

## Design and Implementation of Vending Machine using Verilog HDL

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**Abstract**— vending machines are used to dispense small different products (snacks, ice creams, cold drinks etc.) , when a coin is inserted. These machines can be implemented in different ways by using microcontroller and FPGA board. Here in this paper, we proposed an efficient algorithm for implementation of vending machine on FPGA board. Because FPGA based vending machine give fast response and uses less power than the microcontroller based vending machine. In this paper FPGA based vending machine supports four products and two coins. The vending machine accepts coins as inputs in any sequence and delivers products when required amount is deposited and gives back the change if entered amount is greater than the price of product. It also supports cancel feature means a user can withdraw the request any time and entered money will be returned back without any product . The proposed algorithm is implemented in Verilog HDL and simulated using Xilinx StateCAD tool. The design is implemented on Xilinx Spartan-3 xc3s400 FPGA development board.

**Keywords**- FSM; Verilog HDL; StateCAD; Xilinx; Vending Machine;

### 1. Introduction

A vending machine is a machine that provides items such as snacks, chocolates, ice creams, cold drinks even diamonds and platinum jewellery to customers, after the vendee inserts currency or credit into the machine using extremely simple steps [1]. These steps would not be time consuming at all. The vendee would get all the details on the screen which he/she should follow. Previous microcontroller or microprocessor based vending machines were inefficient as compared to FPGA based vending machine. So it is necessary to make it more reliable with efficient algorithm that will be fully commanded by FPGA based solution [3].

The main purpose of writing this paper was to create a vending machine which could provide four products, namely Snacks, Chocolate, Ice cream and Coca-Cola to the people using extremely simple steps. We have made an attempt to vend four products of different prices in the same machine. The machine will also provide the change to the vendee depending on the amount of money he/she has inserted. It is also possible to withdraw the deposited money in between, if consumer wishes by pressing a cancel button.

#### 1.1 Finite State Machine

A finite state machine (FSM) is a digital sequential circuit that consists on number of pre-defined states that are controlled by one or more inputs[2]. The finite state machine remain stable until the inputs changes. There are two types of finite state machines: 1- Synchronous FSMs 2-Asynchronous FSMs. Synchronous FSMs have a clock input and are also called Mealy machines, while asynchronous FSMs are without clock input and are also called Moore machines[2][3].The proposed algorithm for FPGA based vending machine is a sequential circuit which is based on Mealy Model. In a Moore machine Model the output of the machine totally depend on the present state, while in a Mealy machine Model the output is depend on the present state

as well as the previous input. The Mealy and Moore machines models are shown in Figure 1. and in Figure 2. respectively.

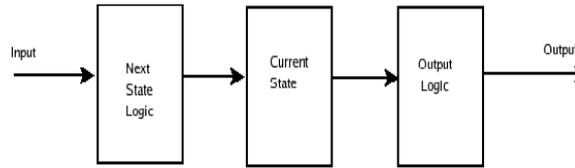


Figure 1. Moore Machine Model

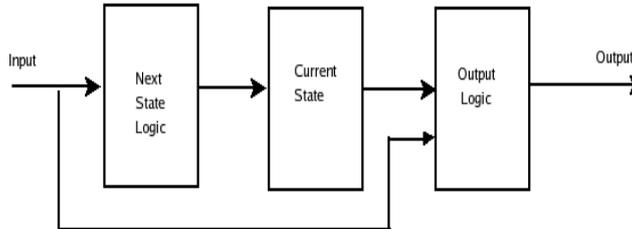


Figure 2. Mealy Machine Mode

### 1.2 Xilinx StateCAD Tool

In this paper the simulation of vending machine is done by using Xilinx StateCAD tool. StateCAD is a wonderful tool in Xilinx that is used by engineers to implement their ideas in graphical form such as state diagram. By using StateCAD tool we can get the required results without facing a lot of steps and errors, that are faced in writing the HDL code directly. The StateCAD eliminates the labour of writing the HDL code. Hence we can say that StateCAD is a time saving tool for engineers. [4],[5],[6].

