DISSERTATION PROJECT

REPORT ON

Design and Implementation of FSM based vending machine with Auto-billing features

Submitted in partial fulfilment of the Requirements for the award of the Degree of

MASTER OF TECHNOLOGY

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by

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CERTIFICATE

This is to certify that **MAKKENA ANIL** bearing Registration no. 11307927 has completed objective formulation of thesis titled, **"Design and Implementation of FSM based vending machine with Auto-billing features"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the thesis has ever been submitted for any other degree at any University.

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DECLARATION

I hereby declare that the dissertation report entitled **"Design and Implementation of FSM based Vending machine controller with Auto-billing features**" is an authentic record of my own work carried out as the requirements for the award of degree of Master of Technology in VLSI Design at Lovely Professional University, Phagwara under the guidance of Mr. Jeripothula Balakrishna, Assistant Professor, Department of Electronics and Communication Engineering.

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It is certified that the above statement is correct to the best of my knowledge and belief.

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ABSTRACT

A Vending machine is a machine which administers items, for example, snacks, drinks, lottery tickets, goldsmiths and train tickets and so on. It conveys the item after the client embeds cash (coin) or credit into the machine. Vending machines are no doubt understood among US, UK, Singapore, Japan and Malaysia. In these nations the amount of machines is on the top worldwide because of the advanced ways of life which oblige fast food preparing with high calibre.

This paper portrays the outlining of proposed Vending machine. This machine acknowledges both either cash (money) or card (credit). In this report we talks about the Vending machine and its working. We composed the Vending machine with the assistance of a Mealy machine state chart. The configuration is demonstrated utilizing Verilog HDL dialect which is a Hardware Description Language used to portray the computerized framework. Aside from that we likewise brought a few highlights into the machine which makes it a development machine. The confirmation of the created model will be made by recognizing the suitable experiments in a test seat. The Verilog code for the proposed Vending machine model is produced and the recreation results are effectively confirmed utilizing Xilinx ISE 14.7i device.

The Vending machine we planned can be gotten to by both cash and card. The card framework will be more practical and aides for a speedier access. The target here is to outline a proposed Vending Machine which acknowledges cash or card as inputs in any grouping and conveys the items when the obliged sum has been stored furthermore gives back the change. In this an extra office is given to the client. It is conceivable to withdraw the stored cash in the middle of if the client wishes so by squeezing a cross out catch. In this I have composed a Vending machine with less construction modelling when contrasted with past outline and it expends less power moreover.

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CHAPTER 1

INTODUCTION

Vending machines are utilized to appropriate different items like espresso, beverages, postcards and gem dealers and so on when cash is embedded into it. The Vending machines are more sensible and functional than the traditional acquiring of items. The vending machines can be discovered all over in schools , universities, rail route stations and airplane terminals and so forth for offering tickets, drinks, in banks for gave that tokens to clients.

In this report a strategy is proposed to plan a FSM based Vending machine. The machine can be gotten to through cash or via card. This machine additionally bolsters a scratch off highlight, which implies that the client can withdraw the interest and the cash will be discounted back to client. The machine can be utilized at better places like schools, universities and rail route stations. This sort machines diminishes cost, time and work.

The Vending machine can likewise be gotten to via card framework in which the card is confirmed via card scanner or the attractive and contrasts it with the data stowed in the host system. After the confirmation the card requests a pin number which is given by the client and afterward the item can be chosen and the exchange could be possible. The card framework can be helpful for consistent clients which help for a speedier exchange cash framework. In nations like Japan Vending machines additionally convey platinum and jewels furthermore gem specialists, all things considered card framework can be helpful choice than cash framework. The card framework will be more achievable than the cash framework for more measures of exchanges. The beneath pictures are the strategies for the Vending machines. The Vending machines are fundamentally FPGA based machines. These are more adaptable, programmable and can be reinvented. Beforehand CMOS, SED and microcontroller based machines are utilized. However, these CMOS and SED based machines are most drawn out than the FPGA based and microcontroller based machines. Anyhow, in microcontroller based machines in the event that we need to upgrade the configuration, we need to change the entire construction modeling however where as in FPGA framework we can simply expand the quantity of items.

Figure 1.2: A live bait vending machine

Figure 1.1: First vending machine for postcard

Previously coin based vending machines were developed for selling products such as snacks, water and cigarettes etc. Vending machine has so many benefits such as flexible in time, no need human power, and fast response i.e. saving time.

Already coin based Vending machines were created for offering items, for example, snacks, water and cigarettes and so on. Vending machine has such a large number of advantages, for example, adaptable in time, no need human power, and quick reaction i.e. sparing time.

Firstly Vending machine is overseen by administrator that is the reason it needn't bother with any human vitality. Vending machine maker offer machines to the administrator that chooses which sort of framework is utilized i.e. which instalment framework. By having administrators that is worked on it can spares the work moreover. Second is the Vending machine is adaptable in time. It can work in 24 hours a day and seven days a week. The Vending machine can be worked whenever even in occasions and weekend. It devours vitality between 2,400 to 4,500 kWh every year. Thirdly Vending machine can spare time i.e. in business hours; a representative does not have to waste time for get ready nourishment that implies if there is Vending machine which gives sustenance simply embed cash into it and push catches to get sustenance or snacks. At last Vending machine segment has noteworthy development throughout the years.

1.1 Project Background

The fundamental issues with Vending machine are specialized issues, for example, system for instalment, substantial structure, level of security and item limit. The issues happen with the instalment system on the off chance that we utilize coin worked Vending machine in this the coin acceptor regularly stick up. From the foundation of past activities, the issue with the instalment system is comprehended by utilizing shrewd card based Vending machine. The issue with past system is tank full with a coin i.e. at the point when the tank was full then after no more coin can be acknowledged and this will bring about no more buy. The issue happens when the coin or notes stuck in the machine when they are not embedded in the right course. The Vending machine can't read the embedded coins and they may be stuck in the machine and will stop the further operation and the Vending machine needs to repair.

Figure 2.1: Vending machine dispensing candies

The vending machine using notes in the payment method, the notes must be in good shape, not folded and original one. The vending machine cannot read the note when it is in very bad condition such as dirty and crumpled and then rejected those notes. Finally coming to conclusion with current method of payment, there are so many problems occur. So to stop those problems I am introducing a new project which is based on both money and card based machine with less architecture.

1.2 Project Objectives

The objective here is to design Vending Machine Controller which accepts money or card as inputs in any sequence and delivers the products when the required amount has been deposited and also gives back the change. In this an additional facility is provided to the user. It is possible to withdraw the deposited money in between if the customer wishes so by pressing a cancel button.

Operation of vending machine:

Through money:

- When the customer insert money, the money counter tells the control unit the amount of money inserted in the vending machine.
- When the user selects the product he wants, the control unit turns on the motor and dispenses the product if correct amount is inserted.

- After the product is dispensed, if there is any change to be given, machine will return to the user.
- The machine will demand for servicing when products are not available in the machine.

Through card:

- When card is inserted into the machine the card scanner or the magnet scans the card details and verifies the details with the host network.
- After the card is verified, the user will be asked for a PIN number.
- The card system has three types of transactions i.e. purchasing product, changing pin number and depositing amount into the card.
- Depending on the type of transaction, the machine responds accordingly and it will be automatically updated through the network.

1.3 Project Scope

In this paper another methodology is wanted to plan a Vending Machine with auto-charging highlights. In this report a methodology is proposed to plan a FSM based Vending machine. The machine can be gotten to through both cash and card. The machine likewise bolsters a scratch off highlight. In the event that the client needs to withdraw the appeal and the cash will be returned back to the client. The machine can be utilized at better places like schools, rail line stations, air terminals, lodgings and nourishment roads and so on. This kind of machines decreases the time and expense. Particular pathway of this Vending machine depicts the degree.

- The established vending machine is only a prototype and is not ready for operative as commercial product.
- The vending is developed for dispensing products such as snacks, milk, candies and soft drinks etc.
- The number of products can be dispensed is only in small unit.
- The method of payment for this vending machine is concentrating on both prepaid payment method (using card) and money.

1.4 Software Used

We designed the code in the Xilinx 14.7i software. Xilinx ISE (Integrated Software Environment) is a software tool produced by Xilinx for synthesis and analysis of HDL designs, enabling the developer to compile their designs, perform timing analysis, and examine the RTL schematics.

CHAPTER 2

HISTORY

The Vending machines are exceptionally famous and broadly spread in numerous nations. Around 215 B.C, the soonest known circumstance is in the work of Hero of Alexandria, Egypt, a first century specialist and mathematician. His machine perceived a coin and apportioned water. As per his machine, when the coin was stored, it cleaves upon a skillet included to a lever. The lever opened a valve which let some water stream out. The skillet kept on inclining with the heaviness of the coin until it tumbled off, and soon thereafter a stabilizer smashed the lever up and killed the valve. In A.D1076, again another Vending machine was displayed by Chinese designers that added to a coin-worked pencil merchant. Coin worked machines which used to administer tobacco and different items were worked in late 1600s in England. Simeon Denham was allowed the British patent for his stamp administering machine in 1867 which is the first completely mechanized Vending machine.

The primary advanced coin worked Vending machines were reported in London in the mid-1880s administering post cards. The Vending machines soon turned into the boundless highlight at railroad stations and post workplaces procurement post cards, envelopes and train tickets and so on. The Vending machine in the U.S was made in 1888 by the Thomas Adams Gum organization, offering gum on New York City train stages.

In late 1920-1930, Vending machines were presented with tremendous cash is embedded in it. Illustration for the item that been sold in the distributing that time is soda. In 1946, espresso sellers were produced and in 1950, the merchants took after by refrigerated sandwich were created.

These days, in Vending machine, numerous things can be discovered, for example, snacks, confections, milk, cigarettes, sodas, postage stamps, cologne, baseball cards, books, live lure, comic books, and numerous more. Some greetings tech Vending machine can administer hot nourishments, for example, pizza, popcorn, French and burger.

The Vending machines are generally spread and used to apportion very nearly different sorts of items. The transformations of the machines are produced and soon the machines used to offer train tickets furthermore the exchange are done through card

framework. In India Vending machines are utilized to administer change to cash notes too. The Vending machines are not generally utilized as a part of a few nations as a result of the specialized learning and unease utilizing these machines. Masters accept that the use of these machines will ascend with changing buyer propensities and way of life.

Figure 2.2: Newspaper vending machine

CHAPTER 3

LITERATURE REVIEW

The present study tolerates some relationship to the previous studies showed. These studies are given below as follows:

Mid 1880s, the first current coin worked Vending machines that appropriating post card were presented in London, England. The principal Vending machine in the U.S. was made in 1888 by the Thomas Adams Gum Company. The Vending machine apportions a bit of gum.

In late 1920 and 1930, more prominent cost introduced into the Vending machine was presents. Illustration for the item that has been sold in the Vending machine that time is cool drink and nickel-confection. In 1946 to 1950, espresso sellers were produced and took after by refrigerated sandwich merchants.

These days, numerous things can be started in Vending machine, for example, apparel, milk, cigarette bundles, postal stamps, cologne, and cards of baseball, books, live snare, story books, and numerous more. Some howdy tech Vending machine can administer hot sustenance's, for example, pizza, popcorn, French and burger.

The creator Roger (2008) predetermined that they characterize a test Java customer server framework and a particular industriousness equipment limit to control a Pepsi B Vending machine over the World Wide Web. This framework licenses clients with prepaid records to offer a pop from the Pepsi A machine (with no coins or bills) utilizing a web program, for example, Netscape or Internet Explorer.

Here the creators Hong (2008) have finished a task on a remote Vending machine framework in light of the GSM system. As a matter of first importance, various routines by which we may comprehend remote information correspondence of GSM system are dissected and thought about.

After that in 2010, the Vending machines in view of Single Electron Devices (SED) are presented in VLSI innovation on the grounds that they have low ultra-power utilization, exchanging pace and high thickness of reconciliation. Structure of SED is in light of the unmistakable way of electrons burrowing through tinny potential hindrances. A definitive

objective of this work is to undertaking one conceivable method for utilizing electron-burrowing gadgets rather than traditional MOS transistors to outline and mimic a programmed tea/espresso distributing framework.

In a coin-worked Vending machine that administers sanitized water. That gadget administers a given measure of water by pressure driven activity and measures precisely. A water apportioning outlet is connected with every heap tube and is jeopardized by a covering that is precisely arranged to include the higher segment of a compartment to support the buyer in legitimately sitting the holder to be filled.

This chapter will explain about the development of vending machine and this chapter contain about the previous research developed on vending machine which accepts coins or notes as inputs.

Vending machine is a coin worked machine for offering items. It gives different items, for example, snacks, cool beverages, milk, water, drinks and tickets. It needn't bother with an administrator or labourer to work it. There are two sorts of capacities that are given by the Vending machine.

- Selling the product
- Sell the service to the customers

The products provided by the vending machine are sold by the customer after inserting money only. After completing the payment, the product is free at the bottom of the machine. There various types of vending machines exist today. Some of them are beverages vending machine, ticket vending machine, snack vending machine and coffee vending machine.

In Card based vending machine, even a payment can be completed using such a card. There are two types of payment methods are available in automated vending machine as shown below

1. Payment in advance and
2. Credit type payment.

In advance payment method, the user should purchase a card in advance for cash. Those cards store the information by means of a magnetisable configuration and gives corresponding information related to a given purchase price. In every time if the card is used in the machine then the logged information is properly changed so as to indicate the

remaining credit amount. In the credit card type payment method, a card holder uses a vending machine for a purchase using a card which has been distributed to him. The information related to the amount and each purchase is stored in the machine. The amounts deducted against each card are gathered over a scheduled period of time.

