DESIGN OF VENDING MACHINE USING VERILOG HDL

A. Krishna Kumar,
Assistant Professor, Dept of ECE, Chaitanya Bharathi Institute of Technology, Hyderabad
G. Ashritha,
M.E (Embedded Systems & VLSI Design), Chaitanya Bharathi Institute of Technology, Hyderabad
D. Deepika,
Assistant Professor, Dept of CSE, Mahatma Gandhi Institute of Technology, Hyderabad

ABSTRACT: The vending machine is an automated machine that dispenses various products such as snacks, beverages, newspapers, tickets etc to customers when money or credit card is inserted. Vending machines are more accessible and practical than the convention purchasing method Now, vending machine market is a big business with huge annual revenue for leading nations like The USA, Japan, China and some other Asian countries including India. The paper aims to design a vending machine that can dispense three products of different prices with additional features of 'return change' when a coin of higher denomination is inserted and 'return money' when request is cancelled. The machine accepts coins of denominations five and ten. The finite state machine (FSM) approach is adopted for the design of vending machine. The design is achieved by formulating the Verilog code for the FSM-based machine using behavioural modeling and simulating the testbench for three products using Xilinx ISE tool.

Keywords:- Vending Machine, Finite State Machine, Behavioural model, CAD.

INTRODUCTION

The Vending Machine is an automatic machine that sells food such as canned soups and packaged sandwiches, snacks such as potato chips, chocolate bars, and candy); hot drinks (coffee, tea, and hot chocolate); cold drinks (juice, bottled water, soft drinks, and in some cases, milk or chocolate milk); or other items such as newspapers or tickets. The machines usually work when a product is selected and some money (usually coins or paper money) is put in a slot. Then, a button needs to be pushed, or a lever pulled. If there is enough money, the selected item will be dropped to a tray, where it can be taken out by the person making the purchase.

From 2000-2010, the specialization of vending machines became more common. Vending extended increasingly into non-traditional areas like electronics, or even artwork or short stories. Machines of this new category are generally called Automated retail kiosks. When using an automated retail machine, consumers select products, sometimes using a touch screen interface, pay for purchases using a credit or debit card and then the product is dispensed, sometimes via an internal robotic arm in the machine. The trend of specialization and proliferation of vending machines is perhaps most apparent in Japan where there is 1 vending machine for 23 people.

Apparently similar to the development of traditional mobile phones into smartphones, vending machines have also progressively, though at a much slower pace, evolved into smart vending machines. Newer technologies at a lower cost of adoption, such as the large digital touch display, internet connectivity, cameras and various types of sensors, more cost-effective embedded computing power, digital signage, various advanced payment systems, and a wide range of identification technology (NFC, RFID, etc) have contributed to this development.. Integrated sensors and cameras also represent a source of such data as customer demographics, purchase trends, and other locality-specific information. It also enables better customer-engagement for the brands through interactive multimedia and social media connectivity. Smart vending machines were #79 by JWT Intelligence on its list of 100 Things to Watch in 2014. According to market research by Frost & Sullivan, global shipments of smart vending machines are forecasted to reach around 2 million units by 2018 and further to 3.6 million units by 2020 with penetration rate of 20.3 percent.

LITERATURE SURVEY

Various researches have been carried out in order to design the Vending Machines. A few of them are discussed below.

In the paper, "FSM Based Design on the Replication of one-hot code using Verilog HDL[1]," a self-checking approach to enhance the SEU/MBUs immunity of FSMs' states by replicating One-Hot code times for state encoding is presented. This approach can correct less than bit-flip faults in the state register per cycle. Characteristics of this approach are obtained by this approach can offer more enhanced reliability than Binary or One-Hot state encoding. a self-checking approach to enhance the SEU/MBUs immunity of FSMs' states by replicating One-Hot code times for state encoding is presented. This approach can correct less than bit-flip faults in the state register per cycle. Characteristics of this approach are obtained by this approach can offer more enhanced reliability than Binary or One-Hot state encoding.