## 2. Implementation

In this paper vending machine is constructed in terms of state diagrams with the help of StateCAD tool. The customer can get four different kinds of products of different prices, namely Snacks, Chocolates, Ice cream and Coca-Cola. The prices of these products are given in the Table 1. The machine can accept the coins of one rupee and two rupees in any possible sequence.

There are four product selection buttons, namely SELECT1, SELECT2, SELECT3 and SELECT4. For instance, to vend out Chocolate, the vendee has to push the button SELECT2. Similarly SELECT1, SELECT3 and SELECT4 represents Snacks, Ice-cream and Coca-Cola respectively. Here COIN1 represents RS.1/- and COIN2 represents Rs.2/- CANCEL button is used when the user wants to withdraw his money at any stage provided that the inserted money is not equal to the price of the selected product. The outputs are CHANGE, RETRN and PRODUCT. Note that COINCOUNT is an internal vector while CHANGE and RETRN are output vectors. The three bit bus or vector variable COINCOUNT counts the amount of money inserted at every transition. CHANGE and RETRN are also three bit wide vectors. These two output vectors are used to display the change and the amount of money that has been returned to the user if he/she cancels. The system changes its states on every transitions of positive edge of clock cycle represented by input CLK. The system returns to its initial state when RESET is asserted. The detail list of input and output ports are shown in Table 2. The code is written and synthesized in Verilog HDL. After synthesizing the Register Transfer Level (RTL) schematic diagram is shown in Figure 2 and the synthesis report is shown in Table 3.

TABLE I. LIST OF PRODUCTS WITH PRICES

No.	Product	Price
1	Snacks	Rs.3/-
2	Chocolate	Rs.4/-
3	Ice cream	Rs.5/-
4	CocaCola	Rs.6/-

TABLE II. PORTS DESCRIPTION

Port Name	Direction	Width	Remarks
CLK	Input	1	Clock
RESET	Input	1	Synchronous Reset
CANCEL	Input	1	Cancel
COIN1	Input	1	One Rupee
COIN2	Input	1	Two Rupees
SELECT1	Input	1	Snacks
SELECT2	Input	1	Chocolate
SELECT3	Input	1	Ice cream
SELECT4	Input	1	CocaCola
PRODUCT	Output	1	Selected product dispense
CHANGE	Output	3	Extra Money
RETRN	Output	3	Return money if cancelled

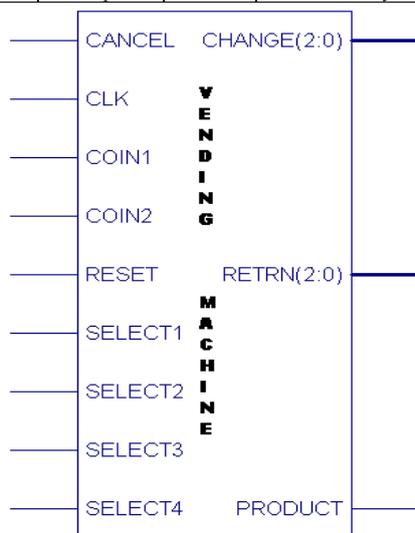


Figure 3. RTL Schematic Diagram

TABLE III. DEVICE UTILIZATION SUMMARY

Logic Utilization	Used	Available	Utilization
Number Of Slices	56	768	7%
Number of Slice Flip Flops	35	1536	2%
Number of 4 input LUTs	107	1536	6%
Number of bonded IOBs	16	124	12%
Number of GCLKs	1	8	12%

### 3. Algorithm Description

When the machine is reset, it become ready for the user to select the desired product and this state is represented by initial state (INIT) in the StateCAD tool. Note that at every transition there is a condition so that machine can decide which next state is to be executed. When the user will insert a coin, the machine will check the condition at every transition. After executing the correct condition, the machine will come back to the WAITING state. At the end, the user will get his/her desired product if the inserted amount of money is equal to the price of the selected product. For four products and two coins, there are twenty two states. The complete state diagram is shown in Figure 3.