There are different payment methods are available. Nowadays vending machines have the facility of providing change and accept notes as money or credit cards.

- Coin operated vending machine
- Note operated vending machine
- Prepaid operated vending machine

A number of researches have been carried out for designing the advanced vending machine. Some of the works previously done are:

- In 1999, controlling a Java enabled Pepsi(R) vending machine over the World Wide Web.
- In 2007, Single Electron Device based automatic tea vending machine.
- This approach in 2011 is an efficient algorithm for implementation of vending machine on FPGA board is used. Because FPGA based vending machine give fast response and uses less power than the microcontroller based vending machine in the paper Vending Machine using Verilog HDL.
- In April 2012, a new approach is proposed to design an FSM based Vending machine with auto-billing features.
- This technique includes the features like cancel, product error and change.
- It is possible to withdraw the deposited money in between if the customer wishes so by pressing a cancel button.
- In 2013, Design and Implementation of FSM based vending machine with Auto-billing features.
- In 2014, Comparison of different attributes in modelling a FSM based vending machine in 2 different styles.
- If the selected product is not available then it will shows the product error.

CHAPTER 4

RESEARCH METHODOLOGY

Previously, the designed vending machine accepts only money. This type vending machine requires more number of gates to design and consumes more power. The proposed vending machine accepts both money and card with less number of gates and consumes less power also. The machine starts with giving an option to the customer i.e. money.

Let's assume first the money system is accessed by the customer. The customer can select the product, if he wants to select the product 1, then it will be checking the availability of the product. Depending on the type of product need to be selected and it will return to the checking of the availability. If the products are available, it will ask for the desired money or else it shows an error indicating non-availability of the product. At this stage the customer have two options i.e. either he can insert the desired amount or cancel the selection. The machine will check until the right amount is entered. If the right amount is inserted the product will be dispensed by the machine with the change if any. If some amount is inserted and you want to abort, then you can click the cancel button and the change will be returned.

Now let's assume the card system is accessed by the customer. Whenever the card is inserted, the card is first verified with the host network and the customer is asked for the Personal Identification Number (PIN) number. The customer is given three times chance for the PIN number to enter correctly. The card would be blocked if the entered PIN is wrong after completing three chances. All the information related to the account will be automatically updated to host network. If the PIN number is correct, the machine asks for the type of transaction needed. There are three types of transactions in this machine.

- Amount deposit
- Purchasing product
- Change pin.

If we want to deposit the money in the account type 1 is selected, we can deposit and it will be automatically updated. If we want to purchase the product type 0 is selected, the same process as in the money system will be followed but the money is deducted from the account. The third type i.e. if we want to change the PIN, we can change the PIN and has to

re-enter for conformation and it is changed successfully and is automatically updated through the network.

4.1 Field Programmable Gate Arrays

A Field Programmable Gate Arrays (FPGA) is a coordinated circuit. It comprises an extensive two-dimensional exhibit of little processing units that can be customized. By utilizing this information can be steered inside the show either evenly or vertically. Adjusting associations between the units can impact re-steering. By utilizing this equipment we have the focal points like adaptability, low advancement cost and low item cost for moderately low volume gadgets. Specifically, it is conceivable to reconfigure a FPGA to change starting with one calculation then onto the next calculation. Reconfiguration takes just a small amount of seconds. However the adaptability preferences are exchanged off against velocities which are lower than those achievable by non-reconfigurable equipment gadgets like ASICs. However, FPGAs can accomplish speeds extensively higher than programming executions. Here and there, the processing units of a FPGA are called Configurable Logic Blocks (CLBs). Reconfiguration changes the elements of Configurable Logic Blocks and the associations in the middle of them and these CLBs comprises of look-up tables and flip-flops. The look-up tables are arranged as either a little measure of combinational rationale or a little RAM. A FPGA might likewise contain the RAM pieces which are implanted that can be utilized as either look-up tables or memory components. In any case, the utilization implanted RAM may influence the transportability and the comprehensiveness of the outcomes got. Moreover RAMs has lower slower get to time than CLBs.

4.2 Verilog HDL

Hardware Description Languages are widely used in logic design. HDLs depict the construction modeling and conduct of discrete electronic frameworks. Present day HDLs and their related test systems are intense apparatuses for incorporated circuit originators. There are two sorts of dialects exist.

1. VHDL
2. Verilog HDL

Hardware Description Languages such as Verilog and VHDL differ from software programming languages because they have the syntaxes for describing the propagation time

and signal strengths. HDL is utilized to portray the equipment utilizing code i.e. to record rationale capacities, to invigorate rationale before building and to blend code into entryways and design. Verilog is simpler to learn and is anything but difficult to use than VHDL. Verilog HDL permits an equipment architect to outline at an abnormal state of reflection, for example, at the compositional or behavioral level and also the lower execution levels i.e. entryway and switch levels. Verilog permits client to express their configuration with behavioral develops. In Verilog there are two sorts task administrators are accessible.

1. Blocking assignment (=)
2. Non-blocking assignment (<=)

The non-blocking task permits creators to portray a state machine without expecting to announce and utilization brief stockpiling variables. Since these thoughts are a piece of Verilog's dialect semantics, planners could rapidly compose portrayals of vast circuits in a generally reduced and brief structure. At the season of Verilog's starter (1984), Verilog spoke to a superb efficiency change for circuit creators who were at that point utilizing graphical schematic detainment programming and extraordinarily composed programming projects to report and reproduce electronic circuits.

The language structure of Verilog is like the C programming dialect. Every one of you thinks about C dialect which was at that point broadly utilized as a part of designing programming advancement. Like C dialect, Verilog is likewise case touchy and has a fundamental pre-processor in spite of the fact that it is less modern than that of ANSI C or C++. In Verilog the catchphrases (while, if/else, case) utilized for control stream are identical to C dialect and its priority of administrators are good with C dialect. Syntactic contrasts contain: obliged bit-widths for variable affirmations, separation of procedural squares (Verilog uses start/end rather than wavy props {}), and numerous other minor contrasts. Verilog obliges that variables be given a positive size. In C these sizes are assumed from the "sort" of the variable (for example a whole number sort may be 8 bits).

A Verilog outline comprises of request of modules. Modules exemplify plan order, and unite with different modules through an arrangement of announced data, yield, and bidirectional ports. Inside, a module can contain any mix of the subsequent: net/variable announcements (wire, register, whole number, and so forth.), simultaneous and successive proclamation squares, and cases of different modules (sub-chains of importance). Successive articulations are put inside a start/end square and actualized in consecutive request inside the

piece. On the other hand, the squares themselves are executed simultaneously, making Verilog a dataflow dialect.

Verilog's idea of "wire" comprises of both sign values (4-express: "1, 0, coasting, unclear") and signal qualities (solid, frail, and so on.). This framework archives dynamic demonstrating of imparted sign lines, where numerous sources drive a typical net. At the point when a wire has various drivers, the wire's (lucid) quality is dictated by a component of the source drivers and their qualities.

A subset of proclamations in the Verilog dialect is synthesizable. Verilog modules that adjust to a synthesizable coding style, known as RTL (register-exchange level), can be really acknowledged by blend programming. Union programming algorithmically interprets the (dynamic) Verilog source into a net rundown, an intelligently comparable portrayal containing just of rudimentary rationale primitives (AND, OR, NOT, flip-flops, and so forth.) that are existing in a particular FPGA or VLSI innovation. Further controls to the net rundown in the long run lead to a circuit manufacture diagram, (for example, a photograph cover set for an ASIC or a bit stream document for a FPGA). Verilog HDL is one of the two most consolidated Hardware Description Languages (HDL) utilized by coordinated circuit (IC) creators, the other one is VHDL. HDL's permits the outline to be mimicked past in the configuration cycle so as to right lapses or exploration (test) with diverse architectures. Plans portrayed in HDL are innovation free, simple to outline and simple to investigate, and are typically more comprehensible than schematics, fundamentally for extensive circuits. Verilog can be utilized to characterize plans at four levels of deliberation:

- Behavioral level (much like c code with if, case and loop statements).
- Data flow (assignment operations and Boolean equations).
- Gate level (interconnected AND, NOR etc.).
- Switch level (the switches are MOS transistors inside gates).

4.3 Finite State Machine method

A limited state machine (FSM) or essentially a state machine and is a numerical model of reckoning or figuring used to outline both the PC programs and consecutive rationale circuits. It is considered as a conceptual machine that can be having a limited number of states. This machine takes stand out state whenever and the state it is in at any given time is known as the present state. It can transform from one state to other when it is

begun by an activating occasion or a condition occasion this is known as a move. Especially FSM is characterized by a rundown of its states and molding occasion for every move.

The conduct of state machines can be seen in numerous gadgets in advanced society which perform a prearranged arrangement of activities relying upon a grouping of occasions with which they are displayed. State machines are utilized to characterize the neurological frameworks and in science and in a counterfeit consciousness research and in semantics to characterize the punctuations of characteristic dialects.

On the off chance that assume consider a FSM as a conceptual model of estimation, then FSM is weak and it has less computational force contrasted with different models of processing, for example, the Turing machine. In Turing machine there are a few assignments that are not accessible in FSM i.e. no FSM can do, yet Turing machines can do those assignments in light of the fact that the FSM has restricted memory. In FSM, the memory is constrained by the quantity of states. By and large the FSMs are considered in the more general field of automata hypothesis. The automata hypothesis is in light of conventional model of calculation and is utilized for some determinations other than the controller circuit outline, incorporating PC program with their compiler development and the confirmations of these calculation, intricacy and association of PC programming dialects and details. A state machine may consider a limited or an interminable arrangement of conceivable states and they are may have deterministic or nondeterministic conduct. An automata is numerical model that create values subordinate upon interior state and potentially some ward data values, they are alluded to as state machines. A deterministic state machine is a machine whose yields are the same for a given inner state and information values. A FSM (limited state machine) is one where all conceivable state qualities made a limited set.

In a Finite State Machine the circuits yield is characterized in an alternate arrangement of states i.e. every yield is a state. A State Register to hold the condition of the machine and a next state rationale to interpret the following state. A yield register characterizes the yield of the machine. In FSM based machines the equipment gets decreased as in this the entire calculation can be clarified in one methodology. The two sorts of state machines are:

1. MEALY Machine
2. MOORE Machine

4.3.1 Mealy machine: In this model the yield is relies on upon the current state and in addition on the data too. The condition of a Mealy machine is controlled by the condition of the machine. It has less number of states contrasted with the Moore machine. Assume there are n-bits, for these n bits we require n number states just.

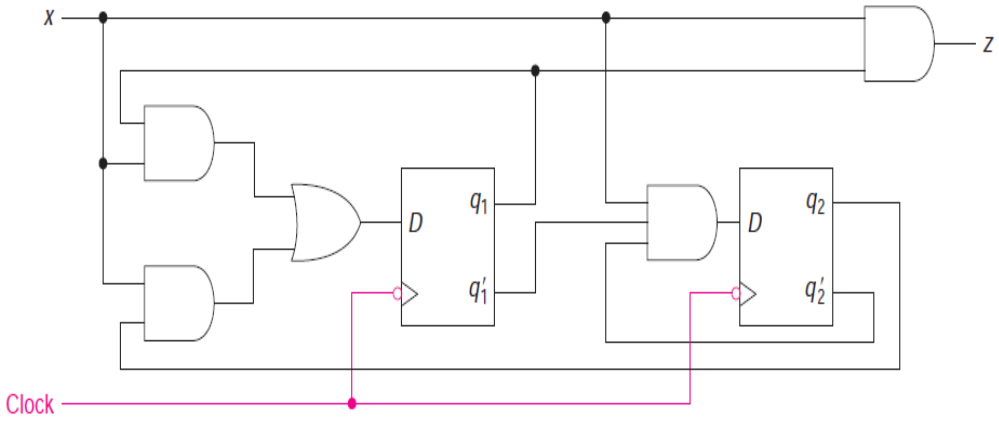

Figure 4.1: Mealy machine

Operation of MEALY State Machine:

From beneath table, the yield of the coarse state machine is controlled by the inputs and the present condition of the machine. In the above outline, the yield Z will be dictated by the condition of the machine.

TABLE 4.1: State table for MEALY machine

Q	Q*		Z	
	X=0	X=1	X=0	X=1
0 0	0 0	0 1	0	0
0 1	0 0	1 0	0	0
1 0	0 0	1 0	0	1
1 1	0 0	1 0	0	1

4.3.2 Moore Machine: In Moore machine the yield just relies on upon the current state. . In the underneath chart the state is controlled by the condition of the JK and D flip-flops.

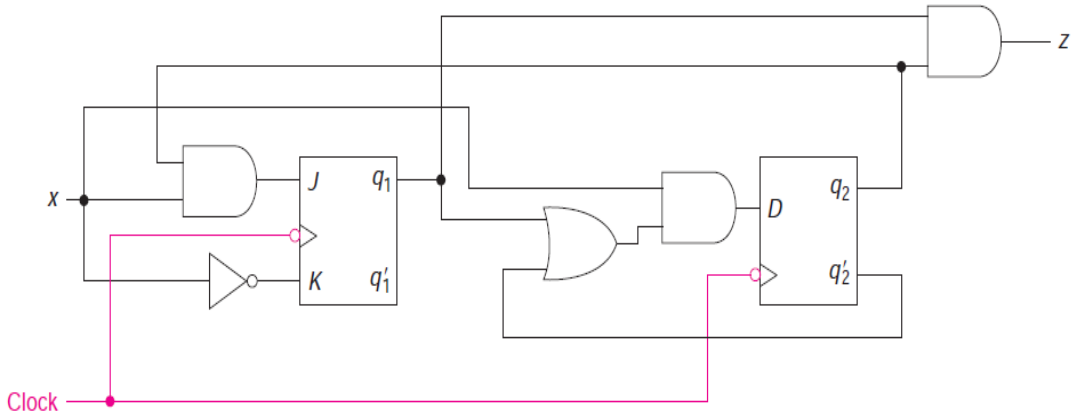

Figure 4.2: Moore machine

Operation of MOORE State Machine:

The table below is the state table for the Moore state machine and is determined by the state of the machine only.