The paper "Design and Implementation of Vending Machine using Verilog HDL on FPGA[2]," describes the modeling of a Finite State based vending machine using the mealy machine model. The proposed machine has been implemented on Spartan3 FPGA development board. The whole design has been functionally verified using Xilinx 9.2i and Modelsim 6.2a simulator. A vending machine isa machine which dispenses items such as snacks, beverages, lottery tickets, consumer products to customers

automatically after the customer inserts currency or credit into the machine. This paper compares different aspects as timing and device utilization of the proposed machine with the previously proposed machine3. Also the paper indicates a future possibility of a betterment over existing vending machines.

The paper, "Finite State Machine based Vending Machine Controller with Auto-Billing Features[3]," describes the designing of multi select machine using Finite State Machine Model with Auto-Billing Features. The process of four state (user Selection, Waiting for money insertion, product delivery and servicing) has been modelled using Mealy Machine Model. The proposed model is tested using Spartan 3 development board and its performance is compared with CMOS based machine.

In the paper, "Design and Implementation of Vending Machine using Verilog HDL[4]," they propose FPGA board VM, which provide to people four products, namely, Ice cream, Coca-Cola, snacks and chocolate. Using very simple steps and design, efficiency can be improved to deliver the product. The machine takes an only coin, two types of coins (one rupee and two rupee). It provides the change depending on the amount of money that the user has inserted, and there is a Cancel button to return the money to the user. Using Xilinx, State CAD tool does the VM simulation.

DESIGN METHODOLOGY

A finite state machine is an abstract machine that can be in one of the finite number of states at any given time. It is an abstract model that describes the synchronous sequential machine. The most general model of a sequential machine has inputs, outputs and internal states. Since in a sequential circuit the output depends on the present input as well as on the past inputs, i.e. on the past histories and since a machine might have infinite varieties of possible histories, it would need an infinite capability for storing them. Since it is impossible to implement machines which have infinite storage capabilities, we consider only finite state machines. Finite state machines are sequential circuits whose past histories can affect their future behaviour in only a finite number of ways, i.e., they are machines with a fixed number of states. These machines can distinguish among a finite number of classes of input histories. These classes of input histories are referred to as internal states of the machine. Every finite state machine therefore contains a finite number of memory devices.

A) PROBLEM FORMULATION

The problem is defined as design of vending machine that accepts coins of denominations five and ten and dispenses three products of different prices. The machine should possess additional features of returning change when a coin of higher denomination is inserted and returning money when request is cancelled.

The machine asks the customer to select the product first and then insert coins as per the price of the selected product. The select and coin signals are therefore inputs to the machine. There is also cancel option which is another input. The machine checks the inserted amount with the price of the select product and dispenses product if both are equal. If the customer inserts a coin of higher denomination, the machine gives the product along with the change. Whenever change is not available in the machine, it returns the total amount. Product and change are therefore outputs of the machine. Money is returned when request is cancelled. Therefore, return money is another output.

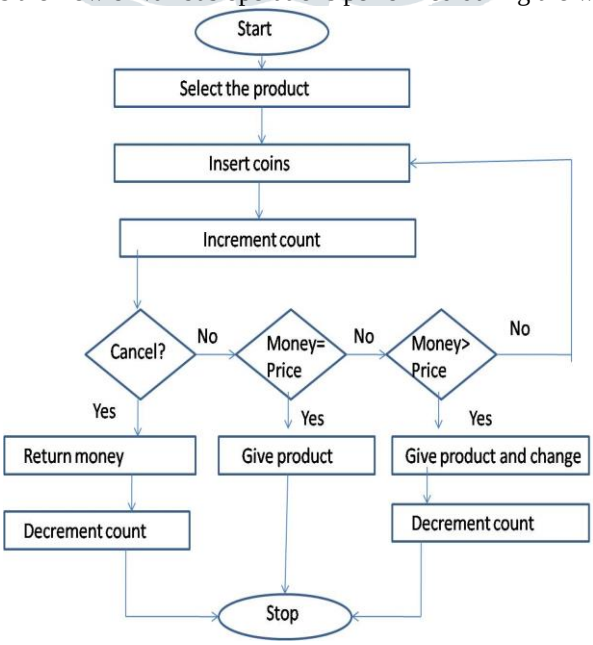
Two registers are needed, one to keep track of the coin count of the present transaction and the other to keep track of the total coin count in the machine. The registers are taken to be ten bit width each. When a higher denomination coin is inserted, change can be given only if the total coin count is higher than the coin count of present transaction. In this way, the machine checks whether the change is available or not.

