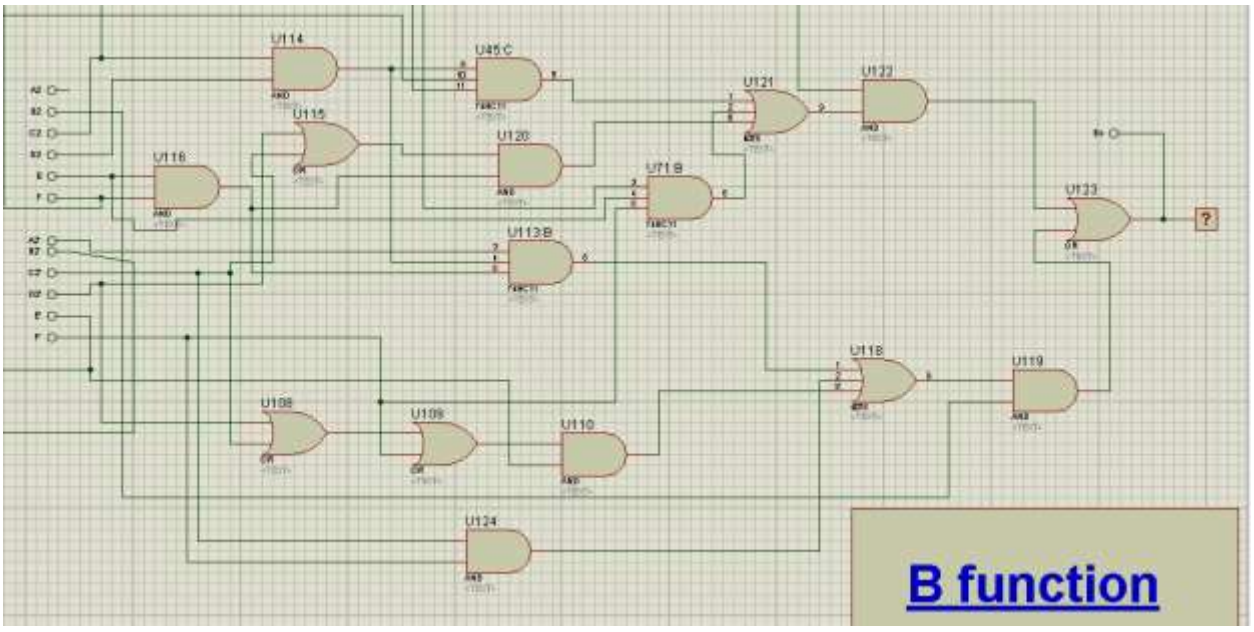
-Alternate method using counters to implement circuit.