TABLE 4.2: State table for MOORE machine

Q	Q*		Z
	X=0	X=1	
0 0	0 0	0 1	0
0 1	0 0	1 0	0
1 0	0 0	1 1	0
1 1	0 0	1 1	1

In the project we used the MEALY model. Mealy model is used because it usually has fewer states than the MOORE model. Mealy machine reacts faster to inputs; they don't need to wait for clock. Moore machine are safer to use and the output changes at the clock edge.

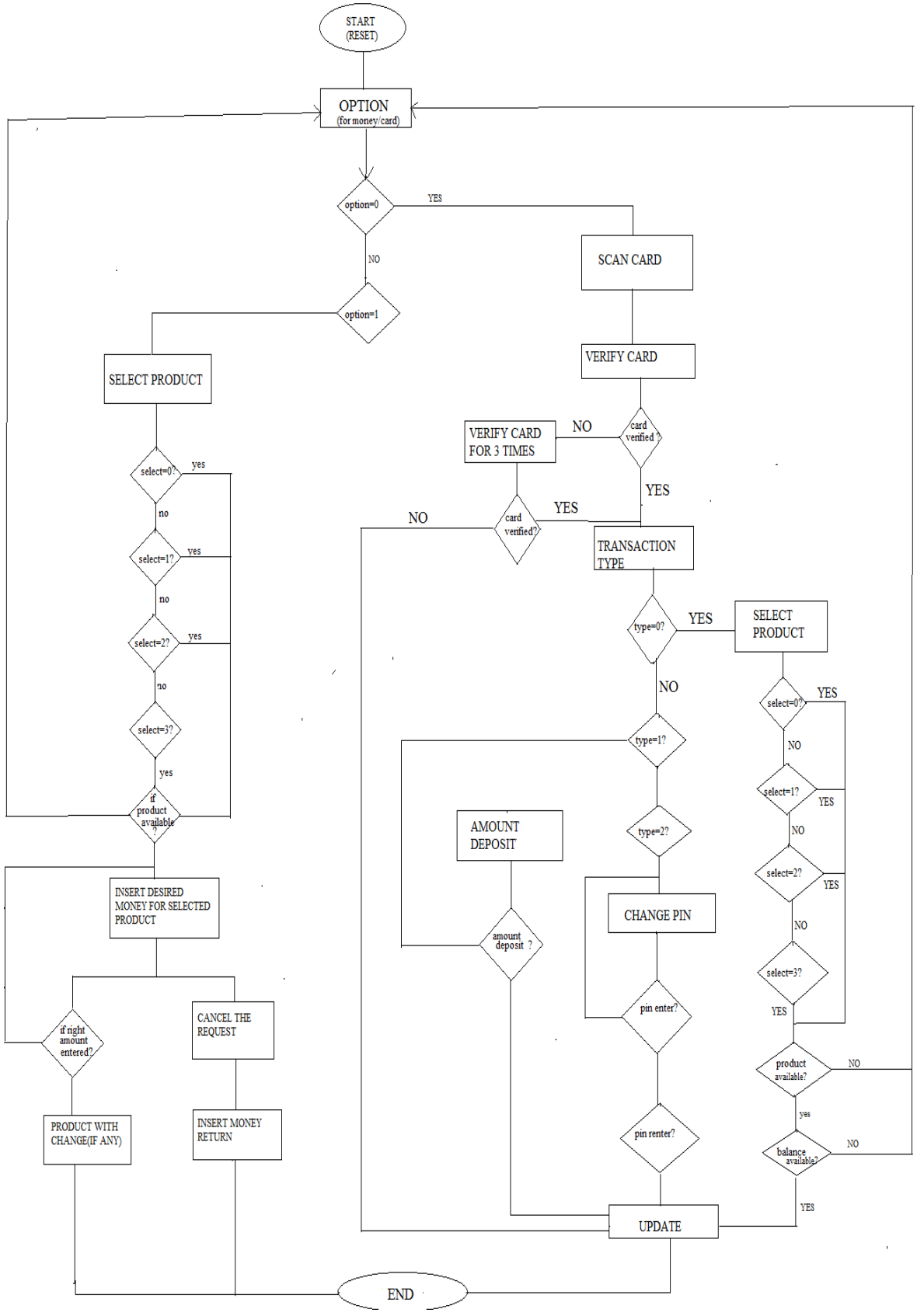

Figure 4.3: Flow chart for proposed vending machine

CHAPTER 5

EXPECTED OUTCOMES

In this project a state diagram is constructed for the proposed vending machine which can vend for products snacks, soft drink, milk and candies using by insertion of money or card. First phase we talk about getting product by insertion of money.

For money phase a select line of 2 bits is used for selection of product such as 00, 01, 10, and 11 for snacks, soft drink, milk and candies respectively. The amount line of 7 bits is used for the insertion of amount. A cancel button is also provided whenever the user wants to withdraw his request and also the money will be returned through the output change line of 7 bits. Products and change are outputs with products as one bit and change as 7 bits. This will update after every transition. The inputs or amount to insert money sel to select a product, a clock signal to get transitions which is of one bit and also a reset signal line of one bit to reset the vending machine. The products with their prices are shown by table 1. The machine will take inputs on positive edge of clock signal and will return outputs on negedge of clock signal. The detail of the entire signal with their direction and description is shown in table 2.

For card phase an insert card line of one bit is used to check whether the card is inserted or not which is taken as input. The card number line of four bits used to input the card number. The card pin line of four bits used to input the card pin. Transaction type is the two bits input line used by user to select the type of transaction such as 00, 01, 10 for select product, amount deposit and change pin respectively. In these three transaction types select product is used to select a product by the user such as sel=00 for snacks, sel=01for soft drink, sel=10 for milk, sel=11 for candies. Amount deposit is the type of transaction used to recharge the user card for this it takes the input from amount line which is of seven bits i.e. it can insert up to 500Rs. Change pin is the type of transaction in which pin_enter is the one bit input line to check whether the pin is entered or not for the change of pin. Enter_pin is the four bit input line used to take new pin to be changed. Pin_reenter is the one bit input line used to conform the new pin. Reenter_pin is the four bit input line used to conform the new pin. New_balance is the seven bit output line to update the user card balance after every transaction and also after every transaction of selecting products. Snacks, soft drink, milk; candies are the outputs signal of one bit same as used in money phase. Amount is also the input signal same as used in money phase. Update signal is the one bit output signal which is

updated after every transition, it is the signal used to update in host network. The machine will take inputs on positive edge of clock signal and will return outputs on negedge of clock signal. The detail of the entire signal with their direction and description is shown in table 2. The proposed vending machine is designed using FSM modeling and is coded in Verilog HDL.

TABLE 5.1: INPUTS/OUTPUTS WITH REMARKS

NAME	WIDTH	DIRECTION	DESCRIPTION
CLK	1	INPUT	CLOCK SIGNAL
RESET	1	INPUT	SYSTEM RESET
CANCEL	1	INPUT	CANCEL
SEL	2	INPUT	SELECT PRODUCT
CHANGE	7	OUTPUT	EXTRA CHANGE
SNACKS	1	OUTPUT	PRODUCT
SOFT DRINK	1	OUTPUT	PRODUCT
MILK	1	OUTPUT	PRODUCT
CANDIES	1	OUTPUT	PRODUCT
ERROR	1	OUTPUT	SYSTEM ERROR
PRODUCT_ERROR	1	OUTPUT	NO PRODUCT
INSERT_CARD	1	INPUT	CARD INSERTED
CARD_NUM	4	INPUT	SCANED CARD NUM
CARD_PIN	4	INPUT	ENTERED CARD PIN
PIN	4	INPUT	PIN FROM HOST
TRANACTION_TYPE	2	OUTPUT	SELECT TRANACTION
AMOUNT_ENTERED	1	INPUT	TO INSERT AMOUNT
AMOUNT	7	INPUT	TOTAL MONEY
ENTER_PIN	4	INPUT	PIN TO CHANGE
REENTER_PIN	4	INPUT	PIN TO CHANGE
BALANCE	7	OUTPUT	MONEY IN CARD
NEW_BALANCE	7	OUTPUT	MONEY FOR TRANACTION
UPDATE	1	OUTPUT	UPDATE FOR HOST NETWORK
CARD_BLOCK	1	OUTPUT	TO BLOCK CARD
PIN_COUNT	2	OUTPUT	WRONG PIN COUNT
OPTION	1	INPUT	SEL MONEY OR CARD SYSTEM

If option is equal to 1 it means transaction using money. For money the inputs are amount, product selection and cancel button.

If option is equal to 0 it means transaction using card. For card the inputs are insert card, enter pin. In card there are three types of transactions are available.

1. Select Product
2. Deposit money
3. PIN change

The input transaction type is used to select any one of the above.

TABLE 5.2: PRODUCTS WITH THEIR PRICES

S.No.	PRODUCTS	PRICE
1	SNACKS	40/-
2	SOFT DRINK	30/-
3	MILK	20/-
4	CANDIES	10/-

CHAPTER 6

EXPERIMENTAL WORK DONE

The operation of Vending machine using either money or card is explained below with their relative state diagrams.

6.1 State machine for MONEY SYSTEM

6.1.1 State machine for product SNACKS using money:

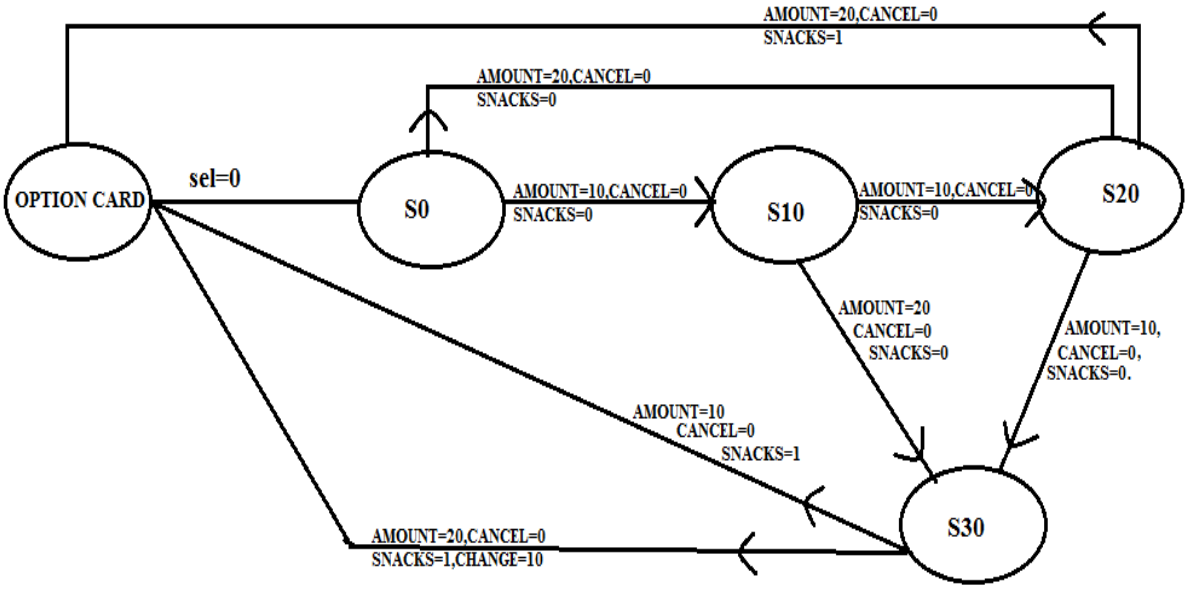

Figure 6.1: state machine for snacks

Description of states:

At the point when option=1 and sel=0 then next_state=S0

State S0:

In the event that amount=10 =>next_state=>S10

In the event that amount=20 =>next_state=>S20

In the event that cancel=>1 next_state=>option card

Snacks=>0, change=>0

State S10:

In the event that amount=10 =>next_state=>S20

In the event that amount=20 =>next_state=>S30

In the event that cancel=>1 next_state=>option card

Snacks=>0, change=>10

State S20:

In the event that amount=10 =>next_state=>S30

In the event that amount=20 =>next_state=>option card

Snacks=>1, change=>0, Snacks_count=Snacks_count-1

In the event that cancel=>1 next_state=>option card

Snacks=>0, change=>20

State S30:

In the event that amount=10 =>next_state=>option card

Snacks=>1, change=>0, Snacks_count=Snacks_count-1

In the event that amount=20 =>next_state=> choice card

Snacks=>1, change=>10, Snacks_count=Snacks_count-1

In the event that cancel=>1 next_state=>option card

Snacks=>0, change=>30

6.1.2 State machine for item SOFT DRINK utilizing cash:

Description of states:

At the point when option=1, sel=1=>next_state=>S0

State S0:

In the event that amount=10 =>next_state=>S10

In the event that amount=20 =>next_state=>S20

In the event that cancel=>1 next_state=>option card

Delicate drink=>0, change=>0

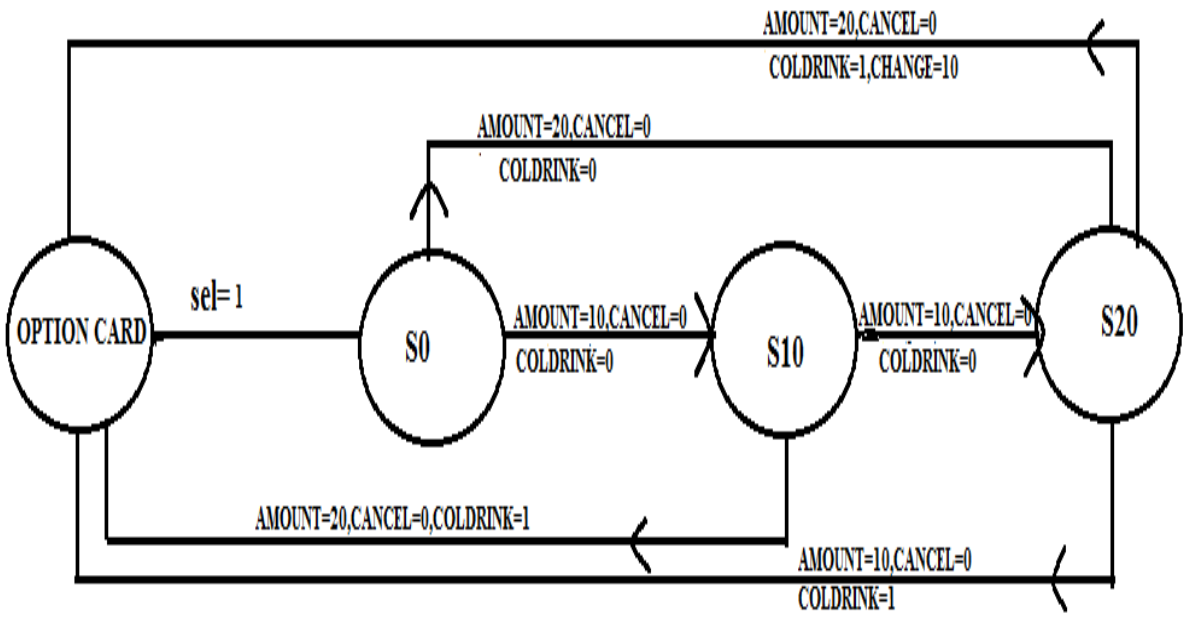

Figure 6.2: state machine for soft drink

State S10:

In the event that amount=10 =>next_state=>S20

In the event that amount=20 =>next_state=>option card

Delicate drink=>1, change=>0, Soft drink _count= Soft drink _count-1

In the event that cancel=>1 next_state=>option card

Delicate drink=>0, change=>10

State S20:

In the event that amount=10 =>next_state=> alternative card

Delicate drink=>1, change=>0, Soft drink _count= Soft drink _count-1

In the event that amount=20 =>next_state=>option card

Delicate drink=>1, change=>10, Soft drink _count= Soft drink _count-1

On the off chance that cancel=>1 next_state=>option card

Delicate drink=>0, change=>20

6.1.3: State machine for product MILK using money:

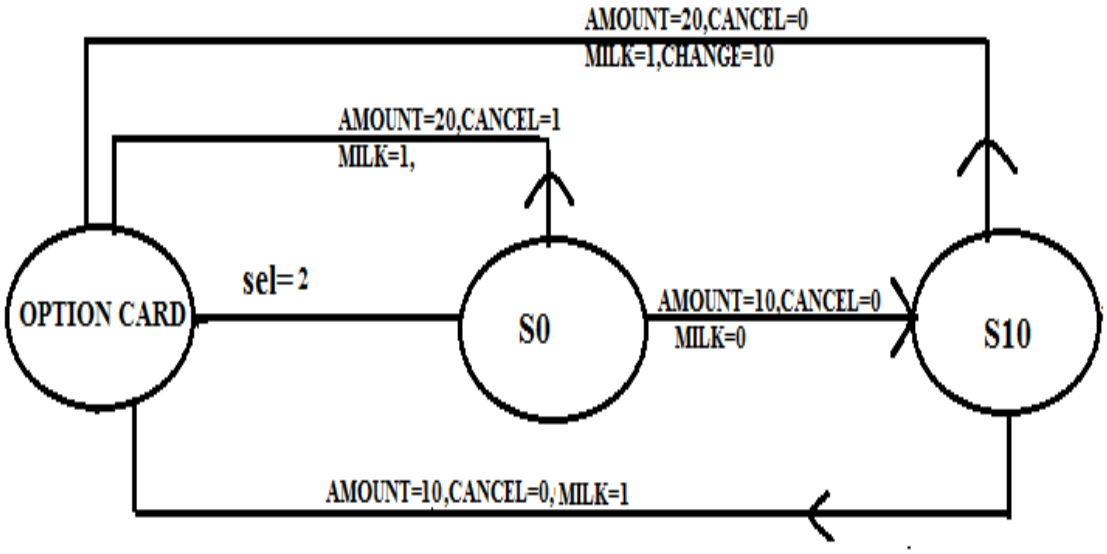

Figure 6.3: state machine for milk

Description of states:

At the point when option=1, sel=2=>next_state=>S0

State S0:

In the event that amount=10 =>next_state=>S10

In the event that amount=20 =>next_state=>option card

Milk=>1, change=>0, Milk _count= Milk _count-1

In the event that cancel=>1 next_state=>option card

Milk=>0, change=>0

State S10:

In the event that amount=10 =>next_state=>option card

Milk=>1, change=>0, Milk _count= Milk _count-1

In the event that amount=20 =>next_state=>option card

Milk=>1, change=>10, Milk _count= Milk _count-1

In the event that cancel=>1 next_state=>option card

Milk=>0, change=>10

6.1.4 State machine for product CANDIES using money:

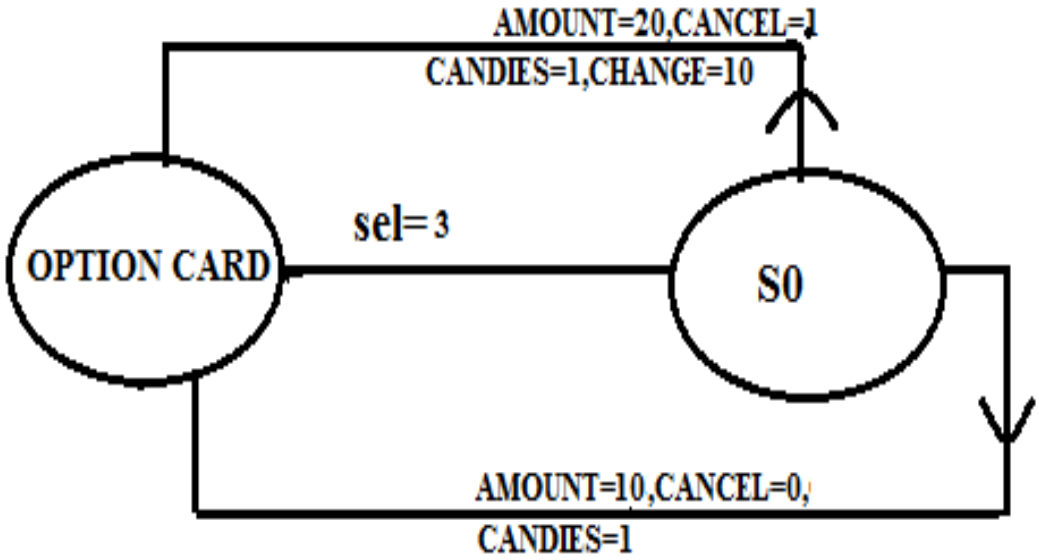

Figure 6.4: state machine for candies

Description of states:

At the point when option=1, sel=3=>next_state=>S0

State S0:

In the event that amount=10 =>next_state=>option card

Candies=>1, change=>0, Candies _count= Candies _count-1

In the event that amount=20 =>next_state=>option card

Candies=>1, change=>10, Candies _count= Candies _count-1

In the event that cancel=>1 next_state=>option card

Candies=>0, change=>0, Candies _count= Candies _count-1

Flow chart for vending machine using money:

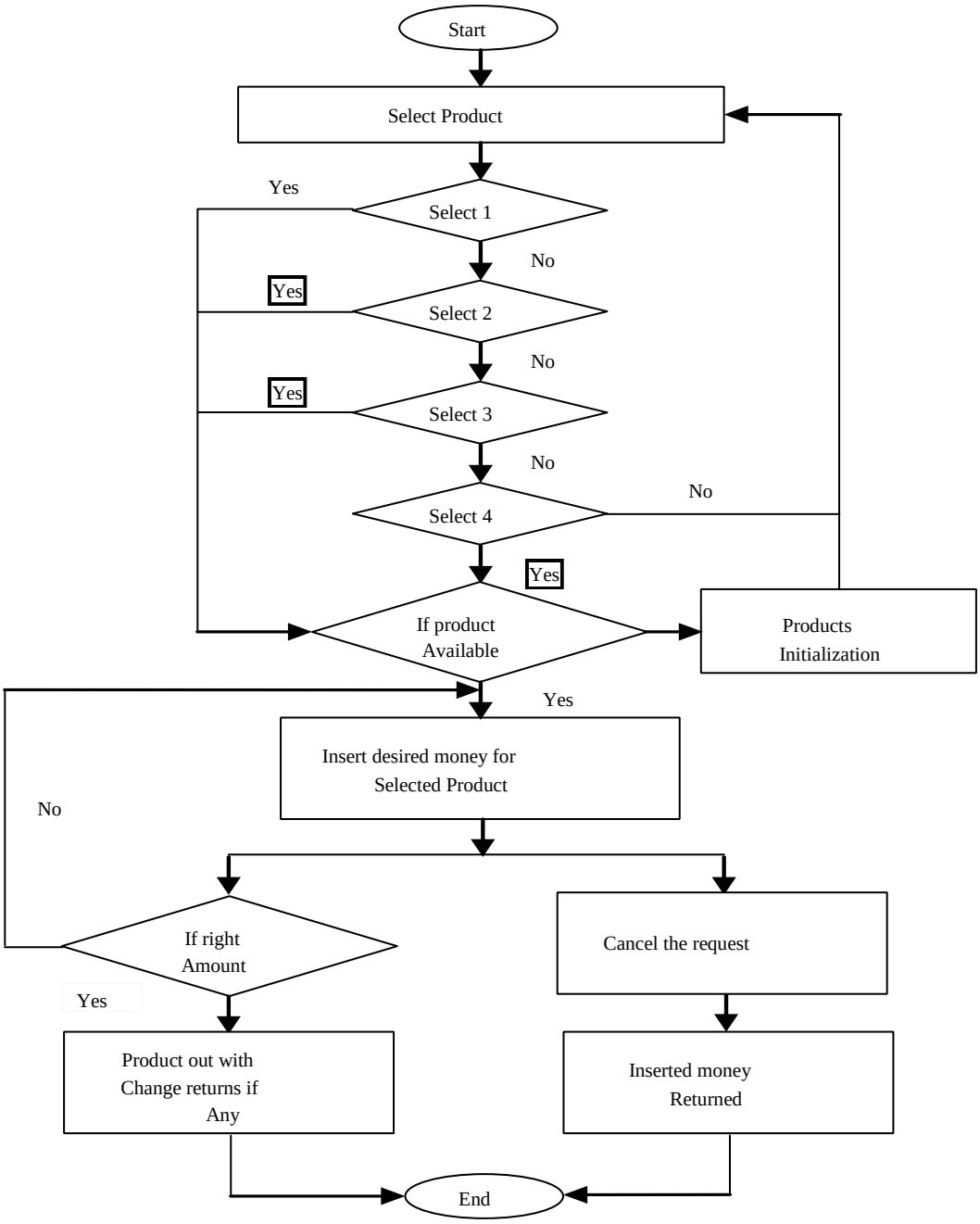

Figure 6.5: Flow chart

6.2 State machine for CARD SYSYTEM

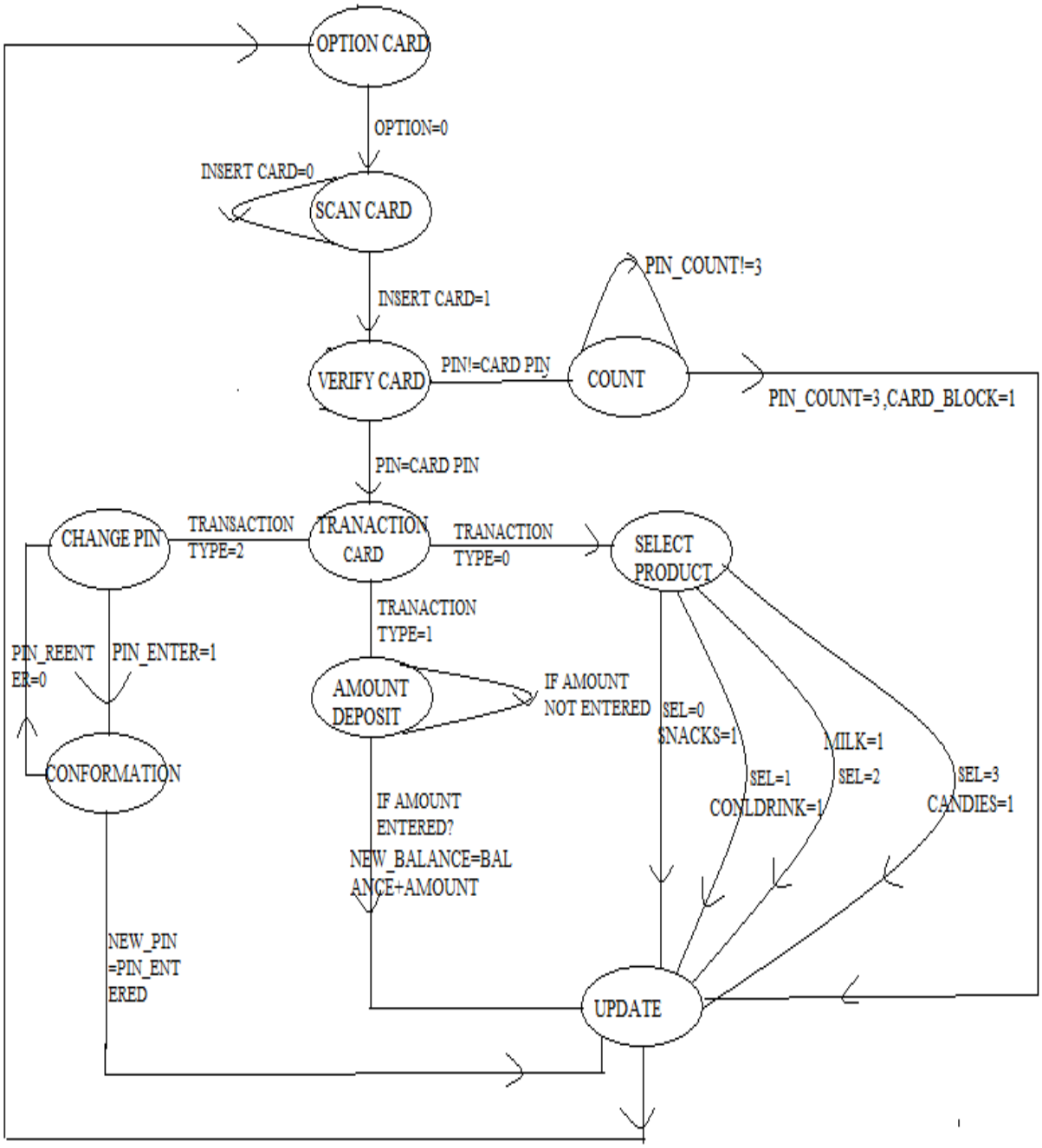

Figure 6.6: state machine for card system

Description of states:

At the point when option=0, next_state=>Scan_card

Scan_card:

At the point when insert_card=>1, next_state=>Verify_card

At the point when insert_card=>0, next_state=>Scan_card

Verify_card:

At the point when card_pin=pin, next_state=>Transaction

At the point when card_pin!=pin, next_state=>Count

Pin_count=1

Count:

At the point when card_pin=pin, next_state=>Transaction

At the point when card_pin!=pin, next_state=>Count

Pin_count=pin_count+1

At the point when pin_count=3, next_state=> Update

Card_block=1

Transaction:

At the point when Transaction_type=0, next_state=>Select_product

At the point when Transaction_type=1, next_state=>Deposit

At the point when Transaction_type=2, next_state=>Change_pin

Select_product:

At the point when sel=>0, Snacks_count!=0, next_state=update_card;

Snacks_count= >Snacks_count-1,

New_Balance=Balance-40, Snacks=1

At the point when sel=>1, Soft drink_count!=0, next_state=update_card;

Soft drink _count=> Soft drink _count-1,

New_Balance=Balance-30, Soft drink=1

At the point when sel=>2, Milk_count!=0, next_state=update_card;

Milk _count= >Milk _count-1,

New_Balance=Balance-20, Milk=1

At the point when sel=>0, Candies _count!=0, next_state=update_card;

Candies _count= >Candies _count-1,

New_Balance=Balance-10, Candies=1

Deposit:

At the point when Amount_entered=1

New_Balance=>Balance+Amount

next_state=>update_card

At the point when Amount_entered=0

New_Balance=>Balance

next_state=option_card;

Change_pin:

At the point when pin_enter=1

New_pin=>enter_pin, next_state=Conformation

At the point when pin_enter=0

New_pin=>enter_pin, next_state=Change_pin

Conformation:

At the point when pin_reenter=1, New_pin=reenter_pin

New_pin=>reenter_pin, next_state=Update_card

At the point when pin_reenter=1, New_pin!=reenter_pin

New_pin=>reenter_pin, next_state=Change_pin

At the point when pin_enter=0

New_pin=>reenter_pin, next_state=Update_card

Update_card:

Snacks=0, Soft drink=0, Milk=0, Candies=0,

Update=1, next_state=option_card

In card based vending machine, first we have to insert the card into the machine. After inserting the card, the machine will check it whether it is blocked or not. If the card is blocked it needs to be update otherwise we should enter correct PIN within three times only otherwise the card will be blocked. After entering the correct PIN, choose the transaction type. This machine provides three types of transactions

i. Select product
ii. Deposit money
iii. Pin change

In Select product state, we need to select which product we want. If the sufficient balance is available in the card then the selected product will come out.

In deposit money state, it is used to deposit money into card.

In pin change state, it is used to change the pin of the card.

CHAPTER 7

ADVANTAGES AND DISADVANTAGES

Advantages:

1. Vending machines give free decision for clients to buy items whenever of the day.
2. Diversity as far as the items that a Vending machine can deal with.
3. Wide territory items can be sold utilizing the machine as beverages, espressos, and organic products among different items.
4. Overhead cost diminishes by procuring of staff.
5. It builds the overall revenue for the proprietor making it a win bound endeavour.
6. The machine can simply be moved to different ranges if need emerges and it will keep conveying the administrations as common.

Disadvantages:

1. It can cost you a ton of cash.
2. Fraud cases are additionally basic in this kind by clients who figure method for hacking into the arrangement of the machine to apportion items.

Safety and Security:

Risk of falling machines:

Most advanced Vending machines are checked and wanted to restrain burglary, with efforts to establish safety resulting in plans comparative in quality to safes. Accordingly, the machines can be overwhelming. A couple of individuals have been genuinely harmed in the wake of having a Vending machine fall over them, either while they were endeavouring to take from the machine or ousting dissatisfaction over a deficiency which brought about an inability to apportion the acquired thing or the best possible change. In the cases in which

men irritating to get a can out of the machine were smashed. The article expresses that in light of the fact that the sodas are situated in the upper 50% of the machine (so they can drop into the administering space), the focal point of gravity of the machine is strangely high. Due to this high focus of gravity, the machine will fall over once it has been tilted just 20 degrees, an eccentrically little edge. A huge, completely loaded soda pop machine can weigh more than 400 kg.

Coin fraud:

One issue with Vending machines, fundamentally mechanical Vending machines, includes the utilization of coins of remote money, or, in more great cases, valueless tokens or gaskets, which have the same size and shape as the coin acknowledged by the machine. This is done to pay less for stock, and now and then keeping in mind the end goal to get change that has more esteem than the at first embedded article.

One astounding case of this was the use of Libyan coins of 100 Dirhams and 50 Dirhams values in Maltese Vending machines in the late 1990s. The 100 Dirham coin was utilized as a part of spot of the 1 Maltese Libra coins which had, in those days, an accepted underground market estimation of around 10 Libyan Dinars and hence having an esteem 100 times cutting edge than that of the fake coin. Essentially, the 50 Dirhams coin was utilized as a part of spot of the 25 Maltese pennies, which implied a 50-fold increment of quality as indicated by the underground market cost. In any case, this issue was rapidly illuminated when the machines included were immediately supplanted with new ones that could distinguish the distinction between the Libyan and the Maltese coins, especially in visitor ranges. In another case, the 2 euro coin is comparable in size to the 10 baht coin (worth just €0.25). Accordingly, numerous Vending machines in the Eurozone won't acknowledge €2 coins; such is the level of the 10-baht trick. In any case, the vast majority of the as of now utilized Vending machines still acknowledge 5-rouble coin rather than 2 euro coin, which prompts the noticeable misfortunes to their proprietors, because of the expanding number of Russian vacationers.

In the United States, most Vending machines have dynamic Currency location methods that can recognize coins by perusing the coins' "attractive mark;" along these lines, a few American Vending machines won't take coins from extra nations, regardless of the fact that their measurements are comparative. This can bring about a few issues because of the way that Canadian coins, which are parallel fit as a fiddle to their American supplements, for

the most part blend close by U.S. money in the northern United States and in minor entireties are generally recognized at standard, however can't be acknowledged in numerous Vending machines owed to a different metallic arrangement. To a certain degree, this matter likewise affects Caribbean coinage, nations whose monetary forms are pegged to the U.S. dollar, and the British 5p, 10p, and 50p, all of which are undifferentiated from in size and quality to the U.S. furthermore, Canadian dime, quarter and dollar coins.

To overcome this I have proposed a new vending machine which accepts both money (currency) and card (credit) as inputs.

CHAPTER 8

RESULTS AND DISCUSSION

The state machine diagram shown in the above chapter is simulated in the Xilinx ISE simulator. The simulator waveforms for the selection of four products like snacks, soft drink, milk, candies. By using money system and card system is shown below which includes the features like cancel button, recharge of card in card system, change of pin in card system and error when product is not available.

8.1 SIMULATION RESULTS

Case: 1

Let us take an example that the user want to take product snacks and also cancel the selected product in next transaction. Simulation is shown in the below figure.

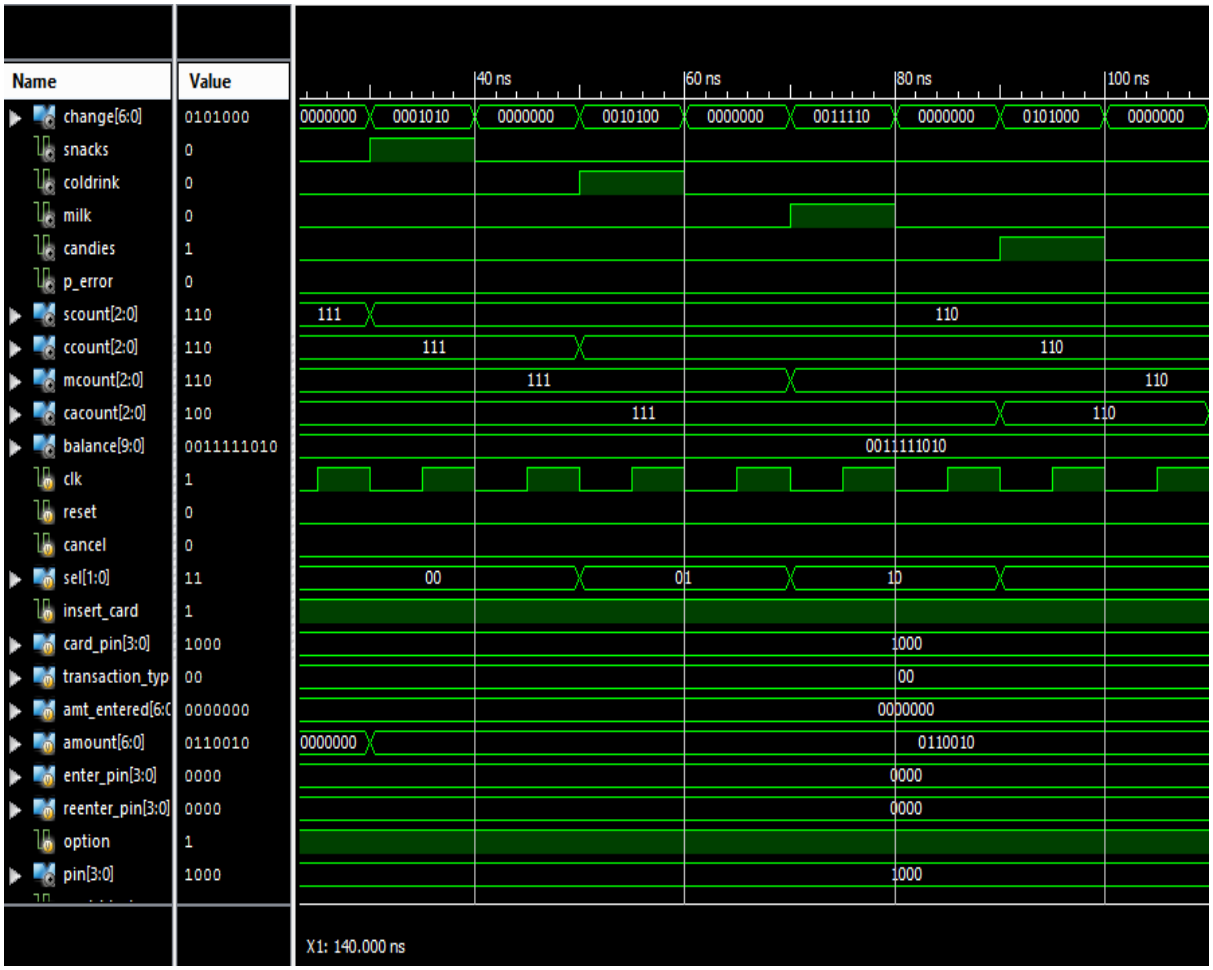

Figure 8.1: Simulation for getting Product using money

Description:

As shown in the above figure for the selection of products snacks we get at time-30ns and in second transition when cancel is pressed machine return the inserted money at time-50ns.

Case: 2

Now let us take an example that user want to take a product by using card system.