In order to meet the above specifications, a finite state machine approach is adopted. The ASM chart and state diagram are drawn, and the corresponding Verilog code is formulated using behavioural modeling.

The subsequent sections deal with elaborate descriptions of the flowchart and state diagram of the Vending Machine.

B) FLOW CHART OF VENDING MACHINE

The flow chart below indicates the flow of various operations performed during the working of the vending machine.



Flow chart of Vending Machine

The explanation is as follows.

Initially, the product needs to be selected followed by the insertion of coins. The count is incremented as the coins are inserted. If a cancel signal is given, the machine returns inserted money and decrements count. Otherwise, the machine checks the inserted money with the price of the selected product. If both are equal, the machine dispenses the appropriate product. If inserted money is greater than price, the machine give the appropriate product along with the change. If inserted money is less than the price of the selected product, the machine waits for the customer to insert more coins.

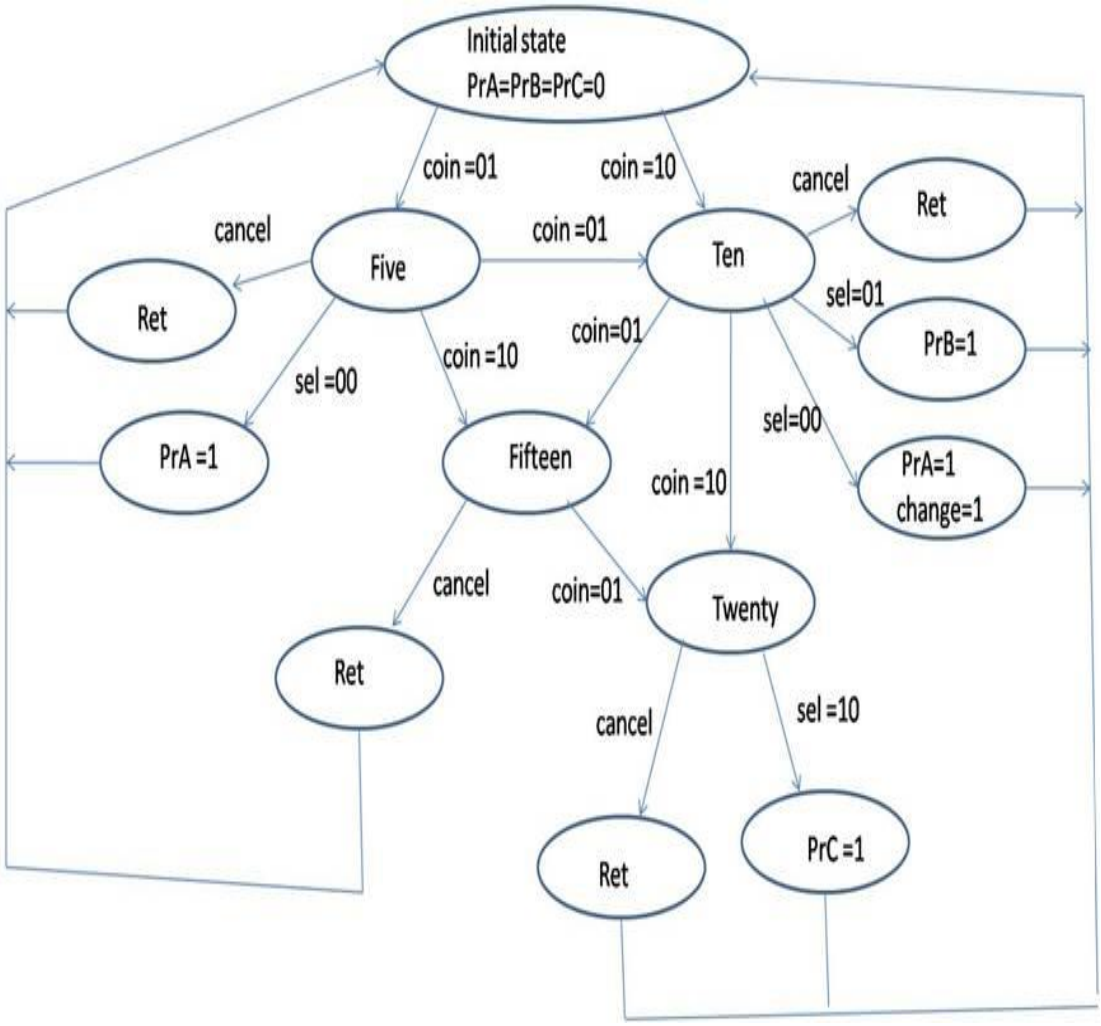
C) STATE DIAGRAM OF VENDING MACHINE

The flow of signals that lead to various states is shown in subsequent figure. The select and coin signals are inputs. Cancel signal is also input. Product, change and return are outputs. The inputs for various products are assigned as given below.