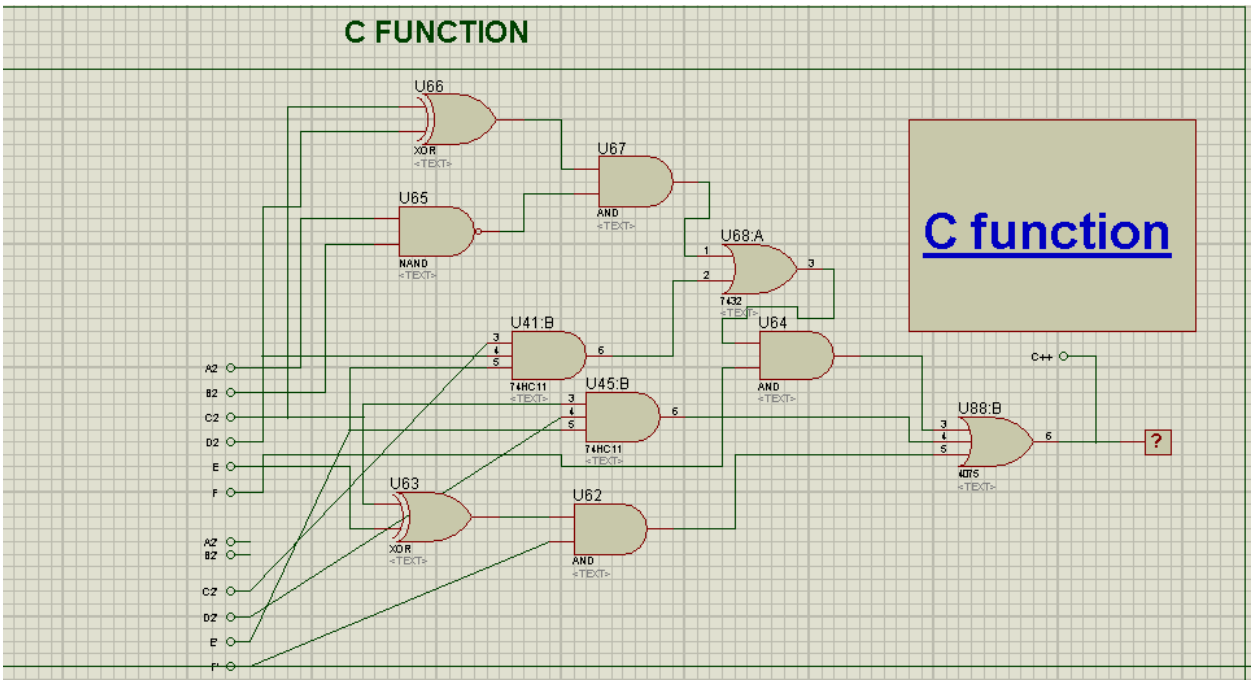


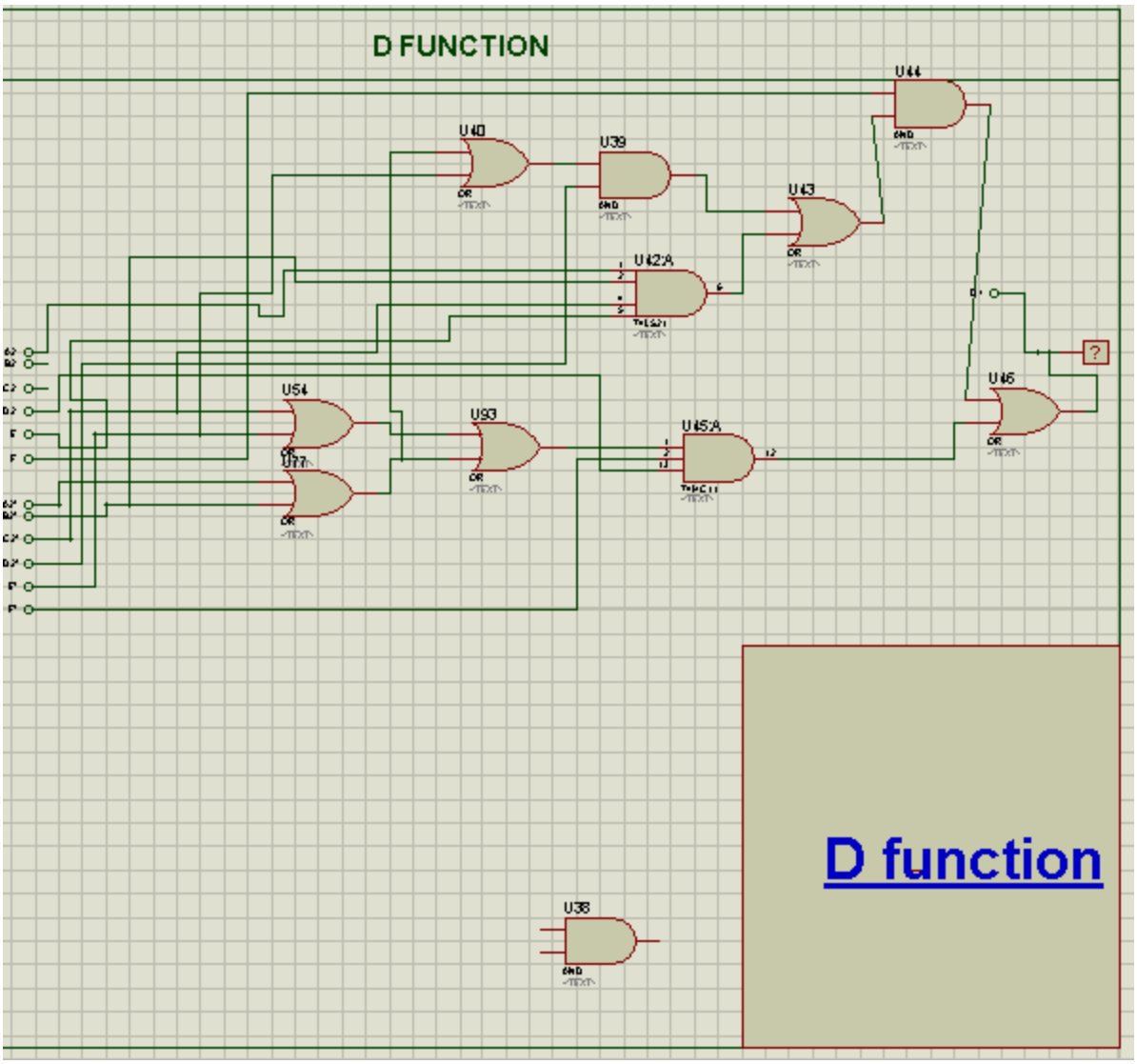
- **Functions A,B,C,D :**

-Simplified expressions using K-maps


A function
U106
U104
U105
U85
U86
U87
U89
U96
U91
U92
U97
U68:B
U98
U99
U41:A
U90
U95
U100
U101
U102
U103
?