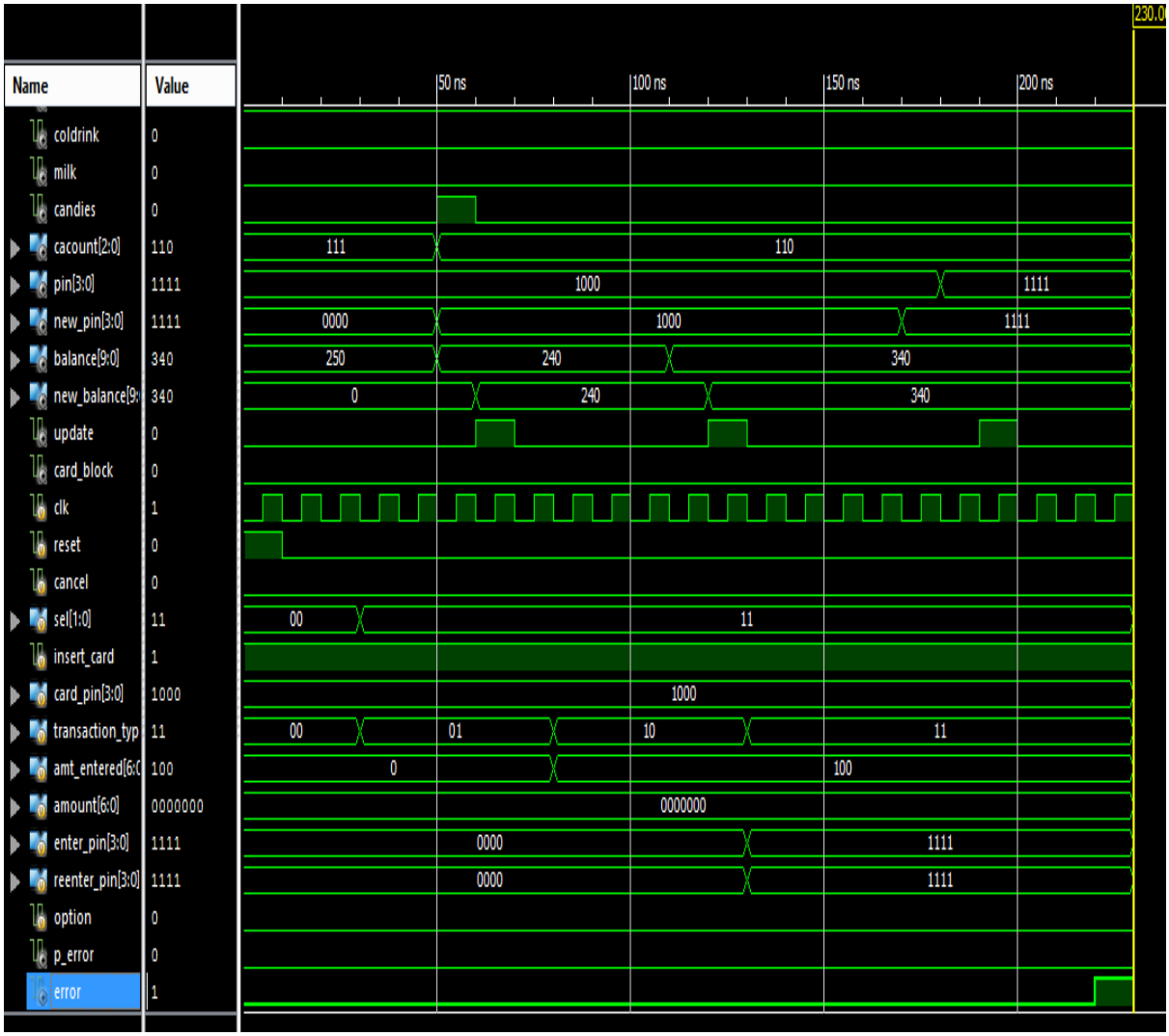

Figure 8.2: Simulation using card

Description:

As shown in the above simulation to select product using card system, we have given inputs as card after that we have to enter pin and after we have to choose the type of transaction.

We got an output of product candies at time 50ns and the new balance i.e. 240 after the transition is updated at time-60ns and in the second transaction the card is recharged with 100 rupees by giving input as amount entered and the new balance is updated as 340 at time 120ns. Previously the available balance in the card is 250. In third transaction New Pin is updated at time 190ns.

Case: 3

Now we simulate the results for change of pin.

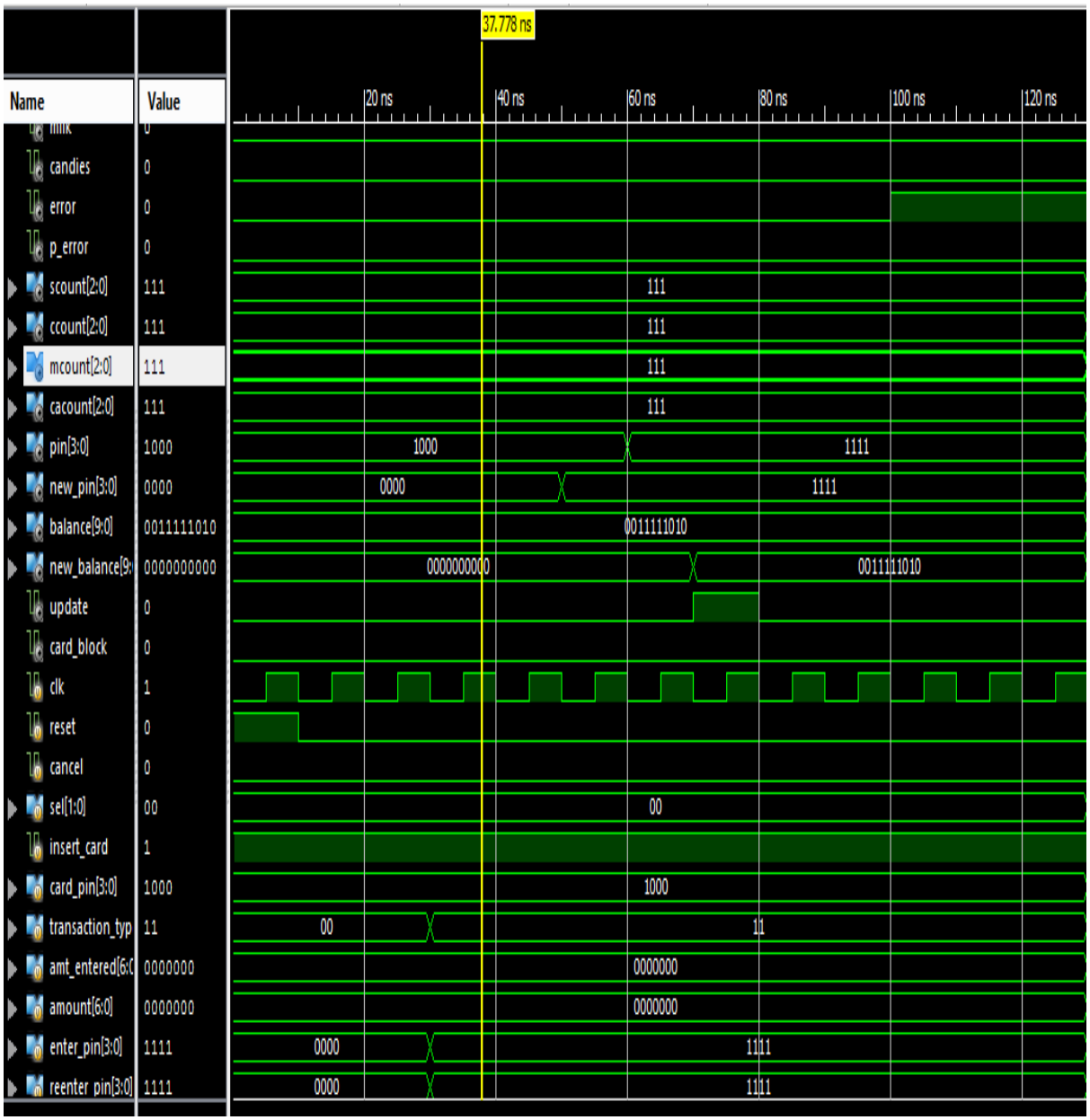

Figure 8.3: Simulation for changing pin

Description:

As shown in the above stimulation figure, pin is changed in the next transition as is affected at 70ns i.e. changed from 1000 to 1111 and in the affected same data is updated in the next clock cycle.

Case: 4

Now we stimulate the results for deposit money

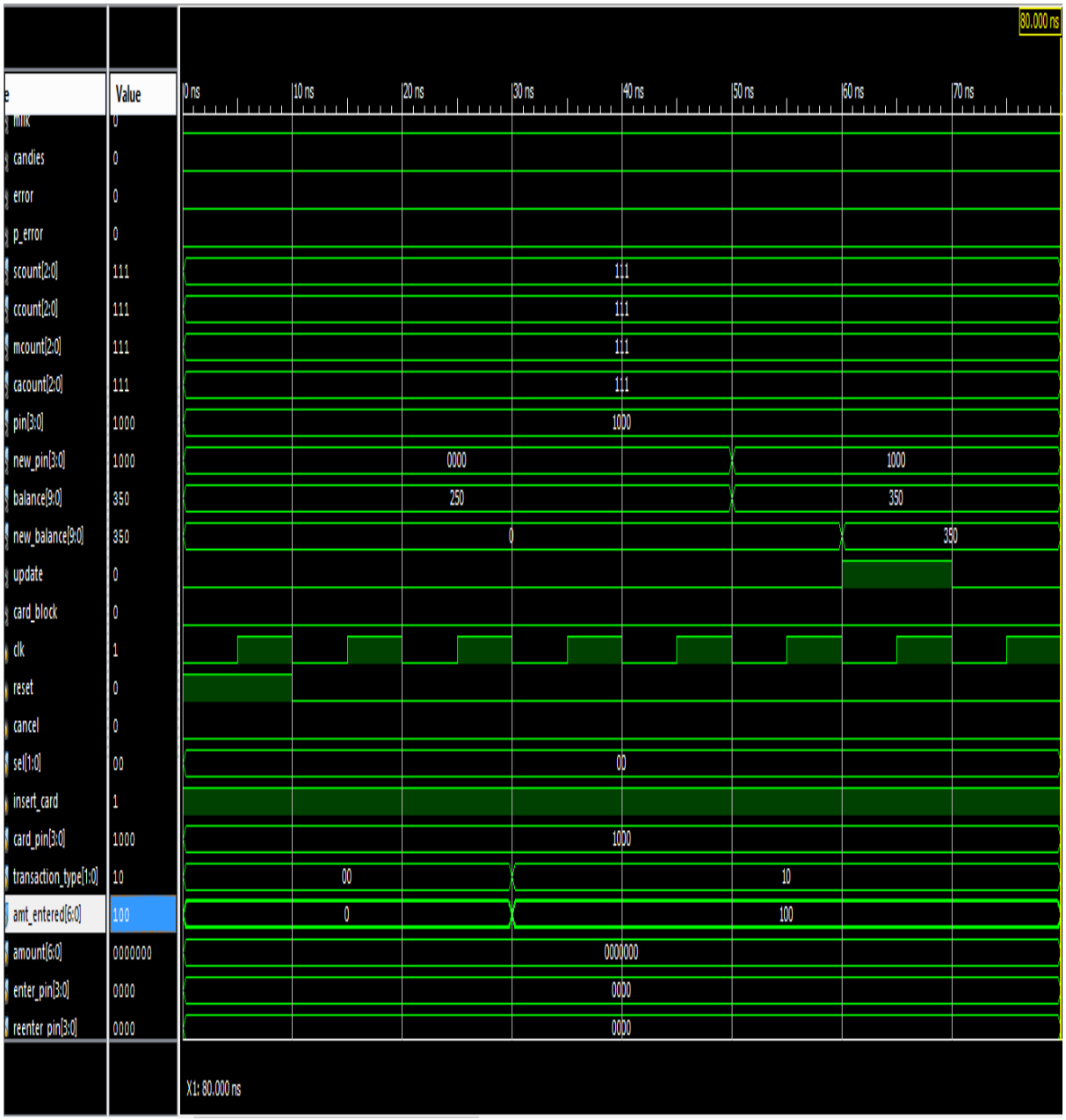

Figure 8.4: Simulation for deposit money

Description:

The card is recharged with 100 rupees by giving input as amount entered and the new balance is updated as 350 at 60ns. Previously the available balance in the card is 250.