Sel = 00 – Product A (Rs. 5/-) Coin = 01 - Five
Sel = 01 – Product B (Rs. 10/-) Coin = 10 - Ten
Sel = 10 – Product C (Rs. 20/-)

Initially, the machine is in intial state where no product is given. The customer selects the product and inserts coins. If a five coin is inserted, the machine goes to 'five' state. If cancel button is pressed, the machine returns the money and goes to initial state. Otherwise, it checks for selection and gives product if select signal is of product A. Similarly, when ten coin is inserted, the machine goes to 'ten' state. If cancel button is pressed , the machine returns the money and goes to initial state. Otherwise, it checks for selection. If selected product has the same price as money inserted, it gives the product and change. If the entered money is of higher denomination than the price of the product selected, the machine gives product B along with change of five.

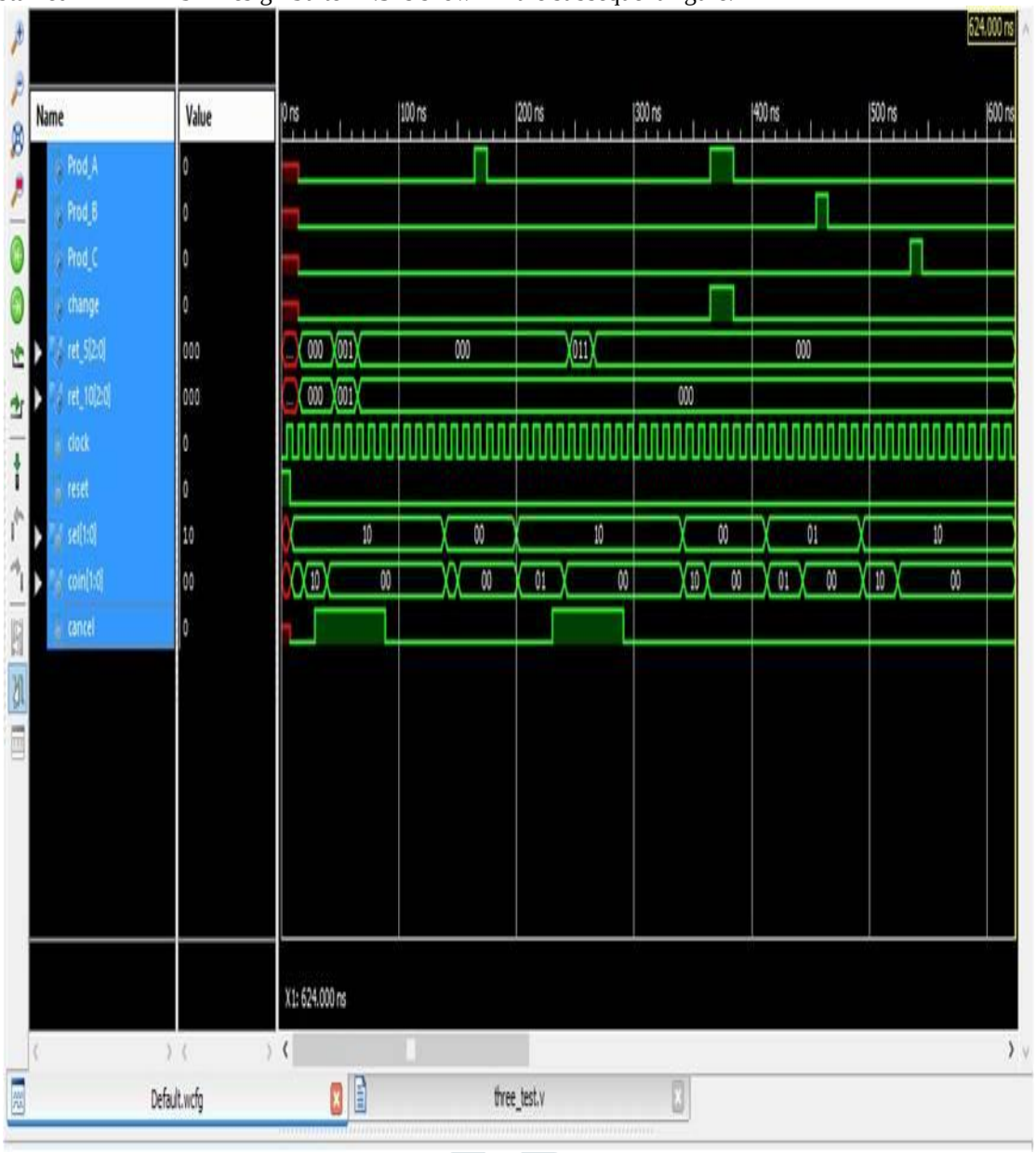
Similarly, the machine enters other states such as fifteen and ten as coins are inserted and checks for selection after reaching each state. The product is dispensed accordingly. The state diagram indicates the flow of various signals and states during the working of vending machine.