Lets take an example that the user wants to purchase Snacks then he/she has to push the SELECT1 button, as a result the machine will enter into the WAITING\_1 state from INIT state. Now the machine will wait for the coins. Suppose the customer inserts a coin of one rupee then the machine will enter into the STATE\_1 which represents that one rupee has been deposited and the value of COINCOUNT will be 1. At STATE\_1, the value of PRODUCT and CHANGE is 0. The machine will comeback automatically to the WAITING\_1 state where it will again ready to accept the coin of any value. Suppose this time he/she inserts the coin of two rupees, the machine will go to STATE\_2 at which the value of COINCOUNT is incremented by two rupees

and will become equal to three. Again the machine will come back to the WAITING\_1 state at which the output condition is checked. As the condition(COINCOUNT>2) is correct therefore the machine will enter to the product state at which product will be released. It is also necessary to describe that if the customer inserts extra money i.e.Rs.4/- then he will get the extra money back as a change(Rs.1/-). If he/she presses the CANCEL button then he/she will get his money back. Similarly the customers can get all the other products by following the same procedure.

## 4. Simulation Results

The algorithm is simulated using Xilinx StateCAD tool. For different choices of products and various coins combinations, the simulation waveforms are generated and shown in Figure 4, 5 and 6.

In Figure 4, the customer selects the product 1(Snacks). As the snacks cost is three Rupees, the vendee inserted two coins of two Rupees,. The value of coincount is 4 as indicated in the figure which exceeds the price of product. At the end the machine vends out the product as well as it gives a coin of one Rupee as a change. Figure 5 verifies the Testbench waveform for product 2. The price of Chocolate is four Rupees. Here State\_4 represents that a coin of two Rupees is inserted into the machine. There are different combinations of coins by which vendee can get this product. In this combination the customer inserts two coins of two Rupees. Therefore, the machine releases the product i.e. Chocolate. Lets take an example that the vendee selects the product 4. After selecting the product the machine will wait for the user to insert the coin. Here State\_8 represents that a coin of two Rupees is inserted into the machine. Suppose he/she inserts a coin of one Rupee and suddenly he/she changes his mind to get some other product then he/she has a option to get his/her money back simply by pressing a Cancel button. The same procedure is adopted in Figure 6.

## 5. Conclusion

It was observed through different scenarios, that FPGA based vending machine give fast response and also show low power consumption and easy to use by an ordinary person. Our results clearly indicate that FPGA based solution increases the efficiency and accuracy of vending machines. Also we can monitor the FPGA based vending machine with the main frame computer. Its algorithm is very flexible and reliable as the vendor can easily enhance the algorithm for large number of products and coins of different denominations at low cost as compared to microprocessor based vending machine.