Case: 5

Now we have an example of showing card block feature

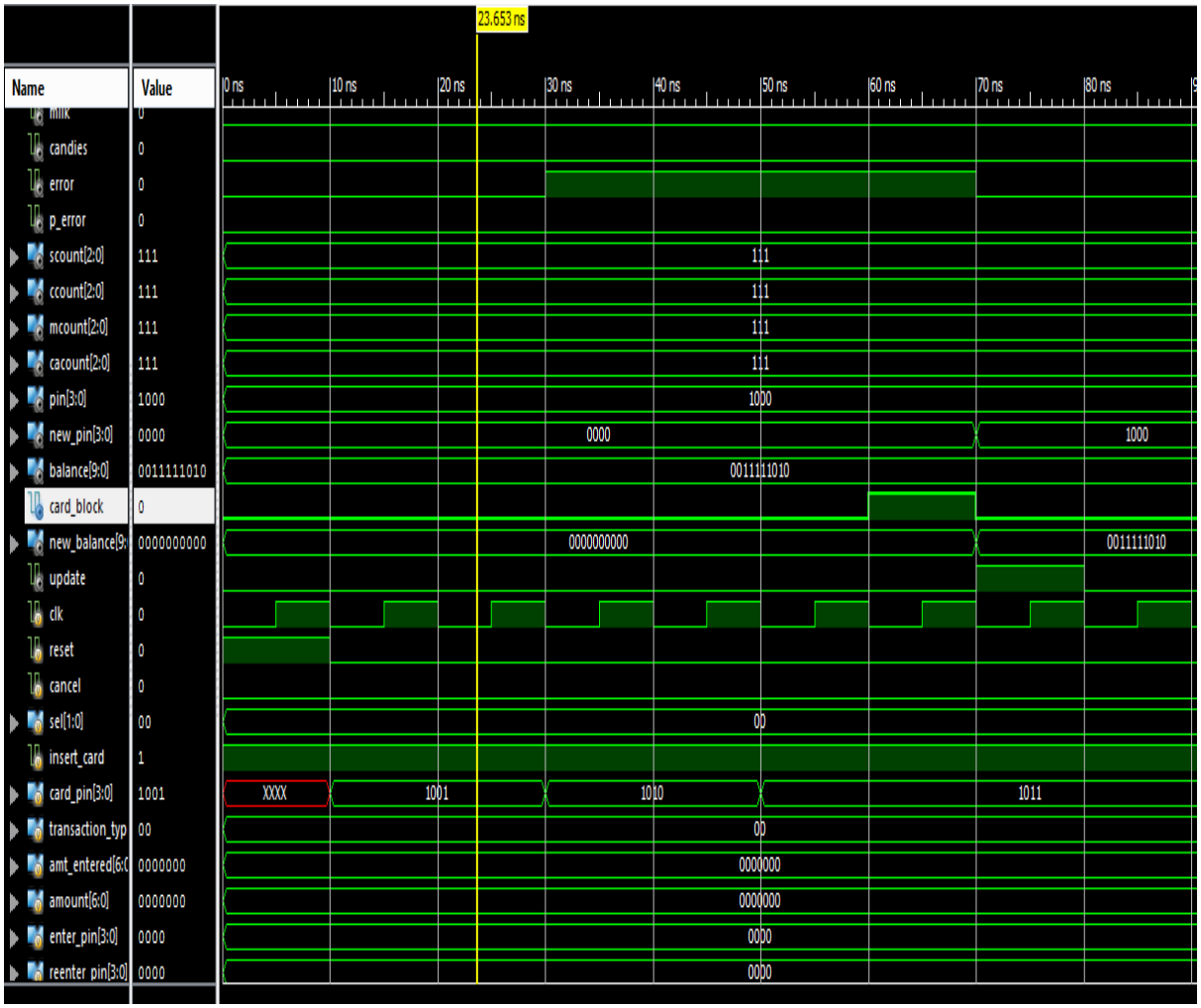

Figure 8.5: Simulation for showing card block feature

Description:

The simulation showing the above states the card block feature, insert the card which is not blocked but after insertion of wrong password for 3 times this card is blocked at 70ns and updated in host network at 80ns.

The actual pin of the card is 1000.

Here entered card pin on first time is 1001 but it is the wrong pin and pin count is updated to 1. In second chance the entered card pin is 1010 but it is also wrong pin and pin count is updated to 2. In the last chance for entering the pin, the entered pin again is 1011, again it is the wrong pin and pin count is updated to 3. Therefore the card is blocked at time 60ns.

Case: 6

Below example shows shortage of products when accessed with money system.

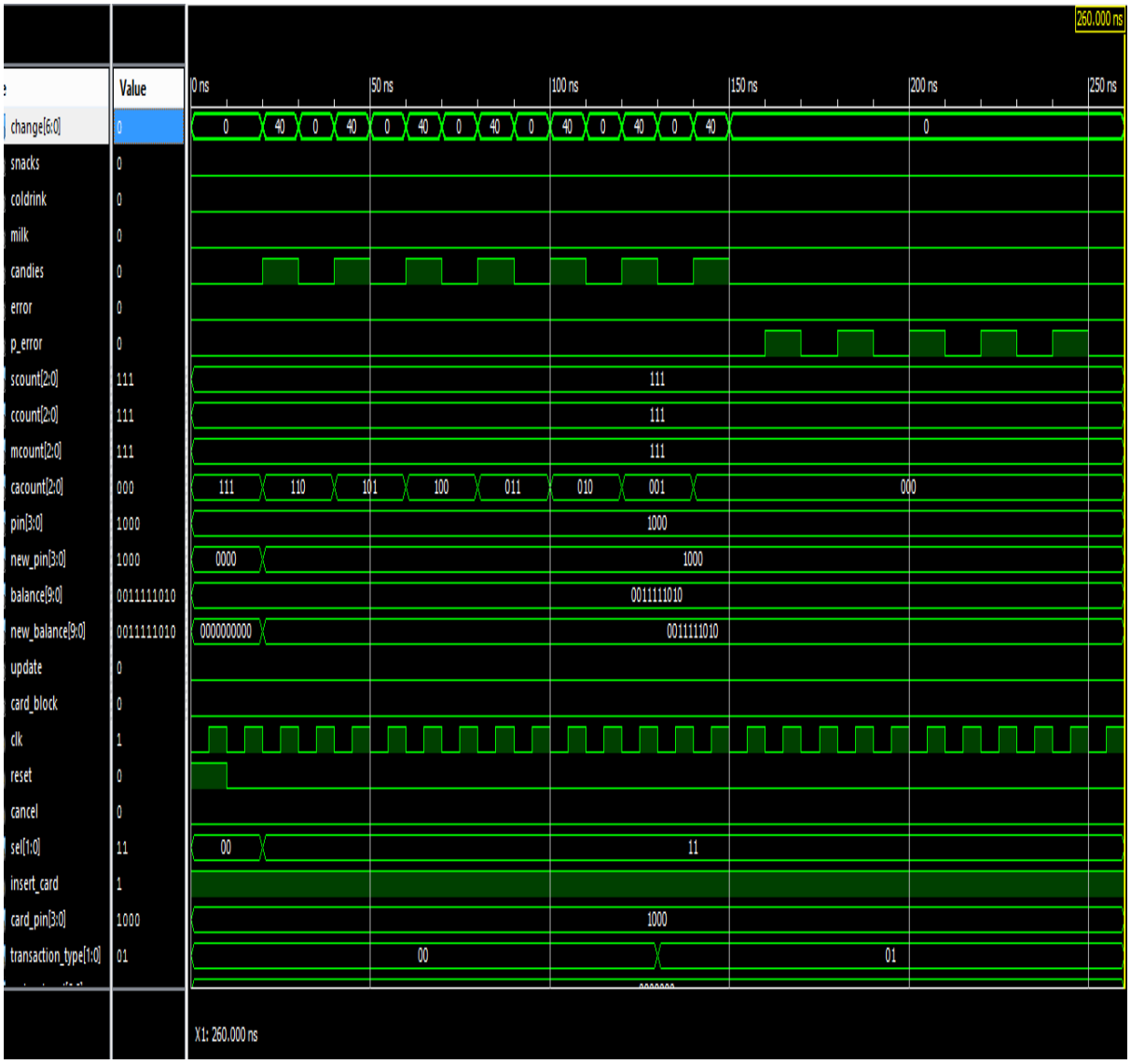

Figure 8.6: Simulation for showing product error

Description:

In the above figure it shows that there is a shortage of product snacks after servicing the candies available in the system.

Case 7

Simulation for showing cancel feature

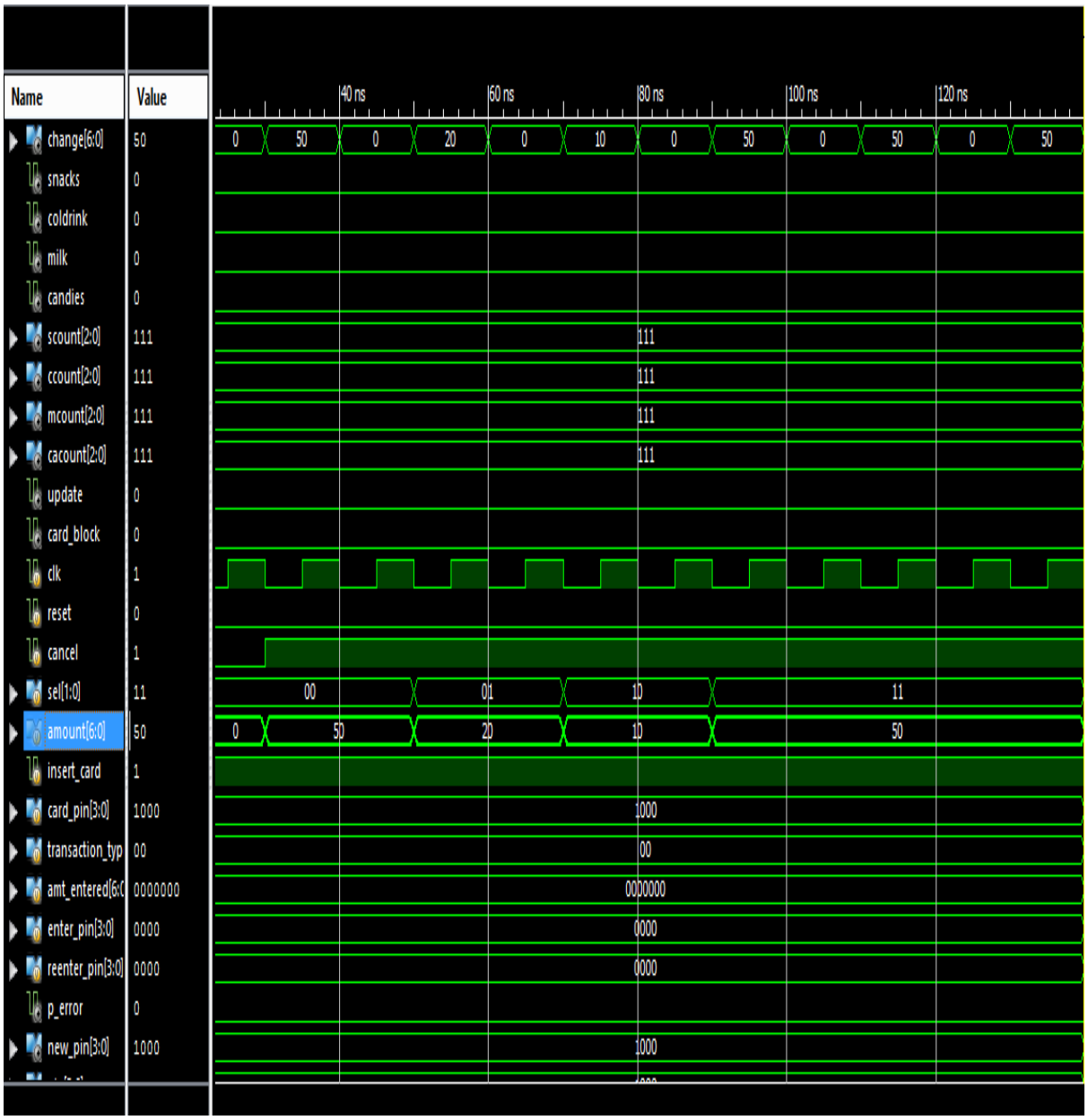

Figure 8.7: Simulation for showing cancel feature

Description:

This machine also supports a cancel feature, which means that the user can withdraw the request and the money will be refunded back to user. In the above figure the money will be refunded back at 20ns is in the form of change. In the above figure we are continuously applying cancel feature and the money will be refunded back to user.