State diagram of Vending Machine

RESULTS & DISCUSSION

The verilog code has been formulated for the vending machine using behavioural modelling. The testbench has been written for three products A, B and C and cancellation of two transactions. The simulation has been performed. The simulation waveform as obtained in Xilinx ISE Design Suite 14.5 is shown in the subsequent figure.



Simulation Result

In the first transaction, Product C – 10 was selected. Cancel signal was given after inserting a five rupee coin and a ten rupee coin. The machine returned the five rupee coin and the ten rupee coin. In the second transaction, Product A – 00 was selected and a five rupee coin was inserted. The machine dispensed Product A. In the third transaction, Product C was again selected and cancel signal was given after inserting three five rupee coins. The machine returned the three five rupee coins.

In the fourth transaction, Product A – 00 was selected and a ten rupee coin was inserted. The machine dispensed Product A of price five rupees along with a change of five rupees. In the fifth and sixth transactions, products B and C were selected and appropriate money was inserted and the products were dispensed.

The first and third transactions indicate cancellation feature. The fourth transaction indicates the return change feature. The fifth and sixth transactions indicate the dispensing of product when money equal to exact price is inserted**.**

Device Utilization summary

Selected Device : 7a100tcsg324-3
Slice Logic Utilization:
Number of Slice Registers: 9 out of 126800 0%
Number of Slice LUTs: 15 out of 63400 0%
Number used as Logic: 15 out of 63400 0%
Slice Logic Distribution:
Number of LUT Flip Flop pairs used: 15

Number with an unused Flip Flop: 6 out of 15 40%
Number with an unused LUT: 0 out of 15 0%
Number of fully used LUT-FF pairs: 9 out of 15 60%
Number of unique control sets: 2
IO Utilization:
Number of IOs: 10
Number of bonded IOBs: 10 out of 210 4%
Specific Feature Utilization:
Number of BUFG/BUFGCTRL/BUFHCEs: 1 out of 128 0%

Timing summary

Delay: 1.402ns

CONCLUSIONS

The vending machine was successful in dispensing three products A, B and C of prices Rs.5/-, Rs.10/- and Rs-20/- respectively, with the additional features of dispensing product along with returning change when higher denomination coin is inserted and returning total money when request is cancelled. The vending machine is successful in meeting the specifications laid out prior to the design.

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