## 6. Acknowledgment

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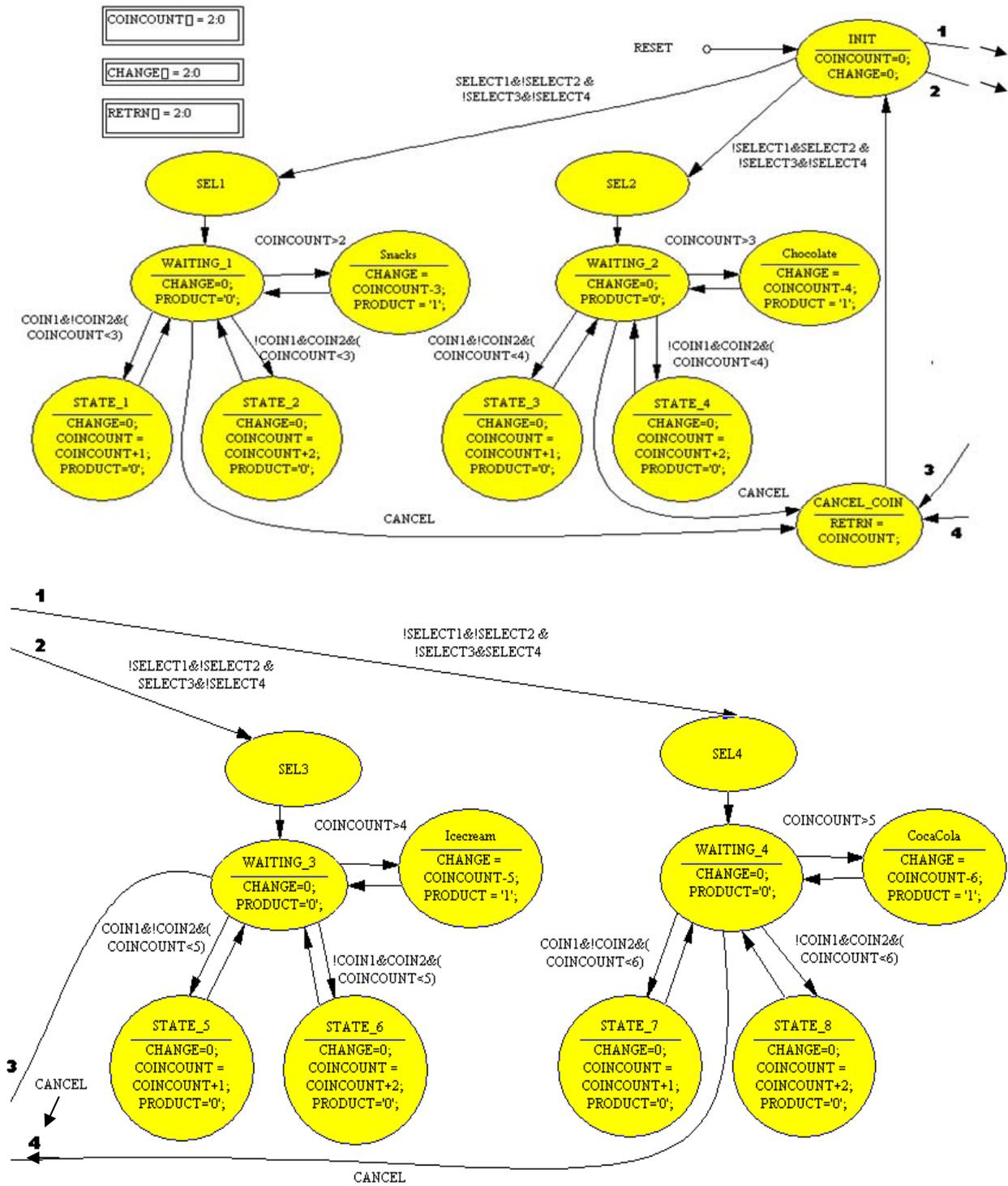