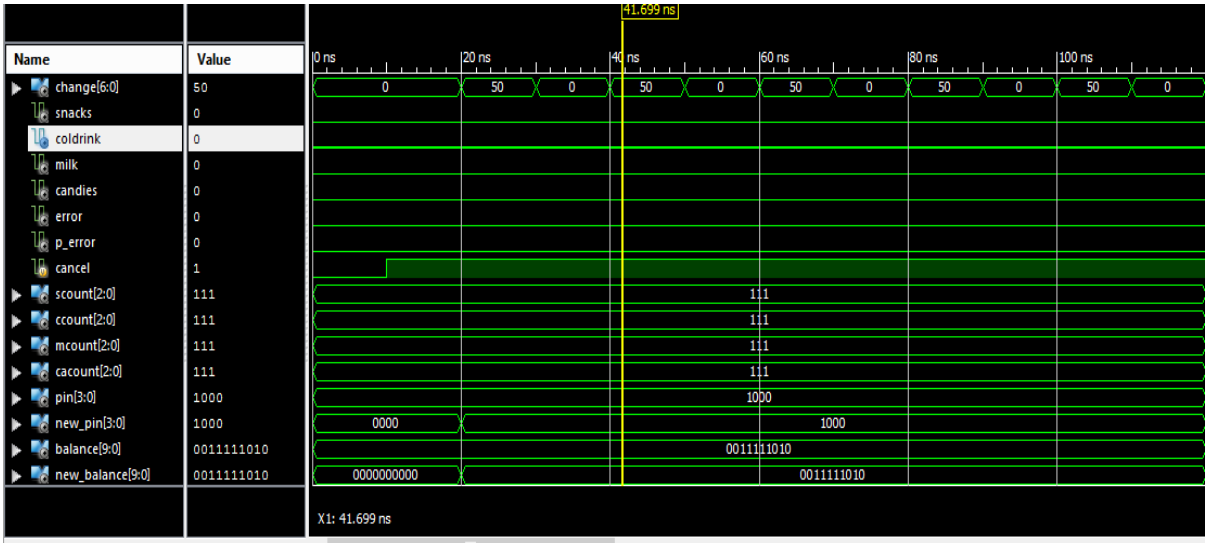

Figure 8.8: Stimulation for showing change and cancel feature

8.2 RTL view of Vending Machine

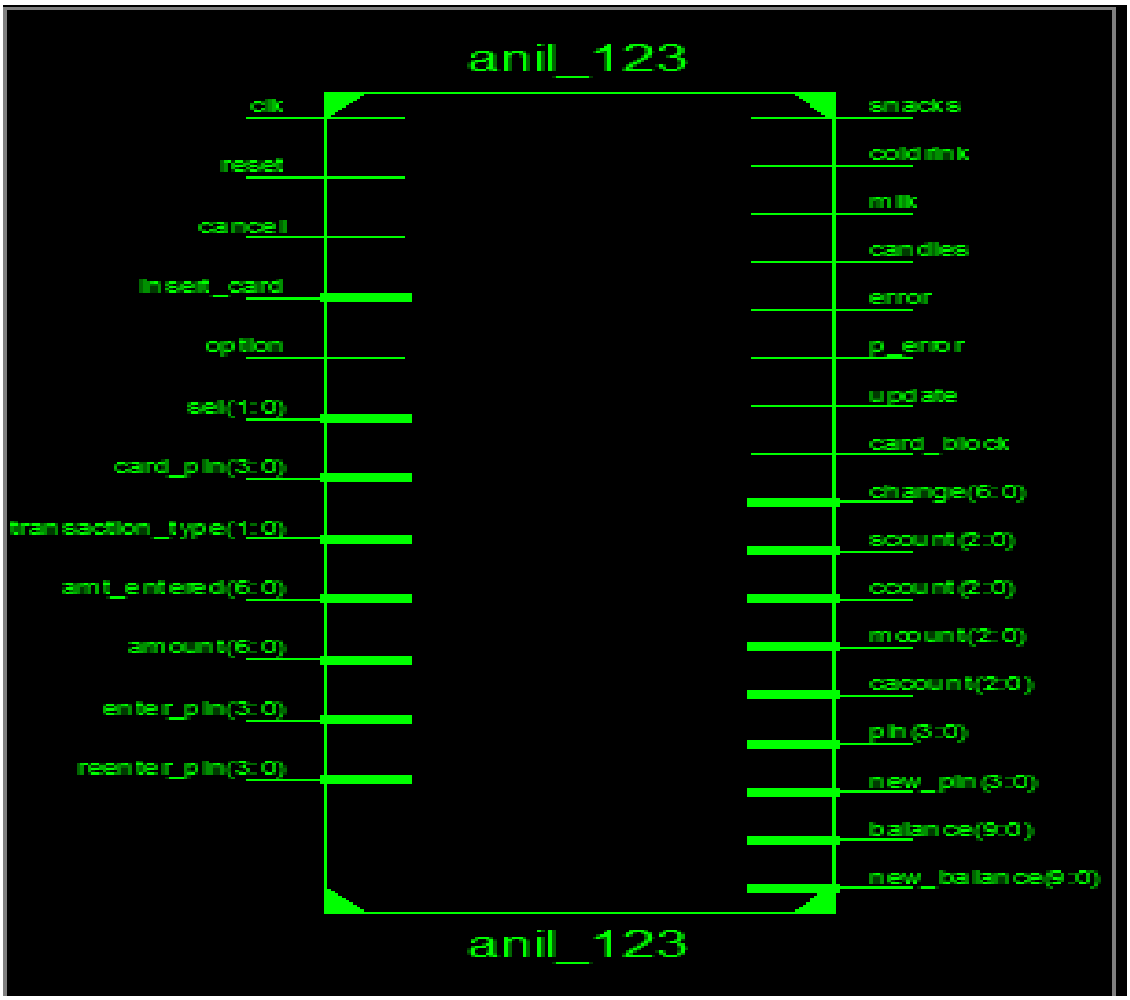

Figure 8.9: RTL view of vending machine

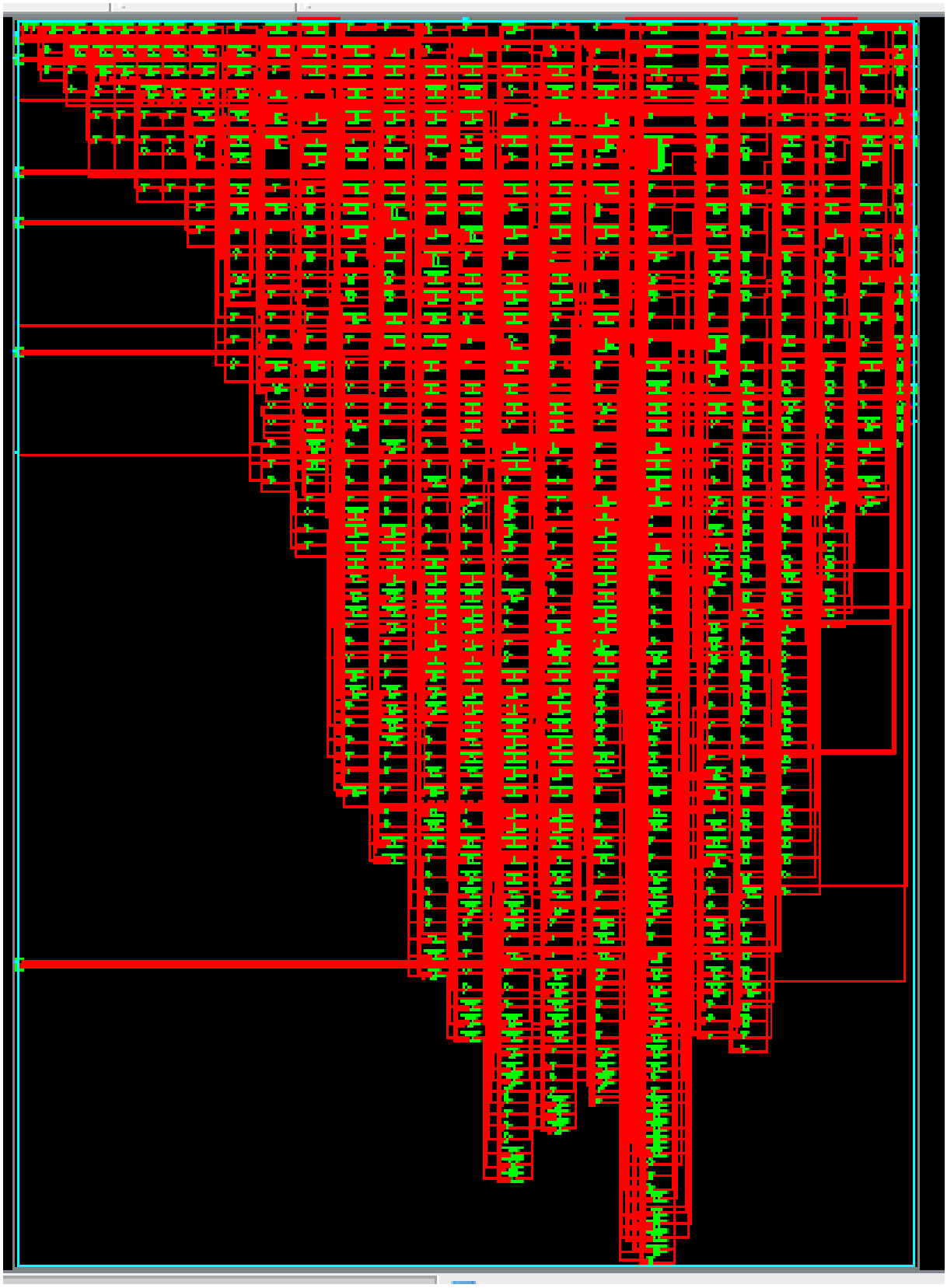

Figure 8.10: Detailed view of RTL schematic

CHAPTER 9

SUMMARY OF THE WORK DONE

We implemented the proposed vending machine which includes money based system and card based system using Xilinx 14.7i version software. First we have studied about all functions related Vending machine. Vending machine mainly works on finite state machine theory (FSM) which includes mealy and Moore machines. But In the project we used the MEALY model. Mealy model is used because it usually has less state than the Moore model. Mealy machine reacts faster to inputs; they don't need to wait for clock. Moore machine are safer to use and the output changes at the clock edge. Second we have done flow chart of money based system and then we written the code about system in Xilinx software. We got the output.

Presently we present new framework which is known as card based framework. This will be presented at the appropriate time course when they get natural. A card based framework meets expectations same as ATM (computerized teller machine) have number of alternatives to exchange cash like store cash, withdrawal, funds, exchange cash, change pin, parity enquiry and so forth. However, in this card framework we acquaint choices like store cash with energize your card, change pin. Presenting new framework in our life is face distinctive world so we have actualized mix of both card framework and cash based framework.

Now a day's people mainly rely on the card system than on the money system. It helps to have a safer and feasible transaction where they can trust, and also feel to carry less money in their wallets. In this project this is main reason to implement both systems.

In this advanced vending machine we have introduced another feature. The new option is cancel button which is not implemented now a day's vending machines. The cancel button used as whenever a person put the money into vending machine but he don't want to purchase any other items which is kept in the vending machine then we use this button. The money will return from vending machine when cancel button pressed.

In this project if there is any shortage of products in the vending machine then upon customer usage of machines it will show the product error indicates there is no availability of selected product.

9.1 Design Summary using ARTIX

The overall report of proposed vending machine development based on Artix-7 FPGA from Xilinx ISE for target FPGA board of XC7A100T-3CSG324C is mentioned below.

HDL synthesis report:

Macro statistics:

#Adders/Subtractors	: 6
10-bit add/sub	: 1
2-bit adder	: 1
3-bit subtractor	: 4
# Registers	: 22
1-bit register	: 10
10-bit register	: 2
2-bit register	: 1
3-bit register	: 4
4-bit register	: 4
7-bit register	: 1
# Comparators	: 6
10-bit comparator greater	: 4
4-bit comparator equal	: 2
# Multiplexers	: 459
1-bit 2-to-1 multiplexer	: 271
1-bit 4-to-1 multiplexer	: 6
10-bit 2-to-1 multiplexer	: 12

2-bit 2-to-1 multiplexer : 5

4-bit 16-to-1 multiplexer : 1

4-bit 2-to-1 multiplexer : 76

4-bit 4-to-1 multiplexer : 3

7-bit 2-to-1 multiplexer : 83

7-bit 4-to-1 multiplexer : 2

Advanced HDL Synthesis Report:

Macro Statistics:

Adders/Subtractors : 1

2-bit adder : 1

Counters : 4

3-bit down counter : 4

Accumulators : 1

10-bit updown accumulator : 1

Registers : 45

Flip-Flops : 45

Comparators : 6

10-bit comparator greater : 4

4-bit comparator equal : 2

Multiplexers : 459

1-bit 2-to-1 multiplexer : 271

1-bit 4-to-1 multiplexer : 6

10-bit 2-to-1 multiplexer : 12

2-bit 2-to-1 multiplexer : 5

4-bit 16-to-1 multiplexer : 1

4-bit 2-to-1 multiplexer : 76

4-bit 4-to-1 multiplexer : 3

7-bit 2-to-1 multiplexer : 83

7-bit 4-to-1 multiplexer : 2

Final Register Report

Macro Statistics

Registers : 68

Flip-Flops : 68

Clock Information:

Clock Signal	Clock buffer (FF name)	Load
Clk	BUFGP	68

Timing Summary:

Speed Grade: -3

Minimum period: 4.312ns (Maximum Frequency: 231.934MHz)

Minimum input arrival time before clock: 4.660ns

Maximum output required time after clock: 0.677ns

9.2 Design Summary using VIRTEX:

The overall report of proposed vending machine in Xilinx ISE for target FPGA board of XC5VLX50T-2FF1136 is mentioned below.

TABLE9.3: **Device utilization summary**

The overall report of this is tabulated in below table and is compared with base paper results.

Slice Logic Utilization	**VM using Money**	**Proposed VM using Money**	**Proposed VM Money and Card**
Number of slice registers	333	38	86
Number used as flip flops	333	38	86
Number of slice LUTs	729	189	321
Number used as logic	720	189	321
Number using O6 output only	205	176	304
Number of occupied slices	238	76	118
Number of LUT flip flop pairs used	753	193	328
Number with an unused flip flop	420	155	242
Number with an unused LUT	24	4	7
Number of fully used LUT-FF pairs	309	34	79
Number of unique control sets	11	16	19
Number of slice register sites lost to control set restrictions	23	42	50
Number of bonded IOBs	31	37	90
Number of BUFG/BUFGCTRLs	1	1	1
Number used as BUFGs	1	1	1
Average fan-out non-clock nets	3.49	4.87	4.66

Timing Summary:

Speed Grade: -2

Vending Machine using Money:

Minimum period: 5.846ns (Maximum Frequency: 171.043MHz)

Minimum input arrival time before clock: 6.079ns

Maximum output required time after clock: 2.858ns

Vending Machine using Money and Card:

Minimum period: 6.303ns (Maximum Frequency: 158.657MHz)

Minimum input arrival time before clock: 6.451ns

Maximum output required time after clock: 2.891ns

TABLE9.1: **Timing Report**

Parameter	**VM using Money**	**Proposed VM using Money**	**Proposed VM using Money and Card**
Minimum period (ns)	4.563	5.846	6.303
Maximum operating frequency (MHz)	219.154	171.043	158.657

TABLE9.2: **Power report**

The dynamic power and quiescent power of proposed Vending Machine in terms of milli watts is shown below table.

Supply Power (mW)	**VM using Money**	**Proposed VM using Money**	**Proposed VM using Money and Card**
Dynamic	6.42	2	3
Quiescent	560.52	560	560
Total	566.94	562	563

CONCLUSION

When we understood that we have at last made a code that could really work as a user friendly vending machine which accepts both money and card as inputs. This code can actually provide a variety of options to the user and also return him/her the balance money. This Verilog code has been successfully verified using the Xilinx ISE 14.7i tool and the desired outputs have been reached. The designed model has maximum operating frequency of 158.657 MHz and the obtained results of optimized area, power and delay are tabulated and discussed the significance.

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