U114
U45:C
U115
U116
U120
U71:B
U113:B
U121
U122
U123
?
U118
U119
U108
U109
U110
U124
B function


C FUNCTION
U66
XOR
U67
AND
U65
NAND
U68:A
7432
U41:B
74HC11
U45:B
74HC11
U64
AND
C function
C++
U88:B
4075
?
A2
B2
C2
D2
E
F
A2
B2
C2
D2
E
F
U63
XOR
U62
AND


D FUNCTION
U44
U40
U39
U43
U42:A
U54
U93
U45:A
U46
U38
D function

3.2 Details of ICs used

a. 7400 Series

74AS00 Quad 2- input NAND gate
74LS04 2-input NOT Hex inverter
74LS21 Dual 4-input AND gate
74LS08N Quad 2- input AND gate
74LS32 Quad 2- input OR gate
74LS11 Triple 3- input AND gate
SN74LS76JK flip flop

b. Other ICs

7 Segment display common cathode

3.3 Details of Other Components used like diodes, transistors, resistors etc.

- 470 Ohm Resistor

3.4 Hardware Issues

Some issues faced while designing the circuit include :

-Difficult managing and intrepreting the complex breadboard functionality.

-Debugging of the entire circuit and checking of each ic was a major problems during the design of hardware.

Chapter 4: Project Applications

Vending machines are used in a variety of settings to provide a convenient way for people to purchase products without any human interaction. Some applications of vending machines include:

1. Retail: Vending machines can be found in shopping malls, airports, train stations, and other public places, offering a wide range of products such as snacks, drinks, electronics, and more.
2. Food and Beverage: Vending machines can be used to dispense a variety of food and beverage products, including prepackaged sandwiches, snacks, and drinks. These machines are often used in locations where there is a high demand for food and drinks, such as office buildings, hospitals, and schools.
3. Medication: Vending machines can be used to dispense prescription and over-the-counter medications, providing a convenient way for people to access their medications. These machines are often found in hospitals, pharmacies, and other healthcare settings.
4. Services: Vending machines can also be used to provide a variety of services, such as ticketing, laundry, and car rentals.

Chapter 5: Future Recommendations

1. Add more states: A Mealy machine with more states will be able to model the behavior of the vending machine more accurately and in greater detail. For example, you could add states for different payment methods (e.g. cash, card, mobile payment) or for different types of products (e.g. snacks, drinks, sandwiches).

2. Add more inputs: Adding more inputs to the Mealy machine will allow it to respond to a wider range of user actions. For example, you could add inputs for different denominations of coins or for different product buttons.

3. Add more outputs: Adding more outputs to the Mealy machine will allow it to provide more information and feedback to the user. For example, you could add outputs for displaying different messages, for dispensing different products, or for providing change.

4. Enhance the transition functions: Improving the transition functions will allow the Mealy machine to respond more intelligently to user inputs and handle edge cases more effectively. For example, you could add logic to handle invalid inputs or to provide the correct change when the user pays with cash.

5. Test and debug the Mealy machine: Thoroughly testing and debugging the Mealy machine will ensure that it functions correctly and as expected. You can use a variety of methods, such as manual testing, simulation, or automated testing, to identify and fix any issues.

References / Bibliography

http://www.32x8.com/index.html

Finite_State_Machine_based_Vending_Machine_Control.pdf

https://ocw.snu.ac.kr/sites/default/files/NOTE/9287.pdf

https://netsonic.fi/en/files/IC-7404-Datasheet-1.pdf

https://www.electroschematics.com/wp-content/uploads/2013/07/7408-datasheet.pdf

https://www.futurlec.com/74/IC7432.shtml

http://www4.ujaen.es/~dlopez/descargas/Hoja%20caracteristicas%207476.pdf

https://www.ti.com/lit/ds/symlink/sn74lvc1g11-ep.pdf?ts=1671999911045&ref_url=https%253A%252F%252Fwww.google.com%252F

https://www.st.com/resource/en/datasheet/m74hc4075.pdf