Figure 4. State Diagram

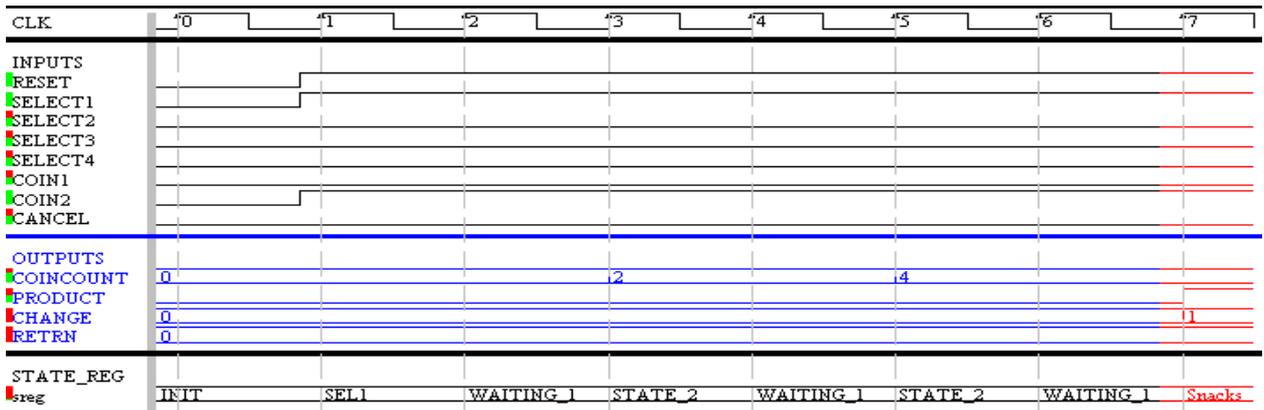


Figure 5. Selection of Product 1

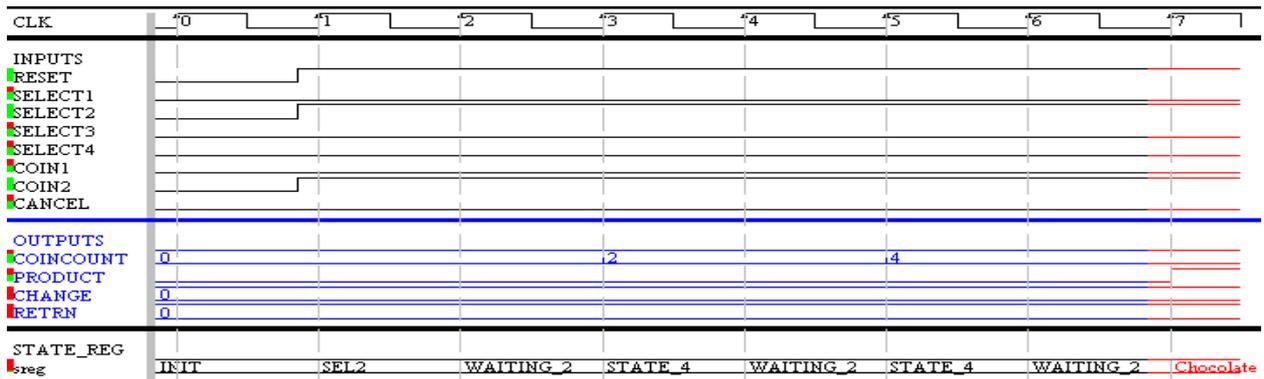


Figure 6. Selection of Product 2

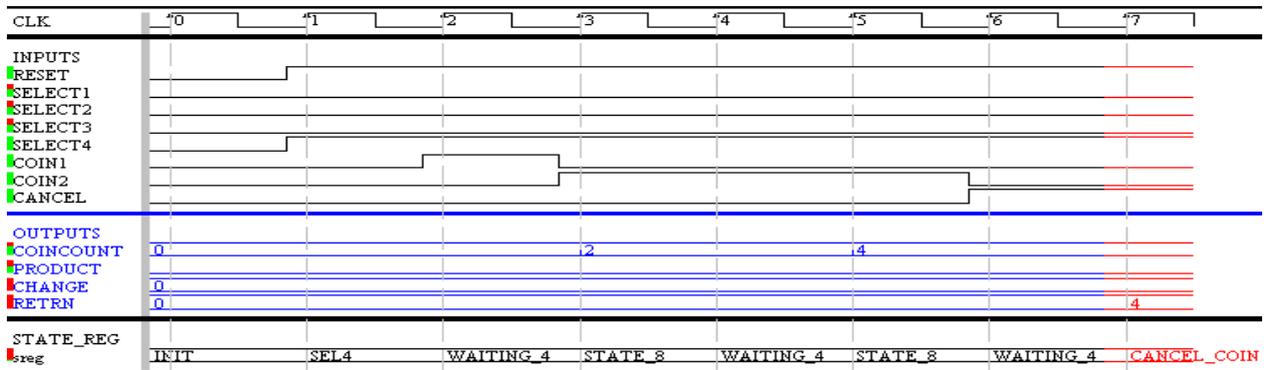


Figure 7. Waveform when Canel Button is pressed